PERANAN BERBAGAI MODALITAS RADIOLOGI PADA PEMERIKSAAN *TEMPOROMANDIBULAR JOINT*

KARYA TULIS ILMIAH

JANER DANILO

19.01.052

PROGRAM STUDI RADIOLOGI PROGRAM DIPLOMA TIGA
FAKULTAS KESEHATAN DAN KETEKNISIAN MEDIK
UNIVERSITAS WIDYA HUSADA SEMARANG
2022

PERANAN BERBAGAI MODALITAS RADIOLOGI PADA PEMERIKSAAN *TEMPOROMANDIBULAR JOINT*

KARYA TULIS ILMIAH

JANER DANILO

19.01.052

PROGRAM STUDI RADIOLOGI PROGRAM DIPLOMA TIGA
FAKULTAS KESEHATAN DAN KETEKNISIAN MEDIK
UNIVERSITAS WIDYA HUSADA SEMARANG
2022

PERSETUJUAN SIAP UJIAN KARYA TULIS ILMIAH

Judul : Peranan Berbagai Modalitas Radiologi Pada Pemeriksaan *Temporomandibular Joint*

Nama Mahasiswa : Janer Danilo

NIM : 19.01.052

Siap dipertahankan di depan penguji

Pada : 03 Agustus 2022

Menyetujui,

(Lucky Restyanti Wahyu Utami, S.Tr.Rad., M.Tr.Kes)

PENGESAHAN KARYA TULIS ILMIAH

Judul KTI : Peranan Berbagai Modalitas Radiologi Pada Pemeriksaan *Temporomandibular Joint*

Nama Mahasiswa : Janer Danilo

NIM : 1901052

Telah dipertahankan di depan tim penguji

Pada : 05/ Agusutus / 2022

Menyetujui,

1. Ketua Penguji : Trisna Budiwati, S.Si., M.Si ( )
2. Anggota Penguji : Siti Akbari P, S.Si., M.Kes ( )

Mengetahui,

Dekan	Ketua
Fakultas Kesehatan Dan Keteknisian Medis Universitas Widya Husada Semarang	Program Studi Diploma III Radiologi
Didik Wahyudi, SKM., M.Kes NIDN : 0602047902	Nanik Suraningsih, S.ST, M.Kes NIDN : 0611127803

SURAT PERNYATAAN KEASLIAN

Saya yang bertanda tangan dibawah ini :

Nama : Janer Danilo

Tempat tanggal lahir : Jelarai Selor, 13 November 2001

NIM : 19.01.052

Program studi : Diploma III Radiologi

Menyatakan dengan sesungguhnya, bahwa penulisan Karya Tulis Ilmiah yang saya susun dengan judul "peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint* " tahun 2022 adalah asli penulisan saya, dan tidak terdapat karya yang pernah diajukan untuk memperoleh gelar akademis di suatu Institusi Pendidikan serta sepanjang pengetahuan saya juga tidak terdapat karya atau pendapat yang pernah ditulis dan/atau diterbitkan oleh orang lain, kecuali yang secara tertulis diacu dalam naskah ini dan disebutkan dalam daftar pustaka.

Jika kemudian hari ternyata ditemukan kesamaan sebagai hasil perbuatan disengaja, meniru atau menjiplak hasil karya orang lain, maka saya bersedia mempertanggungjawabkan perbuatan saya tersebut dengan menanggung segala konsekuensi sesuai dengan aturan yang berlaku atas plagiat yang saya lakukan. Demikian surat pernyataan ini saya buat dengan penuh kesadaran dan tanggung jawab.

Semarang, 03 Agustus 2022

(Janer Danilo)

DAFTAR RIWAYAT HIDUP

Nama	: Janer Danilo
Tempat, Tanggal Lahir	: Jelarai Selor, 13 November 2001
Alamat	:Jelarai Selor, Jl Uma Bilung-Lung RT 032 / RW 000, Tanjung Selor Bulungan, Kalimantan Utara
Jenis Kelamin	: Laki-Laki
Agama	: Kristen Protestan
Kewarganegaraan	: Indonesia
Nomor Handphone	: 082234206139
Nomor Telpon	: -
Email	: jannerdanilo13@gmail.com
Riwayat Pendidikan	:

No.	Riwayat Pendidikan	Tahun Masuk dan Tahun Lulus
1.	SD Negeri 004 Tanjung Selor	2007-2013
2.	SMP Negeri 3 Tanjung Selor	2013-2016
3.	SMA Negeri 1 Tanjung Selor	2016-2019
4.	Program Diploma III Radiologi Universitas Widya Husada Semarang	2019-2022

HALAMAN PERSEMBAHAN

Karya Tulis Ilmiah ini penulis persembahkan untuk :

1. Tuhan Yesus Kristus atas semua hikmat, rahmat dan kekuatan, Kesehatan serta berkat melimpah yang dikaruniakan kepada penulis sehingga penulis dapat menyelesaikan Karya Tulis Ilmiah dengan baik dan lancar.
2. Bapak (Alm) Yasa Ngelukung, dan Nenek (Alm) Incan Bato terima kasih untuk pelajaran hidup dan didikannya. Karya tulis ini penulis dedikasikan agar menjadi sebuah kebanggan.
3. Ibu Betha La yang selalu memberikan kasih, cinta, semangat, motivasi, Do'a dan dukungan serta senantiasa memberikan yang terbaik.
4. Om niko terima kasih sudah menjadi sosok pengganti Ayah bagi penulis yang selalu memberikan dukungan baik secara materi maupun teori.
5. Kakak Ton, Kak Ibing, Kak Cell, dan Kak Ita. Terima kasih sudah mampu menghantarkan penulis hingga ke titik saat ini, yang selalu memotivasi dan mendukung dalam setiap keputusan penulis.
6. Tante Lafang serta keluarga besar penulis yang senantiasa memberikan nasihat, bimbingan, semangat, motivasi dan doa serta dukungan moral dan materi dalam penyusunan Karya Tulis Ilmiah ini.
7. Dosen Pembimbing Ibu Lucky Restyanti Wahyu Utami, S.Tr.Rad., M.Tr.Kes yang sedia meluangkan waktu untuk membimbing dan memberikan saran serta masukan yang bermanfaat sehingga saya dapat menyusun dan menyelesaikan Karya Tulis Ilmiah ini.
8. Dosen dan seluruh staf Program Studi Diploma III Teknik Rontgen Universitas Widya Husada Semarang, terima kasih untuk semua ilmu dan bimbingan yang diberikan selama penulis kuliah.
9. Novia yang selalu membantu dan mensupport, serta dorongan dalam menyusun Karya Tulis Ilmiah ini.
10. Kepada Mas Gilang, Diagy, Firdaus, Faisal, Yogi, Rama, Raihan, Doves dan Gunawan tanpa kalian masa-masa kuliah saya akan biasa saja terima kasih atas support selama tiga tahun ini, sampai saya bisa menyelesaikan Karya Tulis Ilmiah ini.

11. Sahabatku Ferdy Aprizal, yang selalu memberikan motivasi dan dukungan dalam perkuliahan, sampai saya bisa menyelesaikan Karya Tulis Ilmiah ini.
12. Sahabat BGJ squad yang selalu mensupport selama masa perkuliahan saya.
13. Teman-teman seperjuangan terutama kelas Rontgen yang selalu memberikan dukungan dan motivasi. Kenangan 3 tahun bersama kalian tidak akan pernah saya lupakan.
14. Semua pihak yang tidak bisa penulis sebutkan satu persatu yang telah membantu sehingga penulis dapat menyelesaikan Karya Tulis Ilmiah ini.

MOTTO

Sebab itu jangan lah kamu kuatir akan hari besok, karena hari besok mempunyai kesusahannya sendiri. Kesusahan sehari cukuplah untuk sehari.
(Matius 6 : 34)

KATA PENGANTAR

Puji syukur kehadirat Tuhan karena atas segala rahmat yang dilimpahkan- Nya, sehingga penulis dapat menyelesaikan Karya Tulis Ilmiah dengan judul "peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint*".

Karya Tulis Ilmiah ini disusun untuk memenuhi mata kuliah Tugas Akhir Program Studi Diploma III Teknik Rontgen Universitas Widya Husada Semarang, dalam penyusunan Karya Tulis Ilmiah ini tidak akan lepas dari segala bantuan dan bimbingan dari berbagai pihak. Untuk itu, penulis juga mengucapkan terima kasih yang sebesar-besarnya kepada:

1. Ibu Dr. Hargianti Dini Iswandari, drg, MM., Rektor Universitas Widya Husada Semarang.
2. Bapak Dr. Didik Wahyudi, SKM., M.Kes., Dekan Fakultas Kesehatan dan Keteknisian Medik Universitas Widya Husada Semarang.
3. Ibu Nanik Suraningsih, S.ST., M.Kes., Ketua Program Studi Diploma III Teknik Rontgen Universitas Widya Husada Semarang.
4. Ibu Lucky Restyanti Wahyu Utami, S.Tr.Rad., M.Tr.Kes, Pembimbing dalam penulisan dan penyusunan Karya Tulis Ilmiah.
5. Seluruh Dosen dan Staf Program Studi Diploma III Teknik Rontgen Universitas Widya Husada Semarang.
6. Mama, Kakak - Kakak, Om dan Tante serta keluarga besar tercinta yang selalu memberikan Do'a, dukungan moral maupun materi serta nasihat selama ini.
7. Teman-teman kelas Rontgen Program Studi Diploma III Teknik Rontgen Universitas Widya Husada Semarang.
8. Semua pihak yang telah membantu menyelesaikan Karya Tulis Ilmiah ini baik secara langsung maupun tidak langsung.

Semoga Tuhan yang Maha Esa memberikan Rahmat-Nya kepada semua pihak yang telah membantu menyelesaikan Karya Tulis Ilmiah ini. Penulis menyadari Karya Tulis Ilmiah ini masih banyak kekurangan dan jauh dari sempurna. Oleh karena itu penulis mengharapkan kritik dan saran yang membangun dari semua pihak demi kesempurnaan Karya Tulis Ilmiah ini. Penulis berharap Semoga Karya Tulis Ilmiah ini dapat bermanfaat bagi penulis pada khususnya dan semua pihak yang telah membaca pada umumnya.

Semarang 3 Agustus 2022

Penulis

DAFTAR ISI

DAFTAR GAMBAR

DAFTAR TABEL

DAFTAR LAMPIRAN

DAFTAR ISTILAH

Anatomi	: Ilmu yang mempelajari susunan tubuh manusia
Anteroposterior	: Bagian depan tubuh
Axial	: Sinar menyudut ke suatu tubuh
Computed Tomography (CT-Scan)	: Bentuk khusus dari tomografi dimana komputer digunakan untuk membuat rekonstruksi dari pesawat tomografi atau slice
Clouse mouth	: Tutup Mulut
CP	: Central Point(Titik Jatuh Sinar)
CR	: Central Ray (Arah Sinar)
Cranium	: Kerangka kepala
Diagnosa	: Penentuan kondisi Kesehatan yang sedang dialam oleh seseorang sebagai dasar pengambilan keputusan medis untuk prognosis dan pengobatan.
Etiologi	: Penyebab suatu penyakit
Grid	: Lempengan timbal yang tersusun sedemikian rupa sehingga dapat menangkap radiasi hambur.
Marker	: Penanda pada radiograf yang terbuat dari Timbal dan biasanya berupa huruf ataupun angka dan sebagainya.
MRI	:Teknik pemindaian radiologi yang menggunakan magnet, gelombang radio, dan komputer untuk menghasilkan struktur tubuh.
Neurocranium	: Tulang yang membungkus otak
Oblique	: posisi tubuh dalam keadaan miring sebesar 45 derajat
Open Mouth	: Buka Mulut
Panoramic	: Pemeriksaan penunjang yang digunakan

	dalam kedokteran gigi berupa foto Rontgen
Patologi	: Ilmu yang mempelajari tentang penyakit
Posterior	: Bagian belakang tubuh
Proyeksi	: Teknik Memposisikan
Radiograf	: Hasil foto Rontgen
Radiologi	: Cabang ilmu kedokteran untuk mengetahui bagian tubuh manusia menggunakan teknologi pencitraan, baik berupa gelombang elektromagnetik maupun gelombang mekanik.
Radiograf Konvensional	: pemeriksaan medis yang menggunakan sinar-x
TMD	: Temporomandibular Disorders
TMJ	: *Temporomandibular Joint*
USG	: Ultrasonography
Viscerocranium	: Tulang yang membentuk wajah

ABSTRAK

Nama : Janer Danilo
Judul : Peranan Berbagai Modalitas Radiologi Pada Pemeriksaan *Temporomandibular Joint*

Latar belakang : pelayanan radiologi diagnostik meliputi pelayanan x-ray konvensional, *CT Scan,MRI*. Sendi *temporomandibular joint* (*TMJ)* sendi yang paling kompleks dan yang menghubungkan tulang rahang atas dengan rahang bawah antara tulang temporalis dengan kepala kondilus mandibularis. Dengan indikasi *erosi condyle, fraktur, hiperplasia condyle, osteofit sklerosis subkortikal, remodeling*.

Metode penelitian : Jenis penelitian yang digunakan adalah kualitatif dengan pendekatan studi literatur. Data diperoleh dari tiga literatur dalam jurnal internasional

Hasil penelitian : *CT Scan* merupakan modalitas paling effisien dalam mendeteksi perubahan tulang, sedangkan *MRI* tetap menjadi standar emas untuk pemeriksaan diskus articular. Akan tetapi memiliki beberapa kekurangan dan kelebihan antara lain *CT* detail tulang yang baik dan penilaian *3D*, kerugiannya biaya dan paparan radiasi yang tinggi. Pada *MRI* mendeteksi jaringan lunak, tidak invasi, dan rendah radiasi, kerugiannya biaya mahal, dikontra indikasikan untuk pasien klaustrofobia.

Kesimpulan : radiografi konvensional lebih cocok untuk mengevaluasi elemen tulang saja. Sedangkan *CT Scan* dianggap sebagai modalitas yang paling efisien untuk mengevaluasi jaringan keras maupun lunak. Sedangkan *MRI* menjadi metode pilihan untuk melihan jaringan lunak sendi.

Kata Kunci : *Temporomandibular Joint*, *CT Scan*, *MRI*, Konvensional, Peranan Pencitraan diagnostik

BAB I
PENDAHULUAN

1.1 Latar Belakang

Rumah sakit adalah suatu organisasi yang dilakukan oleh tenaga medis profesional yang terorganisir baik dari sarana prasarana kedokteran yang permanen, pelayanan kedokteran, asuhan keperawatan yang berkesinambungan, diagnosis serta pengobatan penyakit yang diderita oleh pasien. Rumah sakit juga mempunyai berbagai macam jenis pelayanan kesehatan yang dapat diunggulkan untuk mempertahankan loyalitas pasien salah satunya adalah pelayanan kesehatan dibidang Radiologi (Supartiningsih, 2017).

Radiologi adalah cabang ilmu kedokteran yang berhubungan dengan penggunaan semua modalitas yang menggunakan radiasi untuk diagnosis dan prosedur terapi dengan menggunakan panduan radiologi, termasuk teknik pencitraan dan penggunaan radiasi dengan sinar-X dan zat radioaktif. Radiologi Diagnostik adalah teknik radiologi untuk mendiagnosis suatu penyakit atau kelainan morfologi dalam tubuh pasien dengan menggunakan pesawat sinar-X (BAPETEN, No 4, 2020).

Pelayanan radiologi diagnostik adalah pelayanan penunjang atau terapi yang menggunakan radiasi pengion atau radiasi non pengion yang terdiri dari pelayanan radiodiagnostik, imaging diagnostik, dan radiologi intervensional untuk menegakkan diagnosa suatu penyakit. Pelayanan radiodiagnostik meliputi pelayanan x-ray konvensional, computed thomography *scan/CT Scan* dan mammografi. Pelayanan imaging diagnostik meliputi pemeriksaan Magnetic Resonance Imaging/*MRI* dan *USG* (PERMENKES, 2020). Banyak modalitas diagnostik baru dan menarik mulai diperkenalkan ke radiologi, dan beberapa modalitas tersebut mulai berpengaruh pada pemeriksaan *Temporomandibular Joint*.

Temporomandibular Joint (*TMJ*) adalah sendi engsel yang menghubungkan tulang rahang atas dengan rahang bawah antara tulang temporalis dengan kepala kondilus mandibularis. *TMJ* merupakan sendi yang paling kompleks karena dapat bergerak ke segala arah dalam pergerakan fisiologis mandibula, yakni membuka dan menutup seperti sebuah engsel, bergeser kedepan dan kebelakang dari sisi yang satu ke sisi lainnya serta memiliki peranan penting dalam proses pengunyahan, penelanan, dan pengucapan. Keadaan *TMJ* yang normal yakni posisi kondilus mandibularis berada pada sentral fossa mandibularis dan menunjukkan oklusi sentrik yang memengaruhi fungsi fisiologis dari *TMJ* (Ginting dan Napitupulu, 2019).

Diagnosis dan pengelolaan gangguan temporomandibular (*TMD*) memerlukan pemeriksaan klinis dan pencitraan sendi temporomandibular (*TMJ*). Berbagai modalitas dapat digunakan untuk mencitrakan *TMJ*, termasuk magnetic resonance imaging (*MRI*), computed tomography (*CT*), cone beam *CT*, *Ultrasonografi*, radiografi konvensional (Talmaceanu Daniel dkk, 2018).

Berdasarkan tiga artikel hasil penelitian yang terpublikasikan dalam jurnal Internasional mengenai peranan masing-masing pencitraan diagnostik *Temporomandibular Joint* dalam menegakkan diagnosa. Penulis menemukan adanya perbedaan modalitas yang digunakan pada pemeriksaan *temporomandibular*.

Dalam jurnal pertama yang ditulis Talmaceanu Daniel dkk, 2018, dengan judul *"Imaging Modalities For Temporomandibular Joint Disorders: An Update"*Peranan masing-masing modalitas pada pemeriksaan *Temporomandibular Joint* bertujuan untuk menguraikan indikasi teknik pencitraan yang paling sering digunakan dalam diagnosis *temporomandibular (TMD).* Metode yang digunakan dalam penelitian ini yaitu deskriptif kualitatif. Modalitas yang digunakan pada jurnal ini antara lain *panoramic,* radiografi konvensional, *computed tomography, magnetic*

resonance imaging (MRI), ultrasonografi resolusi tinggi(USG) dan memaparkan terkait beberapa kelainan yaitu *erosi condyle, fraktur, hiperplasia condyle, osteofit sklerosis subkortikal, remodeling.*

Pada jurnal kedua yang ditulis oleh Asim K Bag dkk, 2014, dengan judul *"Imaging Of The Temporomandibular Joint: An Update"*. Peranan masing-masing modalitas radiografi pada pemeriksaan *Temporomandibular Joint* bertujuan untuk pencitraan dari sendi temporomandibular. Metode penelitian yang digunakan yaitu deskriptif kualitatif. Modalitas yang digunakan pada jurnal ini antara lain *magnetic resonance imaging (MRI), computed tomography (CT), arthrography,* radiografi konvensional. Dan memaparkan terkait beberapa kelainan yaitu *condyle bifida, hiperplasia condyle, resorpsi condyle idiopatik, hipoplasia condyle, effulsi sendi, osteocondritis dissecans (OCD), hippermobilitas*

Pada jurnal ketiga yang ditulis oleh Ferreira L. A. dkk (2016), dengan judul *"Diagnosis Of Temporomandibular Joint Disorders: Indication Of Imaging Exams"*. Peranan masing-masing modalitas radiografi pada pemeriksaan *Temporomandibular Joint* bertujuan untuk menyajikan dan menilai tes pencitraan diagnostik utama untuk gangguan temporomandibular dan secara rasional mendiskusikan kriteria indikasi, keuntungan, dan kerugiannya. Metode penelitian yang digunakan yaitu tinjauan literatur di database *Web of Knowledge, PubMed dan SciELO.* Modalitas yang digunakan pada jurnal ini antara lain *panoramic, arthrography, magnetiv resonance imagingv(MRI), computed tomography (CT), ultrasonografi (USG),* resolusi tinggi. Dan memaparkan beberapa kelainan yaitu perubahan tulang yang meliputi *fraktur, neoplasma dan ankilosis.* Sedangakan untuk remodeling tulang tanpa gejala yaitu evaluasi pasca operasi, *hiperplasia prosesus condyle, koronoid, dan stiloid*

Dari ketiga jurnal yang penulis temukan memiliki tujuan penelitian yang sama, yaitu untuk mengetahui peranan masing-masing modalitas radiografi pada pemeriksaan *Temporomandibular Joint*. Namun

terdapat perbedaan yang ditemukan yaitu penggunaan modalitas yang digunakan pada pemeriksaan *temporomandibular*. Oleh karena itu, dengan disertainya perbedaan penelitian dari ketiga jurnal tersebut, penulis tertarik untuk mengangkat topik tersebut menjadi sebuah Karya Tulis Ilmiah dengan judul **"Peranan Berbagai Modalitas Radiologi Pada Pemeriksaan *Temporomandibular Joint*"**.

1.2 Rumusan Masalah

Bagaimana peranan masing-masing modalitas radiologi pada *TMJ* menurut jurnal yang dikaji?

1.3 Tujuan Penelitian

Berdasarkan latar belakang dan rumusan masalah yang telah dijelaskan diatas, maka tujuan penulisan Karya Tulis Ilmiah ini yaitu untuk menjelaskan peranan masing-masing modalitas radiologi pada *TMJ*.

1.4 Manfaat Penelitian

Adapun manfaat penelitian yang ingin penulis capai dalam penyusunan Karya Tulis Ilmiah ini adalah :

1.4.1 Manfaat Teoritis

Hasil dari penelitian ini diharapkan dapat menambah pengetahuan dan wawasan penulis serta memberikan informasi kepada pembaca berkaitan dengan peranan masing-masing modalitas radiologi pada pemeriksaan temporomandibilar joint. Khususnya di Institusi Pendidikan, sebagai tambahan sumber Pustaka yang dapat dijadikan referensi selanjutnya bagi mahasiswa Program Studi Diploma III Teknik Rontgen Universitas Widya Husada Semarang.

1.4.2 Manfaat Praktis

Hasil dari penelitian ini diharapkan dapat menjelaskan peranan masing-masing modalitas radiologi dalam pemeriksaan *Temporomandibular Joint* sehingga dapat diterapkan sebagai masukan dan menambah pengetahuan yang berguna bagi petugas kesehatan, khususnya petugas yang ada di Instalasi Radiologi.

BAB II
TINJAUAN PUSTAKA

2.1 Anatomi Dan Fisiologi *Temporomandibular Joint*

2.1.1 Macam- macam tulang pada kepala (Lampignano dan Kendrick, 2018)

Tulang tengkorak atau *cranium* adalah tulang pembentuk kepala. Fungsi tulang *cranium* adalah :

a. Mempertahankan organ – organ vital manusia, dan menopang tegak tubuh manusia (tulang punggung)
b. Penggerak, ketika otot otot yang melekat pada tulang tertarik atas perintah dari otak, maka tulang akan bergerak yang menyebabkan pergerakan tubuh pada manusia
c. Produsen sel darah, tulang sumsum melakukan tugas penting yakni memproduksi sel darah. Sel darah merah pembawa oksigen, dan sel darah putih melindungi tubuh dari infeksi

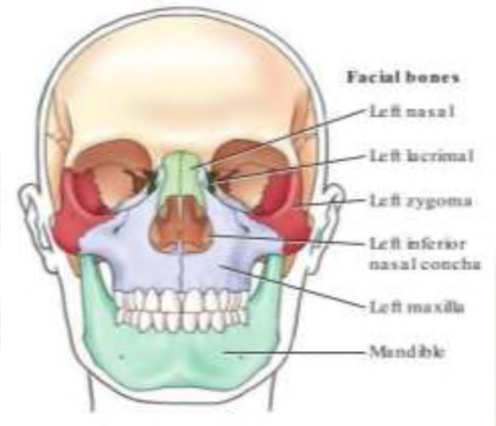
Tulang *cranium* dibagi menjadi :

a. *Neurocranium* (tulang yang membungkus otak)
b. *Viscerocranium* (tulang yang membentuk wajah)

Tulang pembentuk kerangka wajah terdiri dari 15 tulang, yaitu :

a. 2 tulang *Os. Nasal* (tulang hidung) membentuk lengkung hidung
b. 2 tulang *Os. Lacrimale* (tulang air mata) membentuk saluran air mata dan bagian dari rongga mata pada sudut dalam rongga mata
c. 2 tulang *Os. Zygomaticum* (tulang lengkung pipi)
d. 2 tulang *Os. Concha nasalis inferior* (tulang kerang bawah hidung)
e. 2 tulang *Os. Palatinum* (membentuk atap mulut dan dasar hidung)
f. 2 tulang *Os. Maxilla* (membentuk rahang atas dan memuat gigi atas)
g. 1 tulang *Os. Vomer* (tulang pisu luka)

h. 2 tulang *Os. Mandibula* (membentuk rahang bawah dan memuat gigi bawah)



Gambar 2. 1 Tulang *Viscerocranium* (Lampignano dan Kendrick, 2018)

Pada mandibula terdapat beberapa bagian yang membentuk tulang rahang bawah :

Gambar 2. 2 *Ramus mandibula lateral view* (Lampignano dan Kendrick, 2018)

a. Ramus

Ramus adalah bagian yang tegak kearah *vertical* yang terdapat disebelaah kiri dan kanan pada bagian *posterior mandibular*, yang bersatu dengan *corpus mandibular* dan *angulus mandibular*.

b. *Corpus*

Corpus mandibula merupakan bagian *mandibula* yang *horizontal*, tebal, tempat tersusunnya gigi geligi rahang bawah, terdiri dari: *tulang alveolar, foramen mentale, oblique line, sulkus ekstramolar, mylohyoid line, fossa submandibula, fossa sublingual, trigonum retromolar, mental trigone, fossa digastrica, sublingual fovea.*

c. *Condyle*

Condilus adalah tulang dengan struktur *elipsoid* melekat pada *ramus mandibula*. *Condilus* berbentuk cembung pada seluruh permukaan, walaupun sedikit terlihat datar pada permukaan bagian *posterior*, dan berbentuk seperti tombol lebih lebar pada daerah *mediolateral* daripada *anteroposterior*.

d. *Angulus mandibula*

Angulus mandibula adalah *regio triangular* yang dibatasi oleh batas *anterior* dari otot maseter hingga perlekatan *posterior* dan *superior* dari otot *masseter* (biasanya *distal* dari *molar* ketiga)

e. *Simfisis mandibula*

Simfisis mandibula merupakan bagian tengah *mandibula* yang menyatukan dua *korpus mandibular*.

2.1.2 Temporomandibular Joint

Temporomandibular Joint (*TMJ*) merupakan persendian yang ada di tiap sisi kepala dan berfungsi untuk menggerakkan *mandibula* saat mengunyah, berbicara, dan bernafas. *TMJ* dapat diraba tepat di *anterior* kedua telinga. *TMJ* ini terbentuk dan berkembang mulai minggu ke 11 sampai ke 12 masa perkembangan prenatal, sejalan dengan perkembangan ligament-ligament, otot-otot, dan tulang-tulang yang berhubungan dengan persendian ini.

TMJ merupakan artikulasi antara tulang temporal dengan mandibula di setiap sisi wajah. Dimana pada bagian superior dari margin tulang temporal bagian tonjol dan *fossa artikulasi* dilapisi oleh kapsul persendian. Sedangkan pada bagian *inferior*, kapsul persendian membungkus kondilus *mandibula* sampai bagian lehernya.

Piring sendi terletak pada tiap sisi wajah, di antara tulang temporal dan kondilus mandibula. Piring sendi ini membagi *TMJ* menjadi 2 bagian secara total, yaitu *kavitas synovial* bagian atas dan bawah. Membran *sinovial* yang melapisi kapsul persendian akan menghasilkan cairan *synovial* dan mengisi kedua *kavitas* tadi.

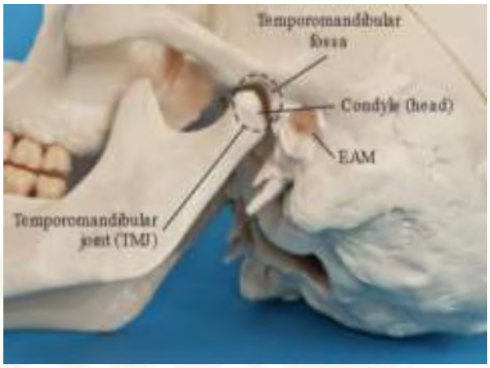
Ada 2 jenis pergerakan dasar mandibula yang dihasilkan oleh persendian ini dan hubungannya dengan otot-otot pengunyahan, yaitu meluncur dan berputar. Dengan adanya 2 macam pergerakan dasar tersebut, serta adanya gerak *TMJ* kanan dan kiri secara bersamaan, maka akan menghasilkan gerakan rahang bawah yang lebih halus. Hal ini mencakup membuka dan menutup rahang, serta gerakan rahang ke samping.

Sendi temporomandibular secara anatomi terbagi atas :

a. Komponen artikulasi yang terdiri dari kondilus *mandibula*, *fosa mandibula* atau *fosa glenoidale* yang terdiri dari *fosa artikulare* dan *eminensia artikulare*, serta *diskus artikulare*
b. Kapsula artikulare dan ligament Serta membran *sinovial*.
c. Ligamen tambahan.(*Sphenomandibula* dan *Stylomandibula*).

Otot otot yang terlibat dalam gerakan membuka dan menutup mulut :

a. Musculus masetter
b. Musculus pterygoideus lateralis (externus)
c. Musculus pterygoideus medialis (internus)
d. Musculus temporalis



Gambar 2. 3 Sendi *Temporomandibular Joint*
(Lampignano dan Kendrick, 2018)

Ada dua gerakan utama pada sendi *TMJ* yaitu :

a. Gerak *rotasi*

Rotasi adalah gerakan berputar pada sumbunya yang terjadi antara permukaan *superior kondilus* dengan permukaan *inferior diskus artikularis*.

b. Gerak meluncur atau *translasi*

Translasi adalah suatu gerakan di mana setiap titik dari obyek bergerak secara serempak dengan kecepatan dan arah yang sama. Di dalam sistem pengunyahan, *tranlasi* terjadi ketika rahang (bawah) bergerak maju, lebih menonjol sehingga gigi, *kondilus* dan ramus semua pindah ke arah dan derajat inklinasi yang sama

Pergerakan bebas mandibular yaitu kombinasi antara Gerakan rotasi dan translasi yang meliputi :

a. Gerakan membuka dan menutup
b. Gerakan *protrusi* dan *retrusi*
c. Gerakan ke samping kiri dan kanan

2.2 Patologi

Kelainan *TMJ* merupakan serangkaian kondisi yang menunjukkan gejala dan tanda-tanda yang melibatkan *TMJ* dan otot-otot pengunyahan berupa bunyi *klicking*, *krepitasi*, dan dapat diikuti dengan nyeri sendi, nyeri otot, nyeri kepala, nyeri telinga, telinga berdengung, keterbatasan gerak mandibula, deviasi dan defleksi. Penyebab kelainan *TMJ* dapat berasal dari kerusakan pada struktur sendi akibat faktor-faktor yang mendukung seperti pemakaian alat cekat *ortodonti*, *edentulus* gigi *posterior*, kebiasaan buruk seperti *bruksism*/ menopang dagu/ tidur satu sisi/ mengunyah satu sisi (Ginting R. dan Napitupulu M. N. 2015).

Adapun beberapa patologi yang sering ditemukan :

2.2.1 Fraktur

Fraktur adalah gangguan dari kontinuitas yang normal dari suatu tulang. Jika terjadi *fraktur*, maka jaringan lunak di sekitarnya juga sering kali terganggu. *Radiografi* (sinar-x) dapat menunjukkan keberadaan cedera tulang, tetapi tidak mampu menunjukkan otot atau *ligamen* yang robek, saraf yang putus, atau pembuluh darah yang pecah sehingga dapat menjadi komplikasi pemulihan klien (Black dan Hawks, 2014). Gejala gangguan tersebut dapat terjadi pada *Temporomandibular Joint* (*TMJ*) setelah adanya trauma yang menyebabkan *fraktur* pada *kondilus*.

2.2.2 Dislokasi

Dislokasi atau *open lock* adalah suatu keadaan terjadinya prosesus *kondiloideus mandibula* bergerak lebih ke *anterior* dan *superior* dari *eminensia artikularis* pada saat membuka mulut, dan terkunci dalam posisi tersebut disertai terjadinya kontraksi otot dan spasme sehingga menyebabkan gerakan menutup mulut terhalang. Keadaan ini menyebabkan pasien merasa tidak nyaman dan terasa sakit (Riawan L. dkk, 2012).

2.2.3 *Disorder Temporomandibular*

Gangguan sendi rahang atau *Temporomandibular Joint disorders* (*TMJ Disorders*) adalah kelainan-kelainan yang menyangkut sendi rahang. Nama-nama lain termasuk *myofacial pain dysfunction* dan *Costen's syndrome*. Tanda-tanda dari *TMD* antara lain adalah kekakuan (*stiffness*), sakit kepala, sakit kuping, persoalan menggigit (*malocclusion*), bunyi-bunyi *clicking* atau rahang yang terkunci (Saleh Edwin, 2015)

Menurut *American Academy of Orofacial Pain* (AAOP), *Temporomandibular Disorder* (*TMD*) didefinisikan sebagai sekumpulan gejala dan tanda yang mencakup sejumlah masalah klinis yang melibatkan otot-otot mastikasi dan atau sendi *temporomandibular* serta struktur penunjangnya. Sendi *temporomandibular* kiri dan kanan berfungsi bersama-sama pada saat yang sama, karena itu secara fungsional, sendi ini harus dapat dilihat sebagai suatu kesatuan. Gerakan yang dilakukannya berbeda dari sendi lain, yaitu kombinasi gerakan *rotasi* dan *translasi* pada *kondilus* kiri dan kanan. Kelainan fungsi sendi *temporomandibular* disebabkan oleh berbagai faktor yang saling berhubungan, yaitu: keadaan lokal yang terdiri dari hubungan kontak *oklusi*, aktifitas dan respon otot juga struktur sendi. Kelainan sendi ini dapat bersumber pada komponen sendi atau diluar sendi, seperti gigi termasuk jaringan periodontal, otot-otot mastikasi, dan masalah psikologis. (Ahmad dkk. 2012; Alonso dkk 2014)

Pada tahun 1992 *The Research Diagnostic Criteria* (RDC) yang dikembangkan oleh Dworkin dan LeResche mengeluarkan kriteria pendekatan *Dual-Axis, Axis I* berupa kondisi fisik dan *Axis II* adalah masalah *psikososial*. Pendekatan *RDC-TMD* berupa alur diagnostik untuk semua kelainan yang menyebabkan nyeri pada wajah. *Axis I* dibagi menjadi beberapa kelompok, kelompok *I* dengan subkelompok Ia yaitu *myofacial pain*, Ib *myofacial pain* dengan

keterbatasan buka mulut. Kelompok II dengan sub kelompok IIa internal dearangement dengan *reduksi*, IIa dengan sub kelompok internal *dearangement* tanpa *reduksi* disertai keterbatasan buka mulut, dan sub kelompok IIc *internal* dearangement tanpa *reduksi* tanpa keterbatasan buka mulut. Kelompok III dengan sub kelompok IIIa *arthralgia*, IIIb *osteoarthritis*, dan IIIc *osteoarthrosis*. (Ahmad dkk. 2012; Okesone 2013)

Gangguan sendi *temporomandibular myofacial* pada beberapa penulis dikenal juga dengan istilah *myofacial pain and dysfunction (MPD)*. Beberapa teori berkembang yang menganalisa penyebab terjadinya gangguan sendi temporomandibular *myofacial* antara lain penyakit psikofisiologis yang mengenai otot-otot pengunyah, ditandai oleh nyeri tumpul yang menyebar, kelemahan otot, dan keterbatasan fungsi atau keterbatasan gerakan *mandibula*. Teori lain menyebutkan sumber penyebab masalah ini terletak pada otot pengunyah dalam keadaan *spasme*. Penyebab tersering *spasme* tersebut adalah *hiperaktivitas* yang disebabkan dari *sentral* atau berhubungan dengan bruksisme kronis. Penyebab lainnya adalah overekstensi otot (membuka yang berlebihan) dan *overkontraksi* otot (menutup yang berlebihan). (Ahmad dkk. 2012; okesone 2013)

Pada penelitian yang dilakukan di Fakultas Kedokteran Gigi Universitas Loma Linda ditemukan sebanyak 58% mahasiswa menderita disfungsi dan nyeri otot dengan sumber gejala khususnya disekitar otot wajah dan pengunyahan yang meliputi rasa nyeri dan kelelahan, serta unilateral pada 70-80% kasus. Pasien tidak hanya mengeluh sakit otot tetapi juga kekakuan rahang, terasa berat, dan kesulitan membuka mulut, disertai keluhan lain seperti otalgia (82% dari pasien), dan tinnitus (33% dari pasien). (Ahmad dkk. 2012; okesone 2013)

Dari *anamnesis* didapatkan nyeri yang akan berulang terutama saat mengunyah atau bicara berlebihan. Nyeri otot biasanya bersifat *unilateral*. Berbeda dengan nyeri pada penyakit sendi yang terlokasir, nyeri pada kelainan ini bersumber dari otot sehingga lebih menyebar, dan pasien umumnya tidak dapat mengidentifikasi secara spesifik lokasi nyeri. Hal ini dapat digunakan sebagai suatu kriteria diagnostik penting untuk membedakan antara kelainan otot dan sendi. Keterbatasan sendi *temporomandibular* yang ringan sampai berat dan keterbatasan pergerakan *mandibula* adalah salah satu gejala utama gangguan sendi *temporomandibular myofacial*. Pembukaan mulut terbatas, tetapi pembukaan interinsisal jarang kurang dari 15 mm. Terdapat kapasitas untuk menambah kemampuan membuka mulut dengan regangan pasif oleh tekanan jari, juga sering disertai gerakan rahang yang terbatas, ragu-ragu, dan terpatah-patah. (Ahmad dkk. 2012; Devaraj and Pradeep 2014)

Klicking (suara ketuk) dapat ditemukan pada beberapa pasien gangguan sendi *temporomandibular myofacial* yang sering dikaitkan dengan spasme otot pterigoid *lateral*. Meskipun suara *klicking* intermiten menyertai spasme otot pterigoid *lateralis* pada beberapa pasien, perubahan friksional yang dimulai oleh kebiasaan kronis adalah faktor penyebab yang lebih umum. Oleh karena itu, ketika bunyi *klicking* dan popping awalnya tidak selalu gejala, tetapi dapat terlambat ditemukan pada beberapa pasien. Secara keseluruhan, hal yang paling penting adalah tidak ditemukannya perubahan sendi *temporomandibular* secara klinis, *radiografis* dan *biokimia*. (Ahmad dkk. 2012; Okesone 2013)

Tahun 1997, pada penelitian epidemologis yang dilakukan oleh Zambito didapatkan gejala berupa nyeri tumpul yang mengganggu dan menyebar, yang tidak terlokalisasi dengan baik. Terdapat keterbatasan gerak sendi yang sedang sampai berat, nyeri otot yang

biasanya unilateral dan mengenai otot pengunyah dan leher, ada suara *klicking* serta tidak ditemukannya nyeri sendi pada palpasi *lateral* atau intrameatal, ataupun perubahan *radiografik* pada sendi *temporomandibular*. (Ahmad dkk 2012; Okesone 2013).

2.3 Etiologi

Etiologi terjadinya *dislokasi* diskus adalah *multi*-faktorial dan masih banyak di perdebatkan dalam literatur (Samara dan Hadidy . 2012). Akan tetapi, beberapa penelitian menunjukkan bahwa *dislokasi* diskus, dan gangguan otot yang mempengaruhi sistem pengunyah merupakan penyebab paling umum ditemukan (Samara dan Hadidy 2012). Okeson mengindentifikasi lima faktor yang berhubungan dengan gangguan sendi *temporomandibular*, yakni trauma, stres emosional, *deep pain input*, aktifitas parafungsional, dan faktor oklusal. Meskipun pada beberapa studi mengemukakan bahwa kondisi oklusal ini tidak selalu dapat menyebabkan gangguan pada sendi *temporomandibular*. Faktor trauma yang terjadi pada struktur wajah dapat menyebabkan kelainan fungsional sistem mastikasi dan lebih mempengaruhi terjadinya kelainan intracapsular daripada kelainan muscular. Trauma yang terjadi dapat dibagi menjadi dua, yaitu macrotrauma (gaya tiba-tiba yang dapat menyebabkan alterasi struktural, seperti benturan langsung ke muka) dan microtrauma (gaya kecil yang terjadi berulang pada suatu struktur dalam periode waktu yang lama). Peningkatan stress emosional dapat juga mempengaruhi fungsi mastikasi. Sumber *deep pain input* akan mempengaruhi fungsi otot, contohnya sakit gigi yang sampai menyebabkan keterbatasan membuka mulut. Untuk aktifitas parafungsional, seperti bruxism atau clenching akan menyebabkan otot dan sendi menerima beban yang lebih besar. (Okeson 2013).

2.4 Jenis Pemeriksaan Radiologi Untuk Diagnosa *Temporomandibular Joint*

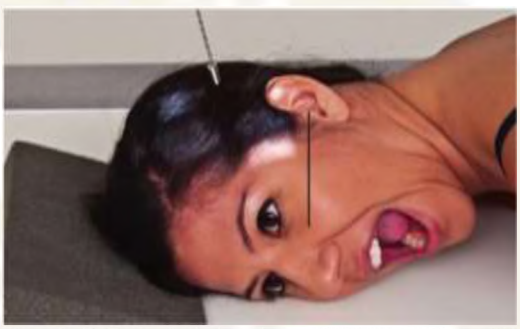
2.4.1 Pemeriksaan Radiografi Konvensional *Temporomandibular Joint*

Radiografi konvensional adalah suatu pemeriksaan radiografi sederhana yang bisa dilakukan sehari-hari. Radiografi konvensional berupa pemeriksaan radiografi kontras dan non kontras. Kelebihan ini adalah cepat, mudah dan murah sedangkan kerugiannya adalah gambar yang dihasilkan sering kurang jelas karena superposisi dengan obyek lain. Pemeriksaan konvensional memiliki beberapa indikasi pemeriksaan antara lain dislokasi, fraktur, dan trauma. Proyeksi yang dapat di gunakan pada pemeriksaan *TMJ* antarai lain Proyeksi Ap *Axial* (Metode Towne), *Axiolateral Oblique* (Metode Law), *Axiolateral* (Metode Schuller), dengan tujuan untuk menampakan *processus kondiloid* dan *fossa tempormandibular*. Pemeriksaan ini dilakukan dengan teknik buka dan tutup mulut.

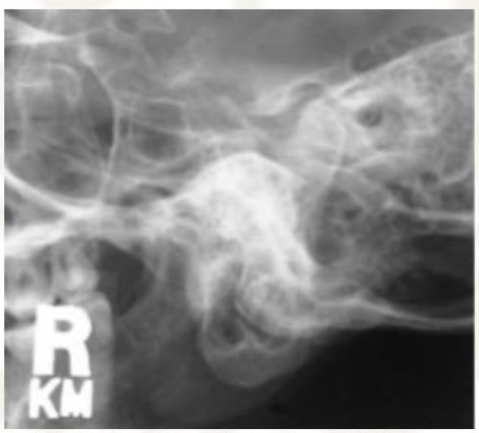
Gambar 2. 4 Proyeksi *AP* Axial *Close Mouth*
(Lampignano dan Kendrick, 2018)

Gambar 2. 5 Kriteria radiograf *AP Axial Clouse Mouth*
(Lampignano dan Kendrick, 2018)

Gambar 2. 6 Proyeksi Axiolateral *Oblique Close Mouth*
(Lampignano dan Kendrick, 2018)



Gambar 2. 7 Proyeksi *Axiolateral Oblique Open Mouth*
(Lampignano dan Kendrick, 2018)



Gambar 2. 8 Kriteria radiograf *Axiolateral Oblique Close Mouth*
(Lampignano dan Kendrick 2018)

Gambar 2. 9 Proyeksi *Axiolateral* tutup mulut
(Lampignano dan Kendrick, 2018)

Gambar 2. 10 Proyeksi Axiolateral buka mulut
(Lampignano dan Kendrick, 2018)

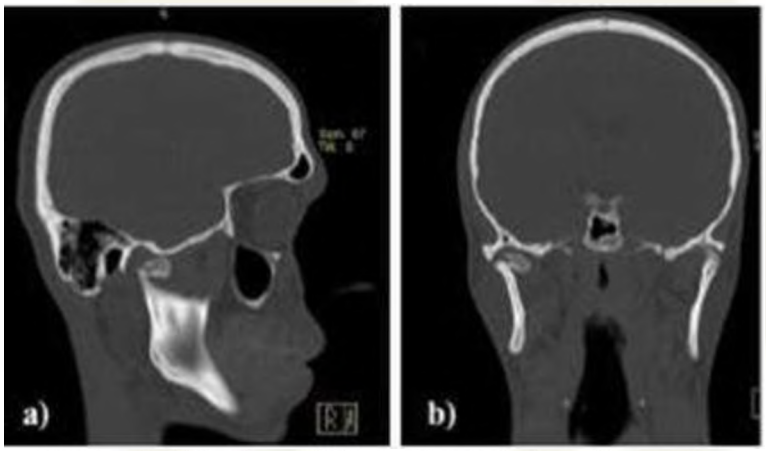
2.4.2 Pemeriksaan *Computed Tomography Scanner/CT Scan Temporomandibular Joint*

Menurut (Priaminiarti M. dkk, 2013) ada dua cara yang dapat digunakan untuk memperoleh gambaran *TMJ* dengan *CT Scan*, yaitu teknik Dire*CT Sagital Scan*ning dan teknik axial dengan rekontruksi modifikasi parasagittal. Teknik Dire*CT* Saginal *Scan*ning dilakukan dengan posisi pasien yang khusus, karena perangkat *CT Scan* tidak dapat melakukan pemeriksaan *TMJ* dalam arah *sagital* secara langsung. Untuk ini diperlukan pengaturan posisi pasien sedemikian rupa sehingga dapat dilakukan *scan*ning *TMJ* dalam arah *sagital*. Setiap sisi *TMJ* dilakukan *scan*ning secara terpisah, dengan 5-10 potongan jaringan dengan ketebalan potongan 1.5 – 2 mm yang

berjarak 1 – 2 mm antara satu potongan dengan potongan lainnya pada posisi buka dan tutup mulut.

Teknik axial dengan rekontruksi modifikasi parasagittal adalah *scan*ning *TMJ* dalam arah axial sebanyak 10-20 potongan jaringan dengan ketebalan potongan 1.5 mm yang berjarak 1 mm antara satu potonga dengan potongan lainnya pada posisi buka dan tutup mulut. Data yang diperoleh selanjutnya diolah computer untuk memperoleh gambaran *TMJ* dalam arah *sagital coronal*.

CT Scan dapat memberikan gambaran yang terbaik untuk kondil, kondisi permukaan artikularis sendi, kondisi fossa dan emenensia artikularis.



Gambar 2. 11 Gambaran CT-*scan*.(a)sagital *plane*, (b)coronal *plane(Talmaceanu D dkk 2018)*

2.4.3 Pemeriksaan *Magnetic Resonance Imaging* (*MRI*) *Temporomandibular Joint*

Penggunaan *MRI* masih sangat terbatas yaitu untuk melihat kelainan *TMJ*. *MRI* adalah metode terbaik untuk menilai jaringan lunak, terutama kelainan internal *TMJ* yaitu posisi dan konfigurasi diskus artikularis. Kelebihan *MRI* yang utama adalah sifatnya non invasive yang tidak menggunakan energi ionisasi. Gambaran jaringan diskus artikularis dan struktur sendi tampat jelas serta sendi

digambarkan sebagai bentuk potongan jaringan dalam arah *sagital*, koronal dan axial.

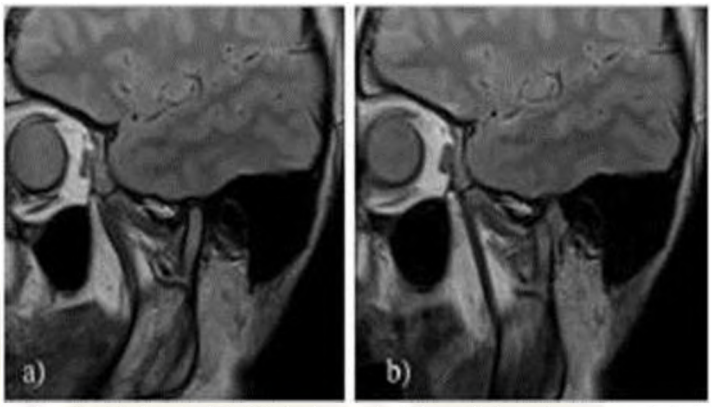
Untuk melihat *TMJ*, biasanya digunakan teknik Dual Surface Coil untuk melihat kedua sisi sekaligus. Pemotretan dilakukan dengan pasien pada posisi tengadah, pada posisi membuka dan menutup mulut. Tebal potongan jaringan 3 – 5 mm, lapangan pandang pemeriksaan 16 – 20 cm dalam axial, *sagital* dan koronal.

Gambaran morfologi sendi dapat langsung dilihat dengan jelas tanpa perlu melakukan perbaikan tampilan gambar. Diskus artikularis yang terdiri dari tulang rawan fibrikartilago tampak gelap karena intensitas sinyalnya rendah, sedangkan jaringan otot yang intensitas sinyalnya rendah-menengah tampak abu-abu. Sumsum tulang pada spongiosa tampak menghasilkan sinyal yang tinggi, sedangkan tulang kortikal yang lebih padat intensitas sinyalnya rendah sekali atau sama sekali tidak ada sehingga tampak hitam. Jaringan lemak akan tampak sangat terang. Diskus artikularis dalam bidang *sagital* terlihat bikonkaf, dan pada bidang koronal berbentuk lengkungan.

Protokol uji diagnostik ini biasanya mencakup perekaman pada posisi MHI dan MMO, dengan menggunakan weighted T1, T2, dan proton density (PD), di bidang *sagital* dan koronal. Dengan T1-weighted images, memungkina bagi kita untuk mendapatkan detail anatomis yang sangat baik. Proton density menghasilkan resolusi spasial yang memuaskan pada cedera diskus sendi, dan merupakan pilihan yang sangat baik untuk mengevaluasi perpindahan diskus ke arah medial dan lateral. T2-weighted images merekam adanya efusi sendi dan edema medulla tulang. Keuntungan utama meliputi mendeteksi perubahan jaringan lunak, nekrosis, edema, ada tidaknya invasi, dan kurangnya paparan radiasi ion. *MRI* juga diindikasikan untuk penilaian integritas dan hubungan anatomis struktur saraf, yang

bila tertekan oleh tumor atau proses vaskular, dapat menimbulkan nyeri orofasial karena demyelinisasi dan deafferentasi. Kelemahannya terkait dengan biaya tinggi dan kebutuhan akan fasilitas yang canggih. Kontraindikasi teknik ini adalah pada pasien sesak, mereka yang memiliki alat pacu jantung dan katup jantung metalik, benda asing feromagnetik, dan wanita hamil. (Asim K Bag dkk 2014)

Untuk pencitraan sendi temporomandibular yang optimal, kumparan kecil pada permukaan bilateral dengan ruang lingkup pandangan yang kecil digunakan untuk mencapai sinyal yang lebih tinggi terhadap rasio kerancuan dan akuisisi bilateral simultan. Pada posisi mulut tertutup, koronal dan *aksial* T1 sequences diperlukan untuk mengevaluasi anatomi dan sumsum tulang serta soft tissue yang berdekatan secara keseluruhan dengan menyingkirkan kelainan lain disekitarnya. Di institusi kami, *aksial* T1 diperoleh sebagai localizer (Asim K Bag dkk 2014). T2 bilateral pada mulut tertutup dan terbuka, proton density (PD) dan urutan dinamis diperoleh pada obligue *sagital* plane. Gambar dinamis diperoleh sebagai akuisisi cepat gambar statis menggunakan *single shot fast spin echo (SSFSE)* densitas proton *sequence* ketika mulut terbuka dan tertutup progresif. Gambar-gambar ini ditampilkan secara berurutan sebagai *loop cine*. Perangkat untuk membuka mulut seperti perangkat pembuka Burnett dapat digunakan sebagai tambahan untuk membuka mulut yang dikendalikan oleh pasien. Dapat dikatakan bahwa pembukaan mulut pasif dengan perangkat Burnet mungkin tidak mereproduksi kondisi fisiologis yang terjadi selama pembukaan mulut memberikan otot pterygoideus lateral kemungkinan untuk menstabilisasi diskus selama pembukaan mulut. Pencitraan oblique dilakukan pada 30° medial dari true *sagital* plane. (Ashley Aiken 2012).



Gambar 2. 12 *Sagital, MRI* dari perpindahan diskus dengan reduksi: (a) mulut tertutup,(b)diskus yang pindah (tanda panah) kembali ke posisi normal saat membuka mulut(Talmaceanu D dkk 2018)

2.4.4 Ultrasonografi(USG)

Ultrasonografi adalah modalitas pencitraan yang murah dan sederhana untuk mengevaluasi sendi *temporomandibular*. ini adalah cara mudah untuk memeriksa retensi cairan sendi. *Ultrasound* juga digunakan untuk menilai pencitraan tulang rawan dan perpindahan diskus pada mulut terbuka dan tertutup. Ini digunakan untuk injeksi yang dipandu gambar, baik untuk tujuan diagnostik dan terapeutik. *Konverter linier* pada 8*MHz* atau lebih tinggi biasanya ideal. Pasien harus berbaring telentang dengan transduser diposisikan sejajar dengan garis yang memanjang dari tragus melalui sendi ke aspek *lateral* hidung sendi *temporomandibular.*

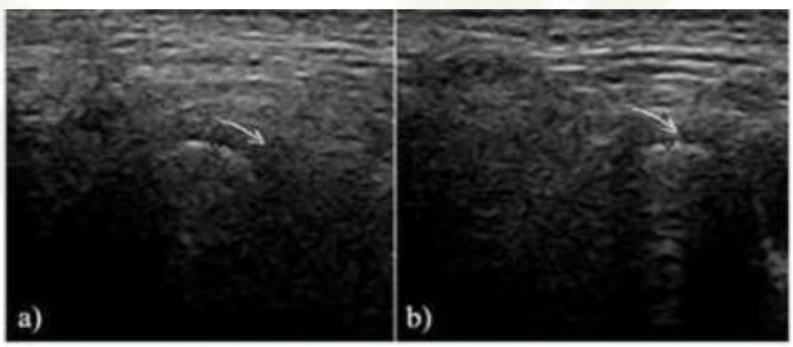
Prinsip *USG* didasarkan pada fakta bahwa ultrasound yang dipancarkan oleh perangkat *(transduser)* melewati sendi *temporomandibular* dan sebagian dipantulkan saat melewati berbagai struktur anatomi. Gelombang suara yang dipantulkan dibaca oleh perangkat transmisi yang sama dan diubah menjadi gambar daerah sendi *temporomandibular* terdiri dari beberapa struktur berbeda yang memantulkan gelombang suara dengan cara yang berbeda. Jaringan tulang diwakili oleh kepala kondilus dan kondilus umumnya

hypoechoic (hypoechoic) dan hitam pada gambar *USG*. Namun, tepi tulang tampak *hyperechoic* (reflektansi gelombang akustik tinggi) dan berwarna putih pada gambar *ultrasound* jaringan ikat yang diwakili oleh kapsul sendi dan jaringan *retrodiscal*, dan jaringan otot yang diwakili oleh otot *pterygoid* dan masseter *lateral*, adalah *isoechoic* (refleksi antara gelombang suara), abu-abu dan *heterogen* pada gambar *ultrasound*. Namun, permukaan kapsul sendi dan permukaan otot sangat memantulkan gelombang suara, menghasilkan garis *hyperechoic (putih)*. Ruang kosong dan air, seperti rongga sendi atas dan bawah, bersifat *hypoechoic* dan berwarna hitam pada gambar *ultrasound*. Namun, rongga anatomi ini bersifat *hipotetis* karena permukaan yang berlawanan saling bersentuhan, dan biasanya tidak dikenali kecuali eksudat ditemukan. Penggunaan pemeriksaan *USG*, terutama dengan peralatan pencitraan resolusi tinggi, merupakan pilihan yang berguna untuk menilai posisi diskus pada lesi internal. sendi *temporomandibular*. Meskipun *sensitivitas* diagnostiknya cukup tinggi, spesifisitasnya tidak cukup untuk mengidentifikasi *osteoartritis*. (Ferrreira dkk 2016)

Temuan terkait perubahan morfologi menunjukkan bahwa metode ini masih kurang akurat dalam mendiagnosis morfologi pada korteks dan cakram artikular. Namun, metode ini mampu mengidentifikasi *efusi pleura* pada pasien dengan penyakit inflamasi terkait nyeri yang divalidasi oleh *MRI*. Terlepas dari keterbatasannya, metode ini dapat menjadi pilihan yang berguna untuk penilaian awal lesi internal sendi *temporomandibular*, terutama pada pasien dengan kontraindikasi *MRI*. Selain itu, metode tidak mahal, memungkinkan visualisasi waktu nyata tanpa menggunakan radiasi pengion, serta cepat dan nyaman. Penilaian *USG* biasanya digunakan untuk menyingkirkan diagnosis banding kelainan struktur kelenjar dan lainnya di sekitar sendi temporomandibular. Manifestasi saat ini pada kasus *sialadenitis*

dan *salamatolithiasis* dapat di salahartikan sebagai sindrom *Eagle, TMD,* nyeri *miofasial*, *neuralgia*, dan nyeri *orofasial* lainnya. (Aiken dan Bolux 2012, Ferreira dkk 2016)

Kesulitan dalam memvisualisasikan sendi temporomandibular menggunakan ultrasound berperan terhadap keterbatasan dalam mengakses struktur anatomi bagian dalam, terutama diskus, karena terjadi penyerapan gelombang suara oleh bagian *lateral caput condyle* dan prosesus *zigomatikus* tulang *temporalis.* Pada *sonogram*, disk di *visualisasikan* sebagai pita *homogen* tpis yang *hypoto-isoechoic*. Dalam mengevaluasi temuan pada posisi mulut tertutup, posisi diskus dianggap normal jika *zona intermediate* diskus berada di antara aspek *anterosuperior* kondilus mandibula dan aspek *posteroinferior articular eminence*. Disk beserta *zona intermediate* yang terletak di *anterior* posisi ini dianggap tergeser ke arah *anterior* (gangguan *internal*). (Ferreira dkk 2016) Dalam mengevaluasi temuan pada posisi mulut terbuka, posisi diskus di anggap normal jika *zona intermediate* disk berada di antara kondilus dan artikular *eminence*. Jika diskus bergeser ke arah *anterior,* maka hal tersebut dianggap sebagai gangguan *internal*. Efusi sendi dapat di deteksi secara tidak langsung dengan mengukur jarak antara dua permukaan articular atau lebar kapsular (Park dkk 2014).



Gambar 2. 13 Gambaran *ultrasonography* pada perpindahan diskus dengan reduksi(a) mulut terbuka, (b) tanda panah menunjukkan perpindahan disk(Talmaceanu D dkk 2018)

2.4.5 *Panoramic*

Berbagai modalitas dari modalitas pencitraan *non-invasif* seperti radiografi *konvensional*, *ultrasound (USG), computed tomography (CT) dan MRI* hingga modalitas pencitraan yang lebih *invasif* seperti *artrografi* dapat digunakan untuk mencitrakan sendi *temporomandibular*. Masing-masing modalitas pencitraan ini memiliki kegunaannya sendiri (Bag dkk 2014).

Sinar-X *konvensional* dalam hal ini, adalah sinar-X *panoramic* yang paling umum digunakan. Modalitas pencitraan ini hanya dapat digunakan untuk menilai komponen tulang dan tidak memberikan informasi yang berguna tentang komponen non-tulang seperti kartilago dan jaringan lunak sekitarnya. Penelitian ini juga tidak memberikan informasi yang berguna tentang efusi sendi, yang umumnya dikaitkan dengan nyeri dan dislokasi diskus. Kelemahan lain adalah masalah tumpang tindih struktur yang berdekatan. Pendekatan yang berbeda seperti subapikal, *transmaxillary*, dan transkranial digunakan untuk mengurangi keberadaan *overlay*. *Rontgen panoramic* ini juga merupakan salah satu teknik *rontgen* gigi yang digunakan untuk membuat gambar *tomografi* struktur wajah, meliputi seluruh lengkung rahang serta anatomi rahang atas dan bawah. Gambar yang dihasilkan diperoleh dengan bergerak maju mundur pada sumbu atau bidang tertentu antara sumber sinar-X dan penerima. (Perschbach S 2012).

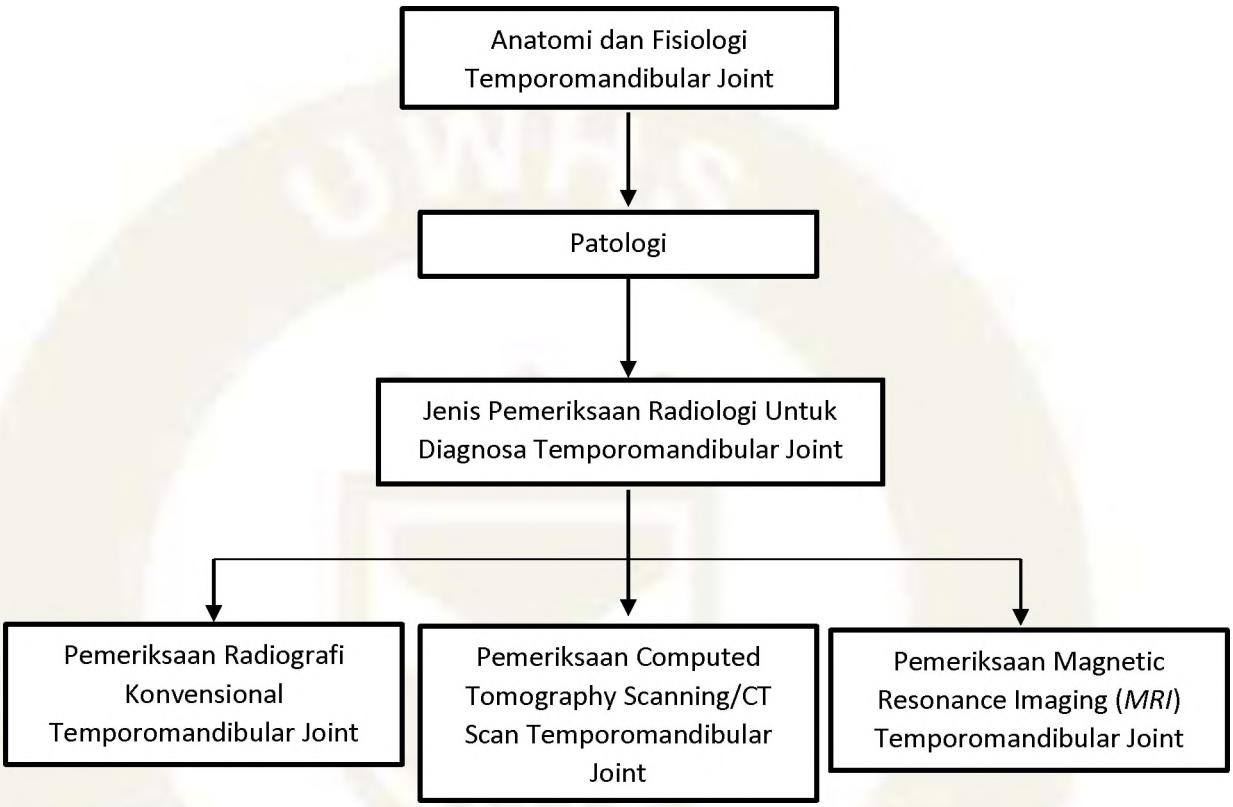
Sinar-X panoramik memiliki keuntungan karena dapat mengambil gambar tulang dan gigi wajah dengan dosis rendah. Selain itu, prosedur pengambilan gambar sederhana, sehingga dapat digunakan untuk pasien yang kesulitan membuka mulut. Gambar yang dihasilkan mudah dipahami pasien dan dapat digunakan sebagai media edukasi pasien dan presentasi kasus. Sinar-X Panoramik biasanya digunakan sebagai evaluasi awal untuk memberikan gambaran umum

tentang atau untuk membantu menentukan perlunya proyeksi lain untuk memberikan gambar yang lebih jelas. Kelemahan radiografi panoramik adalah bahwa gambar yang dihasilkan tidak mengandung detail anatomi yang diperoleh dari radiografi periapikal. Selain itu, radiografi panoramik dapat mengalami ketidakseimbangan pembesaran dan distorsi geometrik jika pasien dimiringkan.

Gambar 2. 14Gambaran radiografi *panoramik* yang menujukkan jaringan keras dan lunak dari regio *orofacial*Pasien meliputi maksila, *mandibula*, gigi geligi, dan struktur terkait(Talmaceanu D dkk 2018)

2.5 Kerangka Teori

Berikut adalah kerangka teori yang diambil penulis dalam penelitian ini berdasarkan berbagai sumber :



Gambar 2. 15 Kerangka Teori

2.6 Petanyaan Penelitian

2.6.1 Bagaimana peranan masing-masing pencitraan diagnostik *TMJ* dalam menegakkan diagnosa menurut jurnal yang dikaji?

2.6.2 Apa kelebihan dan kekurangan dari ketiga kajian teori yang digunakan dalam Karya Tulis Ilmiah ini ?

2.6.3 Apa persamaan dan perbedaan dari ketiga kajian teori yang digunakan dalam Karya Tulis Ilmiah ini ?

BAB III
METODE PENELITIAN

3.1 Rancangan Penelitian

3.1.1 Jenis Penelitian

Jenis penelitian yang digunakan dalam Karya Tulis Ilmiah (studi literatur) ini adalah kualitatif dengan menggunakan metode studi literatur (*literature review*) terkait .

3.1.2 Waktu Penelitian

Waktu penelitian pada Karya Tulis Ilmiah (studi literatur) ini dilakukan pada bulan Januari 2022 – Agustus 2022

3.2 Metode Pengambilan Data

Metode pengumpulan data dalam menyusun Karya Tulis Ilmiah ini berasal dari hasil penelitian yang sudah dilakukan dan diterbitkan dalam jurnal online nasional maupun internasional. Dalam penulisan ini, penulis melakukan pencarian literatur yang dipublikasikan di internet menggunakan situs google scholar. Dari banyak literatur yang tersedia di internet, penulis hanya mengambil tiga literatur yang sesuai dengan topik yang dibahas yaitu peranan pencitraan diagnostik *Temporomandibular Joint* dalam penegakkan diagnosa.

Untuk memperoleh data dalam penulisan ini, penulis menggunakan metode pengambilan data studi literatur. Penulisan studi literatur adalah penulisan yang persiapannya sama dengan penulisan lainnya akan tetapi sumber dan pengumpulan data yang digunakan yaitu mengambil data pustaka, membaca, mencatat, dan mengolah bahan penulisan.

Langkah-langkah yang dilakukan penulis dalam pengumpulan data adalah sebagai berikut :

3.2.1 Mendefinisikan Kriteria Kelayakan Literatur

Pendefinisian kriteria kelayakan literatur ditentukan dengan kriteria inklusi dimana :

a. Jumlah literatur dari jurnal yang digunakan ada tiga, sumber literatur menggunakan textbook dan jurnal internasional untuk bab II dan sebagai acuan dalam pembahasan.
b. Literatur jurnal yang digunakan dengan ketentuan tahun terbit 10 tahun terakhir. Literatur yang digunakan penulis untuk penelitian ini dipublikasikan pada tahun 2014, 2016 dan 2018.
c. Literatur dari jurnal ini merupakan riset hasil yang telah dikaji dan dituliskan dalam bahasa indonesia dari situs jurnal yang sudah terakreditasi skala nasional. Literatur yang digunakan penulis dalam penelitian ini diantaranya didapat dari Jurnal National Library of Medicine (NLM) PubMed, Jurnal World Journal of Radiology, dan Jurnal National Library of Medicine (NLM) PubMed

3.2.2 Mendefinisikan Sumber Informasi

Literatur yang digunakan dalam penelitian ini diperoleh dari berbagai sumber pustaka penelitian diantaranya adalah Jurnal National Library of Medicine (NLM) PubMed dengan nomor DOI: 10.15386 / cjmed-970, Jurnal World Journal of Radiology dengan nomor ISSN 1949-8470 dan DOI:http://dx.doi.org/10.4329/wjr.v6.i8.567, dan Jurnal National Library of Medicine (NLM) PubMed dengan nomor ISSN 1808-8694 dan DOI:https://doi.org/10.1016/j.bjorl.2015.06.010 yang diakses oleh penulis melalui situs yang telah terakreditasi yaitu google scholer.

3.2.3 Pemilihan Literatur

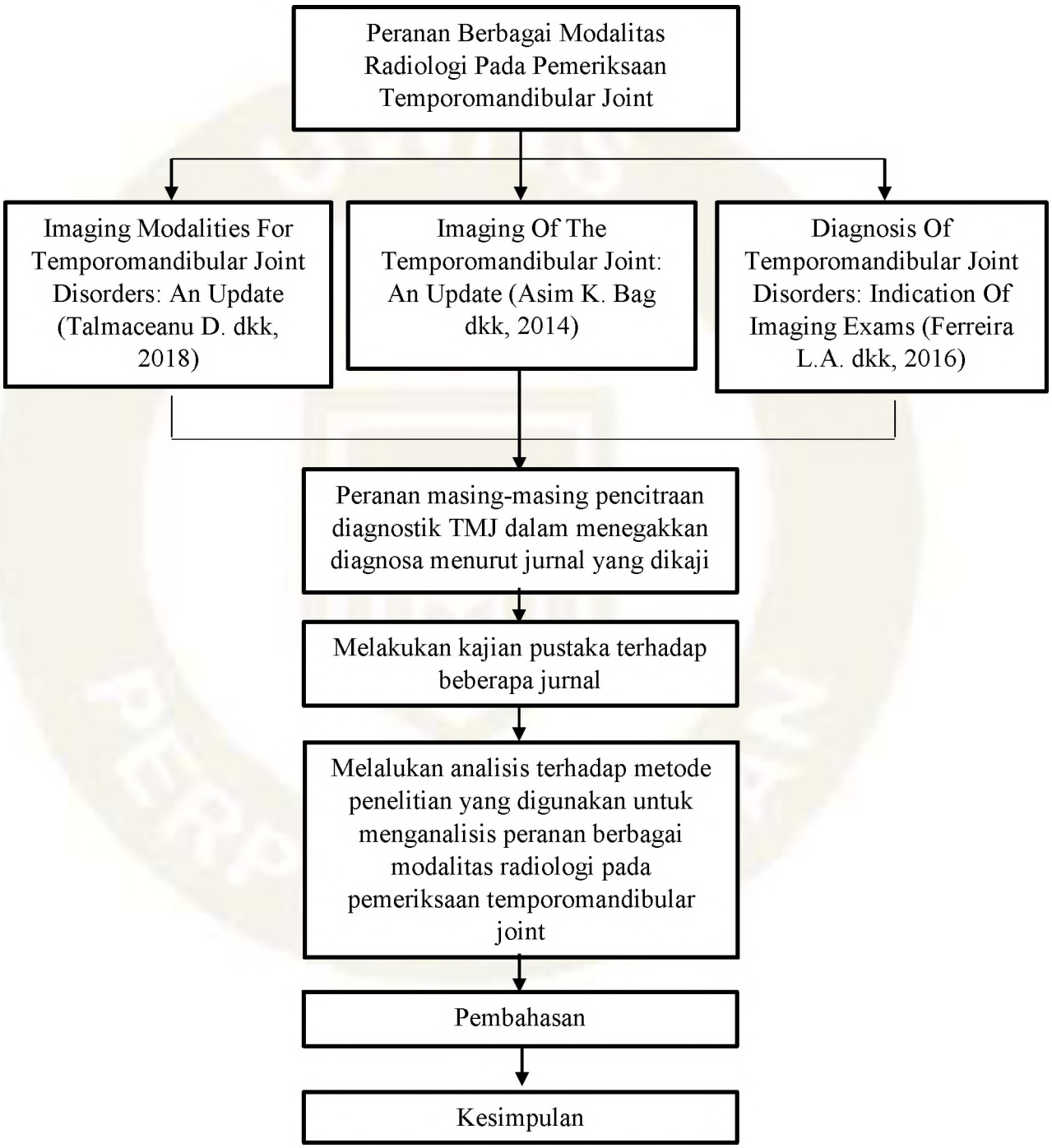
Pemilihan literatur dilakukan dengan pemilihan topik dari beberapa jurnal yang sesuai dengan tema yang diangkat oleh penulis yaitu peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint*. Kemudian data yang diperoleh dari jurnal dikumpulkan untuk dijadikan landasan atau sumber dari data studi literatur.

3.2.4 Pengumpulan Data

Data yang digunakan dalam penelitian ini berasal dari hasil penelitian yang sudah dilakukan dan diterbitkan dalam jurnal online nasional. Penulis melakukan pemilihan literatur yang sesuai dengan topik peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint* yang akan dibahas dengan membuat formulir ekstrasi sesuai dengan isi jurnal seperti tipe artikel, nama peneliti, tahun terbit, judul, negara, tujuan penelitian, kata kunci, metodologi penelitian, dan hasil penelitian atau temuan.

3.3 Alur Penelitian

Alur penelitian yang digunakan dalam penulisan Karya Tulis Ilmiah (Studi Literatur) adalah sebagai berikut :



Gambar 3. 1 Kerangka Alur Penelitian

3.4 Pengolahan Dan Analisis Data

Dalam penelitian ini, pengumpulan data dilakukan dengan menggunakan cara literature review terhadap tiga jurnal yang terkait dengan peranan berbagai peranan modalitas radiologi pada pemeriksaan *temporomandibular joint*. Tujuan dari analisis dan pengolahan data adalah untuk menjawab rumusan masalah. Data didapatkan dari ketiga jurnal yang terkait peranan berbagai modalitas radiologi pada pemeriksaan *temporomandibular joint* dengan cara meringkas jurnal penelitian tersebut dan dimasukan ke dalam tabel. Kemudian data disajikan dengan tujuan untuk menggabungkan informasi yang telah diambil dari jurnal. Hasil ringkasan jurnal tersebut dilakukan analisis dan pengolahan data. Analisis dibuat dengan cara membuat persamaan dan perbedaan antara ketiga jurnal yang diambil oleh penulis beserta texbook, mengenai berbagai modalitas radiologi pada pemeriksaan *temporomandibular joint*.

BAB IV
HASIL PENELITIAN

4.1 Seleksi Artikel

Artikel yang digunakan pada studi literatur ini yaitu berjumlah tiga jurnal yang terkait dengan peranan berbagai modalitas radiologi pada pemeriksaan *temporomandibular joint* sebagai landasan acuan data penulis dalam mengerjakan karya tulis ilmiah studi literatur dengan judul "peranan berbagai modalitas radiologi pada pemeriksaan *temporomandibular joint*". Literatur ini didapatkan dari situs yang sudah terakreditasi yaitu google scholar. Jurnal-jurnal tersebut direduksi dengan menggunakan kriteria tertentu. Kriteria yang digunakan dapat dibagi menjadi dua macam. Kriteria pertama adalah kelengkapan artikel dan bahasa. Artikel ilmiah atau jurnal yang dipilih adalah artikel yang diterbitkan dalam bahasa inggris. Kelengkapan jurnal dianggap utuh jika memuat judul, nama pengarang, penerbit, abstrak, serta terdapat isi artikel yang lengkap hingga daftar pustaka. Kriteria kedua adalah relevan artikel yang dipilih adalah artikel yang membahas tentang peranan berbagai modalitas radiologi pada pemeriksaan *temporomandibular joint*. Terkait kelayakan literatur penulis menggunakan jurnal yang dipublikasikan dalam 10 tahun terakhir dari situs penelitian yaitu *National Library Of Medicine (NLM) Pubmed, Jurnal World Journal Of Radiology*.

4.2 Pemaparan Jurnal

Pemaparan dari jurnal yang digunakan dalam penelitian ini adalah sebagai berikut :

4.2.1. Peranan berbagai modalitas radiologi pada pemeriksaan *temporomandibular joint* menurut jurnal pertama :

Pada penulisan karya tulis ilmiah studi literatur ini penulis menggunakan jurnal pertama sesuai dengan tema penulisan yaitu :

Daniel Talmaceanu, dkk "*Imaging Modalities For Temporomandibular Joint Disorders: An Update*"

a. Pendahuluan

Diagnosis dan pengelolaan gangguan temporomandibular (*TMD*) memerlukan pemeriksaan klinis dan pencitraan sendi temporomandibular (*TMJ*). Berbagai modalitas dapat digunakan untuk mencitrakan *tmj*, termasuk *Magnetic Resonance Imaging (MRI)*, *Computed Tomopragphy (CT)*, *Cone Beam CT*, *Ultrasonografi*, radiografi konvensional. Tinjauan ini menguraikan indikasi teknik pencitraan yang paling sering digunakan dalam diagnosis *TMD*. Memilih teknik pencitraan yang tepat sangat penting.

b. Metode

Metode penelitian yang digunakan yaitu deskriptif kualitatif.

c. Hasil dan Pembahasan

Pencitraan sendi temporomandibular

1. Radiografi Panoramik

Menunjukkan rahang dan struktur terkait, menjadi alat yang berguna bagi dokter dalam mengidentifikasi penyebab periodontal atau odontogenik untuk nyeri orofasial. Radiografi panoramik tidak muncul dalam daftar teknik pencitraan yang disediakan oleh RDC/*TMD*. Radiografi panoramik dapat membantu mengevaluasi hal-hal berikut:

a) Perubahan tulang degeneratif (hanya pada tahap akhir;
b) Tidak memadai untuk deteksi dini modifikasi tulang);
c) Asimetri kondilus;

d) Hiperplasia, hipoplasia;

e) Trauma;

f) Tumor

Radiografi panoramik jika dibandingkan dengan *CT* terdapat perbedaan yang antara lain dari status fungsional dan spesitifitas yang relatif rendah, serta radiografi panoramic tidak mengungkapkan status fungsional sendi. Epstein dkk mempertimbangkan temuan klinis relevansi yang lebih besar daripada gambar panoramik untuk pasien dengan *TMD*. Namun demikian beberapa penulis telah menyarankan radiografi panoramik sebagai modalitas pencitraan yang baik untuk visualisasi *TMJ*. Selain itu, di karenakan posisi kepala dapat mempengaruhi citra *TMJ*.

2. Radiografi Polos

Terdiri dari proyeksi transkranial *TMJ*. Angulasi yang berbeda digunakan untuk menghindari superposisi tulang temporal dan *TMJ* yang berlawanan: proyeksi transkrnial miring lateral, proyeksi *anterior-posterior*, proyeksi submental-vertex, tampilan transfaringeal. Teknik kontak yang diperkenalkan oleh Parma tidak dianjurkan karena dosis radiasi yang tinggi dan superposisi struktur tulang. Radiografi polos berguna dalam menggambarkan penyakit sendi degeneratif pada stadium lanjut. Posisi kondilus juga dapat dinilai, tetapi variasi besar posisi kondilus di fossa glenoidalis ditemukan, bahkan pada populasi tanpa gejala. Posisi kepala selama pemeriksaan dapat mempengaruhi ruang sendi, yang dapat mempengaruhi interpretasi radiografi. Penggunaan film bidang datar

untuk patologi *TMJ* tidak cukup, karena sambungan ini membutuhkan tampilan pencitraan tiga dimensi.

3. *Computed tomopragphy (CT)*

CT dianggap sebagai metode terbaik untuk menilai kondisi patologis tulang *TMJ*. Hal ini memungkinkan rekonstruksi multi planar (*sagital*, *aksial*, koronal) dari struktur *TMJ*, memperoleh gambar 3D dalam posisi mulut tertutup dan terbuka. Tanda-tanda perubahan degeneratif pada sendi, seperti erosi permukaan, osteofit, remodeling, sklerosis subkortikal, pendataran permukaan artikular dapat dievaluasi menggunakan *CT*. Beberapa penelitian telah melaporkan bahwa perubahan radiografi pada sendi tidak selalu berhubungan dengan nyeri. Oleh karena itu, beberapa pasien dengan kelainan tulang mungkin mengalami rasa sakit, yang lain mungkin bebas rasa sakit. Perubahan bentuk dan letak zona pembebanan juga dapat dilihat pada *CT*. *CT* adalah pemeriksaan radiologi utama untuk tumor, anomali perkembangan pertumbuhan dan patah tulang.

Studi otopsi dilakukan untuk penilaian kelainan kondilus menunjukkan hasil yang lebih baik untuk *CT* daripada *MRI*. Wesetesson dkk menemukan sensitivitas 75% dan spesifisitas 100% untuk diagnosis perubahan tulang kondilus. Mengenai visualisasi jaringan lunak *TMJ* (diskus, membran sinovial, ligamen, otot pterigoid lateral), *CT* tidak digunakan sebagai metode diagnostik utama. Patologi diskus *TMJ* dan patologi otot pterygoid lateral lebih baik dinilai dengan *MRI*. Pada *CT scan*, posisi dan bentuk kondilus

mandibula di fossa glenoidalis terlihat jelas, Kerugian utama *CT*, dibandingkan dengan metode radiologi lainnya, adalah biaya tinggi dan paparan radiasi. Keuntungan utama dari *Cone Beam CT*, dibandingkan dengan *CT*, adalah dosis radiasi yang lebih rendah untuk pasien. Resolusi spasial dari *Cone Beam CT* lebih tinggi daripada *CT* konvensional. *Cone Beam CT* bekerja lebih baik daripada radiografi konvensional dan sebaik *CT* konvensional, memungkinkan untuk menggambarkan perubahan awal tulang pada *TMJ*.

a) Memungkinkan perhitungan volume dan permukaan kondilus
b) Meningkatkan analisis kualitatif permukaan condylar dan memungkinkan mendeteksi bentuk kondilus mandibula
c) Meningkatkan akurasi pengukuran linier dari kondilus mandibula
d) Mengklarifikasi bahwa, dalam kasus asimetri wajah, kondilus sering simetris, sedangkan ruang sendi dapat berubah antara kedua sisi

4. Memperjelas posisi kondilus di dalam lubang. *MRI*

MRI saat ini dianggap sebagai metode referensi untuk pencitraan struktur jaringan lunak *TMJ* (diskus artikular, membran sinovial, otot pterigoid lateral) dan telah ditunjukkan sebagai modalitas pencitraan terbaik dalam mendiagnosis perpindahan diskus. *MRI* juga dapat mendeteksi tanda-tanda awal disfungsi *TMJ*, seperti penebalan pita anterior atau *posterior*, ruptur jaringan retrodiscal, perubahan bentuk diskus, efusi sendi. Gambar dapat diperoleh di semua

bidang (*sagital*, *aksial*, koronal). Di sebagian besar urutan pemindaian, gambar pembobotan T1, pembobotan T2, dan densitas proton (PD) diperoleh., yang berfungsi untuk memvisualisasikan hubungan disc-condyle, sedangkan gambar T2-tertimbang digunakan dalam mendiagnosis peradangan pada sendi. Ketebalan irisan penting untuk kualitas gambar. Ketebalan bagian yang paling sering digunakan adalah 3 mm. Mengurangi ketebalan irisan meningkatkan kualitas gambar, tetapi membutuhkan waktu pemindaian yang lebih lama.

Gambar *pelokalan aksial* digunakan untuk mengarahkan sumbu panjang kondilus dalam posisi mulut tertutup. Gambar *sagital* diperoleh tegak lurus terhadap sumbu panjang kondilus, dan gambar koronal diperoleh sejajar sumbu Panjang.

Dalam pemeriksaan *MRI*, kondisi *patologis* dianggap ada relatif terhadap zona menengah meniskus (sebagai titik acuan) dan interposisinya antara kondilus dan tulang temporal. Posisi diskus normal, dievaluasi pada bidang *sagital*, adalah dengan pertemuan pita *posterior* sejajar kira-kira pada pukul 12, posisi relatif terhadap kondilus. Perpindahan diskus didiagnosis ketika pita *posterior* berada pada posisi anterior, *posterior*, medial atau lateral sehubungan dengan permukaan kondilus. Pada posisi mulut tertutup, gigi harus bersentuhan, sedangkan pada posisi mulut terbuka, rahang harus berada pada bukaan terlebar yang nyaman.

Beberapa penelitian *telah* menyelidiki hubungan antara morfologi eminensia artikular dan pola diskus pada pasien dengan perpindahan diskus. Hasil penelitian menunjukkan bahwa perubahan morfologi eminensia artikular (flattened) dan diskus dapat berkontribusi pada munculnya diskus displace tanpa reduksi pada sisi tersebut. Studi lain juga menemukan perubahan bentuk dan dimensi cakram pada kasus perpindahan cakram *TMJ*. Di antara kerugian dari penyelidikan *MRI*, berikut ini dapat disebutkan:

a) Mahal dan memakan waktu;
b) Penggunaan terbatas pada pasien dengan claustrophobia;
c) Ada kemungkinan kehilangan bagian dari kondilus memiliki kista semu;
d) Mungkin melewatkan kondisi tulang dan jaringan lunak yang berbeda kalsifikasi dengan penyakit radang atau tumor; dalam kasus ini, *CT* adalah modalitas pencitraan yang lebih disuka

5. *Ultrasonografi* (*USG*)

Ultrasonografi resolusi tinggi (*USG*) pertama kali digunakan untuk eksplorasi *TMJ* pada tahun 1991, oleh Nabeih dkk, menggunakan transduser 3,5 MHz. Meskipun merupakan prosedur non-invasif, dinamis, murah, tidak umum digunakan dalam eksplorasi *TMJ*. Penggunaan *ultrasonografi* resolusi tinggi *USG* (transduser setidaknya 7,5 MHz atau lebih tinggi) secara signifikan meningkatkan nilai diagnostik teknik ini.

Pemeriksaan *USG* berguna dalam menggambarkan perpindahan dan efusi diskus. Biasanya, diskus terletak di antara dua garis hyperechoic yang diwakili oleh kondilus mandibula dan eminensia artikular. Jika disk dipindahkan dalam posisi mulut tertutup, diagnosisnya adalah perpindahan disk. Jika cakram kembali ke posisi normalnya selama pembukaan, diagnosisnya adalah perpindahan cakram dengan reduksi. Jika tidak, diagnosisnya adalah perpindahan diskus tanpa reduksi. Mengenai perubahan degeneratif *TMJ*, *USG* masih tidak direkomendasikan. Salah satu kesulitan *USG* adalah kemungkinan untuk mendapatkan gambar yang jelas, terutama pada posisi mulut terbuka, karena struktur tulang di atasnya. Keterbatasan lain dari *USG* adalah bahwa bagian medial dari disk tidak dapat divisualisasikan.

Nilai diagnostik *USG* resolusi tinggi sangat bergantung pada keterampilan pemeriksa dan peralatan yang digunakan. Oleh karena itu, ada kebutuhan terus menerus untuk ahli radiologi terlatih danberpengalaman di bidang ini.

d. Kesimpulan

Pemilihan teknik radiologi yang tepat untuk *TMJ*, serta pasien, harus dilakukan dengan hati-hati oleh praktisi, dalam kaitannya dengan tanda dan gejala klinis. Tujuan pemeriksaan radiologis yang dipilih harus meningkatkan diagnosis dan hasil pengobatan sesuai dengan indikasi spesifik setiap pemeriksaan pencitraan dan berbagai tingkat sensitivitas dan spesifisitas. *CT* dan *MRI*, saat ini, adalah teknik pencitraan yang paling banyak digunakan. *CT* adalah pemeriksaan yang

paling efisien dalam mendeteksi perubahan tulang, sedangkan *MRI* tetap menjadi standar emas untuk pemeriksaan diskus artikular. *Ultrasonografi* resolusi tinggi adalah teknik diagnostik pencitraan yang menjanjikan dalam menilai posisi diskus *TMJ*.

4.2.2. Peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint* menurut jurnal kedua :

Pada penulisan Karya Tulis Ilmiah studi literatur ini penulisan menggunakan jurnal pertama sesuai dengan tema penulisan yaitu : Asim K, dkk "*Imaging Of The Temporomandibular Joint: An Update*".

a. Pendahuluan

Pencitraan sendi temporomandibular (*TMJ*) terus berkembang dengan kemajuan teknologi pencitraan. Banyak modalitas pencitraan yang berbeda saat ini digunakan untuk mengevaluasi *TMJ*. Pencitraan resonansi magnetik biasanya digunakan untuk evaluasi *TMJ* karena resolusi kontrasnya yang superior dan kemampuannya untuk memperoleh pencitraan dinamis untuk demonstrasi fungsionalitas sendi. Computed tomography dan ultrasound imaging memiliki indikasi spesifik dalam pencitraan *TMJ*.

b. Metode

Metode penelitian yang digunakan yaitu deskriptif kualitatif.

c. Hasil dan Pembahasan

Berbagai modalitas dapat digunakan untuk mencitrakan *TMJ*. Ini termasuk modalitas pencitraan non-invasif seperti radiografi konvensional, ultrasound, *Computed tomopragphy (CT)* dan *MRI* hingga pencitraan yang lebih

invasif seperti arthrography. Setiap modalitas pencitraan memiliki kegunaannya.

1. Radiografi Konvensional

   Radiografi konvensional memiliki peran terbatas dalam evaluasi *TMJ*. Mereka dapat digunakan untuk mengevaluasi hanya elemen tulang *TMJ*. Mereka tidak memberikan informasi yang berguna ketika datang ke elemen non-tulang seperti tulang rawan atau jaringan lunak yang berdekatan. Mereka juga tidak memberikan informasi yang berguna mengenai efusi sendi, yang umumnya terkait dengan nyeri dan perpindahan diskus. Kerugian lain mengenai radiografi konvensional adalah masalah superimposisi dari yang berdekatan struktur. Banyak pandangan yang berbeda seperti submento-vertex, transmaxillary, dan transkranial digunakan untuk mengurangi superimposisi.

2. *Ultrasonografi* (*USG*)

   Ultrasound adalah modalitas pencitraan yang lebih murah dan mudah dilakukan yang dapat digunakan untuk mengevaluasi *TMJ*. Ini adalah cara sederhana untuk mencari keberadaan efusi sendi. Ultrasound juga digunakan untuk mengevaluasi kartilago serta perpindahan diskus dengan pencitraan mulut terbuka dan tertutup. Ini digunakan untuk injeksi yang dipandu gambar untuk tujuan diagnostik dan terapeutik. Biasanya, transduser linier 8 MHz atau lebih tinggi adalah ideal. Pasien harus berbaring terlentang dengan transduser ditempatkan sejajar

dengan garis memanjang dari tragus telinga ke permukaan lateral hidung di atas *TMJ*.

3. *Computed tomopragphy (CT)*

   CT berguna untuk mengevaluasi elemen tulang *TMJ* serta jaringan lunak yang berdekatan. *CT* sangat ideal untuk evaluasi fraktur, perubahan degeneratif, erosi, infeksi, invasi oleh tumor, serta anomali kongenital. Protokol pencitraan yang khas adalah: 120 kV, 100 mA, kolimasi 1 mm, 1 mm/rotasi (pitch), dan dicitrakan dengan mulut tertutup. *CT* juga memungkinkan rekonstruksi 3D, yang dapat digunakan untuk mengevaluasi anomali kongenital dan fraktur. *CT* sebagian besar dilakukan ketika ada kecurigaan keterlibatan tulang dari *MRI* dan jika patologi tulang primer dicurigai secara klinis. Keuntungan relatif *CT* dibandingkan *MRI* meliputi, detail tulang yang sangat baik dan penilaian 3D dari kondisi kongenital, traumatis, dan pascaoperasi.

4. *MRI*

   Evaluasi klinis *TMJ* bisa tidak spesifik karena tumpang tindih gejala antara gangguan internal dan disfungsi nyeri *myofacial*. *MRI* harus menjadi bagian dari evaluasi standar ketika dicurigai adanya kelainan struktur internal sendi karena *MRI* memberikan resolusi tinggi dan kontras jaringan yang bagus. Hal ini memungkinkan untuk evaluasi rinci anatomi serta biomekanik sendi melalui pencitraan mulut terbuka dan tertutup. Untuk pencitraan *TMJ* yang optimal, kumparan permukaan bilateral kecil dengan bidang pandang kecil digunakan untuk mencapai rasio sinyal

terhadap *noise* yang lebih tinggi dan akuisisi bilateral simultan. Urutan koronal dan *aksial* T1 mulut tertutup diperlukan untuk mengevaluasi keseluruhan anatomi dan sumsum tulang serta jaringan lunak yang berdekatan untuk mengecualikan patologi lain yang berdekatan. Di institusi kami, T1 *aksial* diperoleh sebagai localizer. Mulut tertutup bilateral dan mulut terbuka T2, kerapatan proton (PD) dan urutan dinamis diperoleh dalam bidang *sagital* miring. Di lembaga kami, gambar dinamis diperoleh sebagai akuisisi cepat gambar statis menggunakan urutan densitas proton *single shot fast spin echo (SSFSE)* selama pembukaan dan penutupan progresif mulut. Gambar gambar ini ditampilkan secara berurutan sebagai cine loop. Alat pembuka mulut seperti alat pembuka Burnett dapat digunakan untuk pembukaan tambahan mulut yang dikendalikan oleh pasien. Dapat dikatakan bahwa pembukaan mulut pasif dengan perangkat Burnet mungkin tidak mereproduksi kondisi fisiologis yang terjadi selama pembukaan mulut mengingat kemungkinan peran otot pterigoid lateral dalam stabilisasi diskus selama pembukaan mulut. Pencitraan miring memerlukan 30° medial.

5. Arthrography

Arthrography adalah teknik pencitraan invasif untuk mengevaluasi *TMJ*. Modalitas pencitraan ini memerlukan injeksi kontras radiopak ke dalam *TMJ* di bawah bimbingan fluoroskopi. Setelah kontras disuntikkan, sendi dapat dievaluasi untuk adhesi, disfungsi diskus, serta perforasi diskus berdasarkan

bagaimana kontras mengalir dalam sendi. Modalitas ini jarang digunakan saat ini karena *MRI* dapat digunakan untuk mengevaluasi *TMJ* tanpa invasif, memaparkan pasien terhadap kemungkinan reaksi alergi dari kontras, kemungkinan infeksi, atau menggunakan radiasi.

6. Penampilan *TMJ* Normal Pada *MRI*

Pada *MRI*, lemak sumsum di kondilus memiliki intensitas sinyal T1 yang tinggi. Tulang kortikal dan diskus memiliki intensitas sinyal yang rendah pada gambar berbobot T1 dan T2 karena densitas proton yang rendah dan T2 yang pendek. Kadang-kadang intensitas sinyal T2 dan PD yang tinggi dapat dilihat di bagian tengah diskus yang serupa dengan diskus vertebra yang terhidrasi secara sentral. Disk sebaliknya homogen, hipointens dan bikonkaf dalam bentuk. Pusat pita *posterior* mungkin sedikit hiperintens karena adanya jaringan areolar yang longgar. Lampiran *posterior* disk memiliki intensitas sinyal yang lebih tinggi daripada otot pada kepadatan proton dan gambar berbobot T1 sekunder untuk jaringan lemak. Zona bilaminar terlihat sebagai struktur intensitas sinyal menengah. Pada posisi mulut tertutup, pertemuan pita *posterior* dan perlekatan *posterior* biasanya terletak di atas kepala kondilus dekat posisi jam 12.

Pita *posterior* dan jaringan retrodiskal paling baik digambarkan dalam posisi mulut terbuka. Pada posisi mulut terbuka, zona tengah terletak di antara kondilus dan eminensia artikularis dan pita *posterior*

berhadapan dengan permukaan *posterior* kondilus. Perut superior pterigoid lateral menempel pada pita anterior diskus. Perut inferior pterigoid lateral menempel pada permukaan anterior leher kondilus dengan pita fibrosa hipointens linier tipis. Pita ini terlihat lebih rendah dari posisi diskus, dan terkadang dapat disalahartikan sebagai diskus, terutama Ketika diskus bergeser ke medial atau lateral. Pada bidang koronal, piringan berbentuk bulan sabit dan batas medial dan lateralnya melekat pada masing-masing aspek kepala kondilus dan kapsul sendi. Kapsul lateral dan medial tidak menunjukkan tonjolan keluar di luar batas dalam kondisi norma.

d. Kesimpulan

Pencitraan *TMJ* harus dilakukan berdasarkan kasus per kasus tergantung pada tanda dan gejala klinis. *MRI* adalah studi diagnostik pilihan untuk evaluasi posisi diskus dan gangguan internal sendi. *CT scan* untuk evaluasi *TMJ* diindikasikan jika keterlibatan tulang dicurigai dan harus dipertimbangkan secara bijaksana karena risiko radiasi. Pemahaman tentang anatomi *TMJ*, biomekanik, dan manifestasi pencitraan penyakit penting untuk mengenali dan mengelola berbagai patologi ini secara akurat.

4.2.3. Peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint* menurut jurnal ketiga :

Pada penulisan Karya Tulis Ilmiah studi literatur ini penulis menggunakan jurnal ketiga sesuai dengan tema penulisan yaitu : Fereira L. A, dkk "*Diagnosis Of Temporomandibular Joint Disorders: Indication Of Imaging Exams*".

a. Pendahuluan

Temporomandibular Joint (*TMJ*) adalah gabungan sendi ginglymus-arthrodial yang komponennya adalah kondilus, rongga glenoid dan tuberculum articular, jaringan disk, articuretrodiscal, membrane synovial dan sendi kapsul. Dalam kebanyakan kasus gejala menyebar dan tidak tepat dimanifesrasikan sebagai mialgia pengunyahan, artragia, sakit kepala, otalgia, dan nyeri leher. Diagnostik *TMJ* metode pencitraan digunakan untuk menilai intregitas komponenya dan hubungan fungsionalnya, untuk mengkonfirmasi tingkat atau perkembangan penyakit yang ada.

b. Tujuan

Studi ini membahas teknik pencitraan utama untuk penilaian *TMJ* dan struktur yang berdekatan dan indikasinya untuk diagnosis amandemen sendi, mengevaluasi keuntungan dan kerugiannya secara rasional.

c. Metode

Menggunakan ISI *Web of Knowledge, PubMed, dan database SciELO*, pencarian dilakukan untuk artikel literatur yang diterbitkan dan tersedia pada tahun 2004-2014

d. Hasil dan Pembahasan

Penilaian pencitraan sendi temporomandibular

1. Radiografi Konvensional

Radiografi *TMJ* memberikan informasi tentang karakteristik morfologi komponen sendi dan hubungan fungsional tertentu antara kondilus, tuberkulum sendi dan fossa, tetapi tidak efisien untuk mengevaluasi jaringan lunak

Beberapa faktor anatomi dan teknis dapat mencegah gambaran radiografi *TMJ* yang jelas dan tidak terhalang. Ketika memilih radiografi *TMJ*, kita perlu mempertimbangkan identifikasi detail struktur tulang, dugaan gangguan klinis spesifik, jumlah informasi gejala yang tersedia secara klinis untuk diagnosis, biaya pemeriksaan ini, dan dosis radiasinya.

2. Radiografi Panoramik

   Memberikan gambaran rahang atas, berguna dalam diagnosis diferensial dari perubahan odontogenic yang gejalanya tumpang tindih dengan *TMJ*D. Itu dapat menggambarkan tulang tingkat lanjut mengubah tindakan di kondilus, seperti asimetri, erosi, osteofit, patah tulang, perubahan ukuran dan bentuk, proses degeneratif dan inflamasi, perubahan pertumbuhan, tumor rahang atas, metastasis, dan ankilosis. Teknik ini berguna sebagai alat skrining, karena memungkinkan diagnosis awal dan penilaian perubahan *TMJ* yang tidak begitu halus. Hal ini juga diindikasikan ketika pasien telah mengurangi pembukaan mulut dan diagnosis banding fraktur dipertimbangkan.

3. Arthrography

   Arthrography adalah metode pilihan untuk identifikasi perpindahan disk. Morfologi, posisi, dan fungsi disk diidentifikasi secara tidak langsung dengan injeksi kontras ke dalam ruang sendi atas dan/atau bawah. Setelah injeksi, gambar dinamis adalah diperoleh, rekaman meskipun itu gerakan mandibula. Berguna untuk disk tidak saat ini adalah prosedur

invasif dan membawa posisi mengidentifikasi direkomendasikan seperti itu risiko iatrogenic perforasi diskus dan kerusakan saraf wajah. Ada juga risiko radiasi pada struktur radiosensitif (kristal dan tiroid), nyeri dan keterbatasan gerakan setelah injeksi, infeksi, alergi terhadap pewarna yang disuntikkan,

4. *Computed tomopragphy (CT)*

   CT terdiri dari satu set gambar yang diperoleh melalui yang canggih dan teknik yang sangat akurat, dibandingkan dengan radiografi pesawat. Baru-baru ini, teknologi cone-beam computed tomography (CB*CT*) telah digunakan untuk diagnosis gigi karena penggunaannya yang spesifik untuk daerah maksilofasial. Indikasi utama dari CB*CT* termasuk stru*CT*ural komponen tulang *TMJ*, yang secara tepat menentukan lokasi dan luasnya perubahan tulang : fraktur neoplasma, dan ankilosis. Jaringan keras, gigi dan tulang ditunjukkan dan diukur dengan baik dalam kondisi morfologisnya yang sebenarnya, dengan kebisingan dan artefak yang minimal.

5. *MRI*

   MRI telah menjadi metode dari pilihan proses yang melibatkan jaringan lunak *TMJ*, seperti ligament, cakram sendi, jaringan retrodiscal, intra synovial kapsuler, serta pengunyahan yang berdekatan otot.

   Tekniknya tiga dimensi bidang *aksial*, koronal, dan *sagital* itu dianggap baik untuk menilai posisi diskus dan sangat sensitive untuk perubahan degenerative intaartikular. Keuntungan utama termasuk mendeteksi perubahan jaringan lunak,

nekrosis, edema, ada atau tidaknya invasi dan kurangnya paparan radiasi pengion. Kekurangannya terkait dengan biaya yang mahal dan kebutuhan akan fasilitas yang canggih. Ini dikontraindikasikan pada pasien klaustrofobia, mereka yang memiliki alat pacu jantung dan katup jantung logam, benda asing feromagnetik, dan Wanita hamil.

6. *Ultrasonografi* (*USG*)

Menggunakan pemeriksaan *USG*, khususnya resolusi tinggi dapat menjadi pilihan yang berguna dalam penilaian posisi disk pada gangguan *TMJ* internal. Meskipun memiliki sensitivitas yang cukup besar, ia tidak memiliki spesifisitas yang cukup untuk mengindentifikasi osteoarthrosis.

Temuan terkait dengan perubahan morfologi menunjukan bahwa metode tersebut masih belum memiliki akurasi untuk diagnosis morfologi diskus kortikal dan artikulasi. Namun metode ini mampu mengindentifikasi efusi pada pasien dengan kondisi inflamasi terkait nyeri, diverifikasi oleh *MRI*.

e. Kesimpulan

Secara individual, beberapa tes pencitraan memiliki indikasi spesifik untuk diagnosis *TMJ*D. Meskipun sensitivitasnya lebih rendah, teknik radiografi memiliki biaya lebih rendah dan menggunakan dosis radiasi yang lebih rendah. Mereka diindikasikan untuk penilaian awal gejala yang kurang kompleks dan diagnosis banding antara *TMD* dan kondisi inflamasi gigi-maksilofasial. Kelainan morfologis, degeneratif tulang, dan patah tulang diidentifikasi secara tepat, dan diukur dengan *CT*. Penilaian kedokteran nuklir terutama diindikasikan untuk penilaian perubahan metabolisme dan pertumbuhan, seperti tumor dan metastasis. Arthrography adalah pemeriksaan intra-artikular invasif; indikasi yang biasa adalah visualisasi dari cakram sendi. Karena risiko yang melekat pada teknik ini, telah digantikan oleh penilaian *MRI*. Faktor-faktor yang perlu dievaluasi untuk pemilihan tes pencitraan *TMJ* meliputi: kebutuhan untuk menentukan keberadaan penyakit dan prognosisnya, kualitas dan kuantitas informasi klinis yang tersedia; ketidakpastian dalam diagnosis banding; menentukan tahap perkembangan penyakit; kebutuhan akan dokumentasi hukum; persiapan pra operasi; evaluasi evolusi pengobatan; dan keamanan dan keakuratan pemeriksaan yang diusulkan.

4.3 Ekstrasi Jurnal

Nama Peneliti	Tahun	Judul	Tujuan Penelitian	Metode Penelitian	Hasil Penelitian
Talmaceanu Daniel, Laviniamanuelalenghel, Nicolae Blog, Smarandabuduru, Rotary Horatif, Mihaelabaciut, Baciut Grigore.	2018	*Imaging Modalities For Temporomandibular Joint Disorders: An Update*	Bertujuan untuk menguraikan indikasi teknik pencitraan yang paling sering digunakan dalam diagnosis temporomandibular (*TMD*).	Metode yang digunakan dalam penelitian ini yaitu deskriptif kualitatif.	Hasil penelitian ini menunjukkan bahwa *CT* dan *MRI* adalah teknik pencitraan yang paling banyak digunakan. *CT* adalah pemeriksaan yang paling efisien dalam mendeteksi perubahan tulang, sedangkan *MRI* tetap menjadi standar untuk pemeriksaan diskus artikular. *Ultrasonografi* resolusi tinggi adalah teknik diagnostik pencitraan yang menjanjikan dalam menilai posisi diskus *TMJ*.
Asim K Bag, Santhosh Gaddikeri, Aparna Singhal, Simms Hardin, Benson D Tran, Josue A Medina, Joel K Curé	2014	*Imaging Of The Temporomandibular Joint: An Update*	Bertujuan untuk melihat pencitraan dari sendi temporomandibular.	Metode penelitian yang digunakan yaitu deskriptif kualitatif.	Hasil penelitian menunjukkan bahwa *MRI* adalah studi diagnostik pilihan untuk evaluasi posisi diskus dan gangguan internal sendi. *CT scan* untuk evaluasi *TMJ* diindikasikan jika keterlibatan tulang dicurigai dan harus

					dipertimbangkan secara bijaksana karena risiko radiasi.
Ferreira Luciano Ambrosio, Edward Grossmanndan, Eduardo Januzzi H, Marcos Vinicius Queiroz de Paula Saya, Antonio Carlos Pires Carvalho	2016	*Diagnosis Of Temporomandibular Joint Disorders: Indication Of Imaging Exams*	Bertujuan untuk menyajikan dan menilai tes pencitraan diagnostik utama untuk gangguan temporomandibular dan secara rasional mendiskusikan kriteria indikasi, keuntungan, dan kerugiannya.	Metode penelitian yang digunakan yaitu tinjauan literatur di database Web of Knowledge, PubMed dan SciELO.	Hasil penelitian menunjukkan bahwa computed tomography dan magnetic resonance imaging dianggap sebagai penilaian standar untuk sendi temporomandibular untuk mengevaluasi jaringan keras dan lunak. Setiap metode diagnostik menunjukkan sensitivitas dan spesifikasi yang berbeda untuk berbagai subtype disfungsi sendi.

BAB V
PEMBAHASAN

5.1 Persamaan Dan Perbedaan Pada Masing-Masing Jurnal

Berdasarkan analisis data yang dilakukan oleh penulis menggunakan kajian literatur terhadap tiga jurnal dengan topik peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint*, terdapat persamaan dan perbedaan pada masing-masing jurnal.

Tabel 5. 1 Persamaan dan Perbedaan Literatur

Nama peneliti dan tahun	Judul jurnal	Persamaan	Perbedaan
Talmaceanu Daniel dkk, 2018	*Imaging Modalities For Temporomandibular Joint Disorders: An Update*	1. Membahas peranan pencitraan diagnostik *Temporomandibular Joint* dalam penegakan diagnosa 2. Membahas tentang modalitas yang sama yaitu : radiografi polos, *computed tomopragphy (CT)*, *Ultrasonografi* (*USG*), dan *MRI*. 3. Indikasi pada jurnal ini : hiperplasia condyle, fraktur, erosi condyle	1. Metode penelitian yang digunakan yaitu deskriptif kualitatif 2. Jurnal ini tidak menjekaskan terkait indikasi : hippermobilitas

Asim K Bag dkk, 2014	*Imaging Of The Temporomandibular Joint: An Update*	1. Membahas peranan pencitraan diagnostik *Temporomandibular Joint* dalam penegakan diagnosa 2. Membahas tentang modalitas yang sama yaitu : radiografi polos, *computed tomopragphy (CT)*, *Ultrasonografi* (*USG*), dan *MRI*. 3. Indikasi pada jurnal ini : hiperplasia condyle, fraktur, erosi condyle	1. Metode penelitian yang digunakan yaitu deskriptif kualitatif 2. Jurnal ini membahas terkait indikasi : condyle bifida, effulsi sendi, osteocondritis dissecans(OCD), hippermobilitas, resoepsi condyle idiopatik, hipoplasia condyle.
Ferreira L. A dkk, 2016	*Diagnosis Of Temporomandibular Joint Disorders: Indication Of Imaging Exams*	1. Membahas peranan pencitraan diagnostik *Temporomandibular Joint* dalam penegakan diagnosa 2. Membahas tentang modalitas yang sama yaitu : radiografi polos, *computed tomopragphy (CT)*, *Ultrasonografi* (*USG*), dan *MRI*. 3. Indikasi pada jurnal ini : hiperplasia condyle, fraktur, erosi condyle	1. Metode penelitian yang digunakan yaitu tinjauan literatur di database Web of Knowledge, PubMed dan SciELO 2. Menjelaskan terkait indikasi stiloid, koronoid, ankilotis.

5.2 Kekurangan Dan Kelebihan Pada Masing-Masing Jurnal

Berdasarkan analisis data yang dilakukan penulis menggunakan kajian literatur terhadap tiga jurnal dengan topik peranan berbagai modalitas radiologi pada pemeriksasn *Temporomandibular Joint*, terdapat kekurangan dan kelebihan pada masing-masing jurnal.

Tabel 5. 2 Kelebihan dan Kekurangan Literatur

Nama peneliti dan tahun	Judul jurnal	Kelebihan	Kekurangan
Talmaceanu Daniel dkk, 2018	*Imaging Modalities For Temporomandibular Joint Disorders: An Update*	1. Menjelaskan tentang modalitas radiografi konvensional	1. Jurnal ini tidak menjelaskan tentang penggunaan modalitas arthrography
Asim K Bag dkk, 2014	*Imaging Of The Temporomandibular Joint: An Update*	1. Menjelaskan tentang modalitas arthrography	1. Jurnal ini tidak menjelaskan tentang penggunaan modalitas radiografi panoramic
Ferreira L. A dkk, 2016	*Diagnosis Of Temporomandibular Joint Disorders: Indication Of Imaging Exams*	1. Menunjukan bahwa *Computed Tomography, dan Magnetic Resonance Imaging* sebagai penilaian standar untuk sendi temporomandibular serta untuk mengevaluasi jaringan keras dan lunak. 2. Menjelaskan secara rinci dan lengkap tentang modalitas yang digunakan yaitu : radiografi konvensioonal, radiografi panoramik, arthrography, *computed tomopragphy (CT)*, *MRI*, dan *Ultrasonografi*.	1. Jurnal ini tidak menjelaskan secara rinci tentang peranan pencitraan pada modalitas radiografi konvensional

5.3 Analisis Jurnal

Menurut jurnal Talmaceanu Daniel dkk, (2018) menunjukan bahwa selain pemeriksaan klinis merupakan langkah terpenting dalam diagnosis patologi *TMJ*, teknik pencitraan khusus diperlukan dikarenakan anatomi dan patologi yang kompleks. Maka dari itu untuk dapat mencapai visualisasi *TMJ* dengan tujuan membandingkan kondilus agar mengetahui interpretasi fungsi sendi dilakukan beberapa pemeriksaan antara lain ; pemeriksaan radiografi panoramik, akan tetapi panoramik tidak dapat mengungkapkan status fungsional sendi dan memiliki spesifitas yang relatif rendah dibandingkan dengan *CT*. Dikarenakan posisi kepala yang dapat mempengaruhi citra *TMJ*. Computed tomography merupakan metode terbaik untuk menilai kondisi patologis tulang *TMJ*, karena dapat merekonstruksi multi planar (*sagital*, *coronal*, *aksial*) dari struktur *TMJ* secara 3D. Tanda-tanda dari perubahan degeneratif pada sendi seperti ; erosi, osteofit, remodeling, sklerosis subkortikal, pendataran permukaan artikular dapat dievaluasi menggunakan *CT*. Pada *CT Scan* posisi dan bentuk kondilus mandibula di fossa glenoidalis terlihat jelas. Akan tetapi *CT Scan* tidak dapat digunakan sebagai metode diagnostik utama untuk melihat diskus dikarenakan memerlukan injeksi media kontras pada sendi(arthrography) yang dimana hal ini bersifat invasif, nyeri dan reaksi alergi. Kerugian *CT Scan* dibandingkan dengan metode radiologi lainnya yaitu biaya yang tinggi dan paparan radiasi. Sebagai metode refrensi, *MRI* lebih diunggulkan dalam pencitraan struktur jaringan lunak *TMJ*(diskus artikular, membran sinoval, otot pterigoid lateral) hal ini juga membuat *MRI* ditunjuk sebagai modalitas pencitraan terbaik dalam mendeteksi tanda-tanda awal disfungsi *TMJ* (ruptur jaringan retrodiscal, perubahan bentuk diskus efulsi sendi, serta penebalan pita anterior maupun *posterior*). *MRI* dapat menghasilkan gambar dari semua bidang (*sagital*, *aksial*, *coronal*). Kerugian dari penggunaan *MRI* yaitu, mahal dan memakan waktu,

penggunaan terbatas pada pasien dengan claustrophobia, ada kemungkinan kehilangan bagian dari kondilus memiliki kista semu, mungkin melewatkan kondisi tulang dan jaringan lunak yang berbeda. *Ultrasonografi* resolusi tinggi berguna dalam menggambarkan perpindahan dan efusi diskus. Penggunaan transduser setidaknya 7,5 MHz atau lebih tinggi. *USG* merupakan salah satu prosedur non-invasif, murah, dinamis. Namun tidak umum digunakan atau tidak direkomendasikan dalam pemeriksaan *TMJ* dikarenakan kesulitan untuk mendapatkan gambar yang jelas, terutama pada posisi mulut terbuka karena struktur tulang di atasnya. Serta bagian medial dari disk tidak dapat divisualisasikan. Maka pemeriksaan menggunakan *USG* resolusi tinggi sangat bergantung dengan keterempilan pemeriksa dan alat yang digunakan.

Menurut jurnal Asim K Bag dkk, 2014 menunjukan bahwa Evaluasi sendi temporomandibular secara klinis tidak spesifik karena adanya tumpang tindih gejala yang ditimbulkan antara gangguan internal dan nyeri yang ditimbulkan akibat disfungsi myofacial. *MRI* harus menjadi bagian dari evaluasi standar ketika diduga terdapat kelainan struktural sendi internal karena *MRI* dapat memberikan resolusi tinggi dan kontras jaringan yang besar. Hal ini memungkinkan untuk mengevaluasi secara rinci anatomi serta biomekanika sendi melalui pencitraan baik mulut pada posisi terbuka maupun tertutup. *CT* berguna untuk mengevaluasi unsur-unsur tulang sendi temporomandibular serta soft tissue disekitarnya. *CT* sangat ideal digunakan untuk mengevaluasi fraktur, perubahan degeneratif, erosi, infeksi, invasi tumor, serta anomali kongenital. Sebuah protokol pencitraan yang khas adalah: 120 kV, 100 mA, 1 mm collimation, 1 mm / rotasi (pitch), dan pencitraan pada posisi mulut tertutup. *CT* juga memungkinkan rekonstruksi 3D, yang dapat digunakan untuk mengevaluasi anomali kongenital dan patah tulang. *CT* dominan dilakukan bila ada kecurigaan keterlibatan tulang yang dilihat menggunakan *MRI* dan jika diduga secara klinis terdapat kelainan primer pada tulang. Keuntungan relatif *CT* jika dibandingkan

dengan *MRI* meliputi, rincian tulang lebih baik dan penilaian 3D dari kondisi kongenital, trauma dan pasca operasi. Radiografi Konvensional memiliki peran terbatas dalam evaluasi *TMJ*, dikarenakan tidak memberikan informasi mengenai elemen non-tulang(tulang rawan), jaringan lunak, efusi sendi yang terkait dengan nyeri sendi atau perpindahan diskus. Serta masalah superposisi struktur tulang. Radiografi Konvensional lebih cocok digunakan dalam pemeriksaan tulang saja. *USG* merupakan pencitraan yang lebi ih mudah dilakukan untuk digunakan mengevaluasi sendi temporomandibular. Ini adalah cara sederhana untuk mencari adanya efusi sendi. *USG* juga digunakan untuk mengevaluasi pencitraan tulang rawan serta perpindahan diskus baik pada mulut terbuka maupun tertutup. Hal ini digunakan untuk image-guided injection baik untuk tujuan diagnostik maupun terapeutik. Biasanya, transduser linier 8 MHz atau lebih sangat ideal. Pasien harus berbaring telentang dengan transducer ditempatkan sejajar garis memanjang dari tragus telinga ke permukaan lateral hidung melalui sendi temporomandibular

Menurut jurnal Ferreira L. A. dkk, 2016 menunjukkan bahwa peranan pencitraan diagnostik *TMJ* untuk menegakan diagnosa perlu diperhatikan beberapa hal antara lain dengan memiih pemeriksaan evaluasi berdasarkan keakuratan, keamanan, dan relevansi klinisnya. Keputusan ini bertujuan untuk dapat membantu menghasilkan diagnosis yang akurat dan rencana perawatan yang optimal dan modalitas yang dianggap sebagai standar emas untuk pemeriksaan *TMJ* yaitu *computed tomography* dan *magnetic resonance imaging* dikarenakan dapat mengevaluasi jaringan keras dan lunak.

Menurut penulis pencitraan diagnostik yang paling efektif dan efisien dalam menganalisis kelainan serta membantu dalam penengakan diagnosa pada *Temporomandibular Joint* yaitu *CT* dan *MRI*. Hal ini sesuai dengan teori yang di sampaikan oleh Boddinghaus R dan Whyte A (2013), di mana *CT Scan* dipandang sebagai modalitas untuk menilai hanya patologi

tulang dan klasifikasi *TMJ,* dengan memperhatikan teknik dan pembacaan interaktif dengan penampil *DICOM* maka *CT Scan* merupakan modalitas yang sangat baik dalam mengevaluasi berbagai patologi pada *TMJ* . sedangkan *MRI* dikontraindikasikan jika dalam pengaturan trauma dan lesi tulang primer menjadi modalitas pilihan. Pemeriksaan *Temporomandibular Joint* dengan memggunakan *CT* dan *MRI* mempunyai peran serta keuntungan dan kerugian. Keuntungan relatif *CT* meliputi, detail tulang yang sangat baik dan penilaian *3D* dari kondisi kongenital, traumatis, dan pascaoperasi. Kerugian utama *CT*, dibandingkan dengan metode radiologi lainnya, adalah biaya tinggi dan paparan radiasi. Sedangkan *MRI* memiliki keuntungan utama termasuk mendeteksi perubahan jaringan lunak, nekrosis, edema, ada atau tidak adanya invasi, dan kurangnya paparan radiasi pengion. Kekurangannya terkait dengan biaya yang mahal dan kebutuhan akan fasilitas yang canggih. Ini dikontraindikasikan pada pasien klaustrofobia, mereka yang memiliki alat pacu jantung dan katup jantung logam, benda asing feromagnetik, dan wanita hamil.

Penulis mengharapkan dengan dilakukannya literature *review* pada peranan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint* dapat menambah pengetahuan mengenai pemilihan modalitas yang tepat bagi penderita berdasarkan setiap jenis peranan pencitraan diagnostik mengenai kekurangan dan kelebihan setiap modalitas.

BAB VI
PENUTUP

6.1 Kesimpulan

Berdasarkan analisis data dari ketiga jurnal yang ditulis oleh Talmaceanu Daniel dkk, (2018), Asim K Bag dkk, 2014, Ferreira L. A. dkk, 2016 mengenai peranan pencitraan berbagai modalitas radiologi pada pemeriksaan *Temporomandibular Joint*, penulis menyimpulkan bahwa peranan dari radiografi konvensional yaitu untuk menampakan atau mengevaluasi elemen tulang saja, dikarenakan struktur tulang yang superposisi serta penggunaan film bidang datar untuk patologi *TMJ* tidak cukup, maka diperlukan gambaran atau pencitraan tiga dimensi. *CT Scan* merupakan pemeriksaan yang paling effisien untuk mendeteksi terjadinya perubahan jaringan keras(tulang) serta jaringan lunak yang berdekatan, dikarenakan memungkinkan untuk rekonstruksi *3D* , sedangkan pemeriksaan *MRI* yang menjadi metode pilihan untuk melihat jaringan lunak sendi *TMJ* seperti; diskus artikular, ligamen, jaringan retrodiscal, konten sinoval, dan medulla komponen tulang.

6.2 Saran

Berdasarkan hasil dari pembahasan, saran yang dapat penulis sampaikan mengenai Tugas Akhir Studi *Literatur* ini yaitu sebaiknya dilakukan pemilihan pencitraan yang tepat, dan sesuai dengan klinis yang di derita dikarenakan kompleksitas struktur anatomi beserta klinis. Sehingga hasil diagnosa yang didapatkan lebih optimal.

DAFTAR PUSTAKA

Aiken, A., Bouloux, G., & Hudgins, P. (2012). MR Imaging of the *Temporomandibular Joint*. Magnetic Resonance Imaging Clinics of North America, 20(3), 397–412.

Alonso, M. B. C. C., Gamba, T. O., Lopes, S. L. P. C., Cruz, A. D., Freitas, D. Q., & Haiter-Neto, F. (2014). Magnetic resonance imaging of the *Temporomandibular Joint* acquired using different parameters. Journal of MorphologicalSciences,31(2),103–109.

Ashley Aiken, M., Gary Bouloux, M., DDS, & Patricia Hudgins, M. (2012). MR Imaging of The *Temporomandibular Joint*.

Bag, A. K., Gaddikeri, S., Singhal, A., Hardin, S., Tran, B. D., Medina, J. A., & Curé, J. K. (2014). Imaging of The Temporomandibular Joint : An Update

Bapeten, (2020) Peraturan Badan Pengawas Tenaga Nuklir Republik Indonesia Nomor 4 Tahun 2020 Tentang Keselamatan Radiasi Pada Penggunaan Pesawat Sinar-X Dalam Radiologi DIagnostik Dan Intervensional.

Ferreira L. A., Grossmann E., Januzzi E., Queiroz de Paula V. M., Carvalho P. C. A., (2016). Diagnosis Of Temporomandibular Joint Disorders: Indication Of Imaging Exams

https://www.researchgate.net/publication/335579550_Gejala_klinis_dan_faktor_penyebab_kelainan_temporomandibular_joint_pada_kelas_I_oklusi_angleClinical_symptoms_and_aetiological_fa*CT*ors_of_temporomandibular_joint_abnormalities_in_class_I_angle_occlusi

Lampignano, John P. dan Leslie e. Kendrick. 2018. Lampignano dan Kendrick's Textbook of Radiographic Positioning and Related Anatomy. Edisi 9th. St. Louis: Elseiver.

Malik, A. (2014). Internal derangement of *Temporomandibular Joint*: role of arthocentesis with steriod. Plastic and Aesthetic Research, 1(1), 29– 32.

Okeson, J. P. (2013). Management of Temporomandibular Disorders and Occlusion (6 ed.). St Louis, Missouri: Mosby Inc.

Priaminiarti Menik, Alhamid Achmad. Dan Iskandar Hanna B.(Pembaruan 2015). Berbagai Pencitraan Radiograafik Sendi Temporo Mandibula. Jakarta

Riawan L. Kasim A. dan Isnandar. 2012. Diagnosa Dan Perawatan Dislokasi Kondilus Mandibula Ke Anterior

Saleh Edwyn. Penanganan Temporomandibular Disorder Non Bedah

Supartiningsih, 2017 Medicoeticolegal dan Manajemen Rumah Sakit, 6 (1): 9-15, Januari 2017 tentang Kualitas Pelayanan dan Kepuasan Pasien Rumah Sakit Pada Kasus Pasien Rawat Jalan

Tanti Ira dan Susanti Laura.(Pembaruan). Penatalaksanaan Keterbatasan Gerak Mandibula Akibat Fraktur Kondilus Dengan Splin Reposisi

Talmaceanu D., Lenghel M. L., Bolog N., Hedesiu M., Buduru S., Rotar H., Baciut M., Bcaiut H. (2018). Imaging Modalities For Temporomandibular Joint Disorder: An Update

Lampiran 1

Formulir Ekstraksi

Tabel 1 Formulir Ekstraksi Jurnal 1

Tipe artikel	Clujul Medical
Nama peneliti	Talmaceanu Daniel, Laviniamanuelalenghel, Nicolae Blog, Smarandabuduru, Rotary Horatif, Mihaelabaciut, Baciut Grigore.
Tahun terbit jurnal	2018
Judul	*Imaging Modalities For Temporomandibular Joint Disorders: An Update*
No ISSN/ISBN	doi: 10.15386/cjmed-970
Cakupan jurnal	Internasional
Tujuan penelitian	-
Kata kunci	*Temporomandibular Joint, temporomandibular disorders, computed tomography, magnetic resonance imaging, ultrasonography*
Metode penelitian	-
Hasil penelitian	Pemilihan teknik radiologi yang tepat untuk *TMJ* diperlukan ,serta pasien harus dilakukan dengan hati-hati oleh praktisi, dalam kaitannya dengan tanda dan gejala klinis. Tujuan pemeriksaan radiologis yang dipilih harus meningkatkan diagnosis dan hasil pengobatan sesuai dengan indikasi spesifik setiap pemeriksaan pencitraan dan berbagai tingkat sensitivitas dan spesifitas. *CT* dan *MRI*, saat ini, adalah teknik pencitraan yang palig banyak digunakan. *CT* adalah pemeriksaan yang paling effisien dalam mendeteksi perubahan tulang, sedangkan *MRI* tetap menjadi standar emas untuk pemeriksaan diskus artikular. *Ultrasonografi* resolusi tinggi adalah teknik diagnostik pencitraan yang menjanjikan dalam menilai posisi diskus *TMJ*.

Tabel 2 Formulir Ekstraksi Jurnal 2

Tipe artikel	*World Journal of Radiology*
Nama peneliti	Asim K Bag, Santhos Gaffikeri, Aparna Singhal, Simms Hardin, Benson D Tran, Josue A Medina, dan Joel K Curé
Tahun terbit jurnal	2014
Judul	*Imaging of the Temporomandibular Joint: An update.*
No ISSN/ISBN	1949-8470
Cakupan jurnal	Internasional.
Tujuan penelitian	-.
Kata kunci	*Temporomandibular Joint; Magnetic resonance imaging; Imaging; Computed tomography; Anatomy; Pathologies.*
Metode penelitian	-
Hasil penelitian	Pencitraan *TMJ* harus dilakukan berdasarkan kasus per kasus tergantung pada tanda dan gejala klinis. *MRI* adalah studi diagnostik pilihan untuk evaluasi posisi diskus dan gangguan internal sendi. *CT scan* untuk evaluasi *TMJ* diindikasikan jika keterlibatan tulang dicurigai dan harus dipertimbangkan secara bijaksana karena risiko radiasi. Pemahaman tentang anatomi *TMJ*, biomekanik, dan manifestasi pencitraan penyakit penting untuk mengenali dan mengelola berbagai patologi ini secara akurat.

Tabel 3 Formulir Ekstraksi Jurnal 3

Tipe artikel	*BRAZILIAN JOURNAL OTORHINOLARINGOLOGI*
Nama peneliti	Luciano Ambrosio Ferreira, Edward Grossmann, Eduardo Januzzi, Marcos Vinicius Queiroz de Paula, dan Antoni Carlos Pires Carvalho
Tahun terbit jurnal	2016
Judul	*Diagnosis Of Temporomandibular Joint Disorders: Indication Of Imaging Exams*
No ISSN/ISBN	1808-8694
Cakupan jurnal	Internasional
Tujuan penelitian	-
Kata kunci	*Temporomandibular Joint disorders; Diagnostic imaging; Temporomandibular Joint; Magnetic resonance imaging; X-ray computed tomography; Radiography*
Metode penelitian	tinjauan literatur di database Web of Knowledge, PubMed dan SciELO.
Hasil penelitian	*Computed Tomography* dan *Magnetic Resonance Imaging* dianggap sebagai penilaian standar untuk sendi temporomandibular untuk mengevaluasi jaringan keras dan lunak. Setiap metode diagnostik menunjukkan sensitivitas dan spesifikasi yang berbeda untuk berbagai subtype disfungsi sendi.

Dental Medicine

DOI: 10.15386/cjmed-970

IMAGING MODALITIES FOR TEMPOROMANDIBULAR JOINT DISORDERS: AN UPDATE

DANIEL TALMACEANU[1], LAVINIA MANUELA LENGHEL[2], NICOLAE BOLOG[3], MIHAELA HEDESIU[2], SMARANDA BUDURU[4], HORATIU ROTAR[1], MIHAELA BACIUT[1], GRIGORE BACIUT[1]

[1]Department of Cranio-Maxillofacial Surgery, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania
[2]Department of Radiology, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania
[3]Phoenix Swiss Med GmbH, Switzerland
[4]Department of Prosthodontics, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania

Abstract

The diagnosis and management of temporomandibular disorders (TMD) require both clinical and imaging examinations of the temporomandibular joint (TMJ). A variety of modalities can be used to image the TMJ, including magnetic resonance imaging (MRI), computed tomography (CT), cone beam CT, ultrasonography, conventional radiography. The present review outlines the indications of the most frequently used imaging techniques in TMD diagnosis.

Because of the anatomic complexity of the TMJ, imaging can be difficult. Choosing the proper imaging technique is essential. Conventional radiography, nowadays, is of limited interest. The use of flat plane films for TMJ pathology is not sufficient, because this joint requires three dimensional imaging views. Osseous changes are better visualized with CT and cone beam CT. Cone beam CT provides high-resolution multiplanar reconstruction of the TMJ, with a low radiation dose, without superimposition of the bony structures. MRI is a noninvasive technique, considered to be the gold standard in imaging the soft tissue components of the TMJ. MRI is used to evaluate the articular disc in terms of location and morphology. Moreover, the early signs of TMD and the presence of joint effusion can be determined. High-resolution ultrasonography is a noninvasive, dynamic, inexpensive imaging technique, which can be useful in diagnosing TMJ disc displacements. The diagnostic value of high-resolution ultrasonography is strictly dependent on the examiner's skills and on the equipment used.

Keywords: temporomandibular joint, temporomandibular disorders, computed tomography, magnetic resonance imaging, ultrasonography

Temporomandibular joint anatomy

The temporomandibular joint (TMJ) is a synovial joint whose common features are represented by a disc, two bones, a fibrous capsule, intra-articular fluid, a synovial membrane and ligaments [1]. The articular disc, a biconcave structure composed of dense fibrous connective tissue, is divided into a thicker anterior and posterior band and a thinner intermediate zone. Posteriorly, the disc is attached to the temporal bone by the retrodiscal tissue (bilaminar zone), highly vascularized and innervated. Anteriorly, the superior belly of lateral pterygoid muscle inserts onto the disc [2,3] (Figure 1).

Manuscript received: 23.01.2018
Received in revised form: 05.02.2018
Accepted: 13.02.2018
Address for correspondence: danieltalmaceanu@yahoo.com

Figure 1. Temporomandibular joint anatomy: GF - glenoid fossa; C - mandibular condyle; D - articular disc; RT - retrodiscal tissue; LPM - lateral pterygoid muscle.

The TMJ is a ginglymoarthrodial joint, allowing a hinge-like movement, combined with an arthroidial, gliding motion. The hinge-like movement represents the first half of the mouth opening, whereas the sliding movement represents the second half, as well as the protrusion and lateral movements [4].

Temporomandibular joint pathology

TMJ pathology is complex and includes temporomandibular disorders (TMD), infections, tumors, traumatic lesions and growth development anomalies.

TMD is defined by the American Academy of Orofacial Pain (AAOP) as a complex term covering a number of clinical problems involving the masticatory muscles, the joint and the associated structures. The AAOP classifies the TMD in two groups: muscular and articular. The most common clinical signs of TMD are represented by pain, limited mouth opening and joint sounds (clicking, crepitation) [5]. In 2014, Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), clearly defined the different internal derangement conditions. According to RDC/TMD, two different degrees of displacement of the disc relative to the condyle exist: disc displacement with reduction and disc displacement without reduction [6].

The Piper disc classification [7] is also useful when dealing with internal derangements:1) Normal; 2) Ligaments or cartilage damage; 3a) Partial disc subluxation, with reduction; 3b) Partial disc subluxation, non-reducing; 4a) Complete disc dislocation, with reduction; 4b) Complete disc dislocation, non-reducing; 5a) No disc, bone to bone-adapting; 5b) No disc, bone to bone- adapted.

Temporomandibular joint imaging

Although the clinical examination is the most important step in the diagnosis of TMJ pathology, special imaging techniques are needed due to the complex anatomy and pathology. It is very common to take an image of the joint when there is locking, pain and articular sounds. The clinician should properly decide which patients would need special imaging techniques depending on the clinical examination and individual selection criteria. One important thing to consider when imaging the TMJ is the interpretation of the joint function, which can be accomplished by comparing the condyle in the closed and opened mouth position. Several imaging techniques are available for TMJ visualization, as follows.

Panoramic radiography

It shows the jaws and the associated structures, being a helpful tool for the clinician in identifying any periodontal or odontogenic causes for orofacial pain. Panoramic radiography does not appear in the list of imaging techniques provided by RDC/TMD. Only the lateral part of the condyle can be assessed with this technique, being limited due to the superimposition of the zygomatic arch and the base of the skull [8]. Panoramic radiography can help evaluate the following:

- degenerative bone changes (only in late stages; it is inadequate for the early detection of osseous modifications);
- asymmetries of the condyles (Figure 2);
- hyperplasia, hypoplasia;
- trauma;
- tumors.

The panoramic radiography does not reveal the functional status of the joint and has a relatively low specificity and sensitivity when compared with CT [8,9]. Epstein et al [10] consider the clinical findings of greater relevance than panoramic images for patients with TMD. Nevertheless, some authors have suggested panoramic radiography as a good imaging modality for TMJ visualization [11]. Although morphological abnormalities of the condyle can be assessed with panoramic radiography, they do not necessarily represent a sign of TMD [12]. Variations of condylar shape are present among individuals. Moreover, changes in head position could affect the image of TMJ, simulating different bone abnormalities (flattening, osteophytes, asymmetries) [13]. Dahlstrom et al. [14] concluded that panoramic radiography is useful in detecting bony changes of the condyle, but when these changes are suspected, and the radiography is normal, CT should be performed.

Figure 2. Panoramic radiography: important asymmetry between right and left mandibular condyle.

Plain radiography

Consists of transcranial projection of TMJs. Different angulations are used to avoid the superposition of the temporal bone and the opposite TMJ: lateral oblique transcranial projections, anterior-posterior projections, submental-vertex projection, transpharyngeal view (Figure 3) [15]. Contact technique introduced by Parma is not recommended due to high radiation dose and superposition of bony structures (Figure 4). Plain radiography is useful in depicting degenerative joint disease in advanced stages [15]. The condyle position could also be assessed, but large variations of condyle position in the glenoid fossa were found, even in asymptomatic population [16,17]. Some studies have shown that the position of the condyle in the fossa is of little clinical significance [18]. Other studies suggest that the posterior position of the mandibular condyle in regard to the fossa, could represent an indirect sign of an anterior disc displacement [19-22]. The position of the head during the examination could influence the joint space, which could influence the interpretation of the radiography [23]. The use of flat plane films for TMJ pathology is not sufficient, because this joint requires three dimensional imaging views. CT has been reported to be more suitable in identifying TMJ changes than conventional radiography [15].

Computed tomography (CT)

First used for TMJ evaluation in 1980 [24], CT is considered to be the best method for assessing osseous pathologic conditions of TMJ. It allows a multi planar reconstruction (sagittal, axial, coronal) of TMJ structures, obtaining 3D images in closed and opened-mouth positions. Signs of degenerative changes in the joint, like surface erosions, osteophytes, remodeling, subcortical sclerosis, articular surface flattening can be evaluated using CT [15]. Some studies have reported that radiographic changes in the joint are not always related to pain [15,25,26]. Therefore, some patients with osseous abnormalities may experience pain, others may be pain free. Changes in the shape and location of the loading zone can also be seen on CT. CT is the main radiological investigation for tumors, growth development anomalies and fractures (Figure 5). Basically, any CT examination of the TMJ should focus on the following: intactness of the cortex, normal size and shape of the condyles and their centered position in the fossa, the adequate joint spaces, centric relation loading zone.

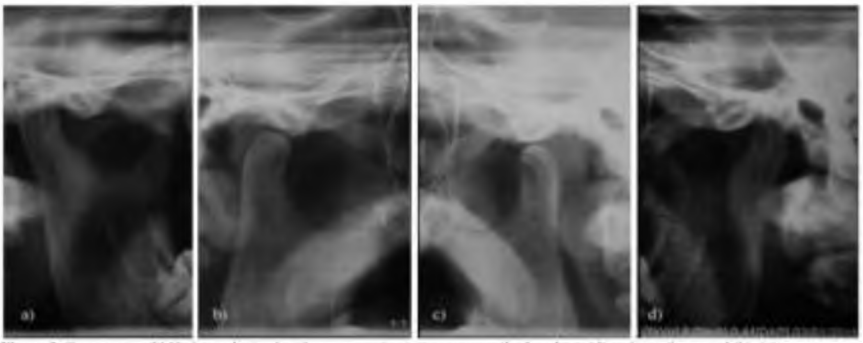


Figure 3. Comparative TMJ views obtained with a panoramic equipment: mouth-closed (a), (d) and mouth-opened (b), (c).

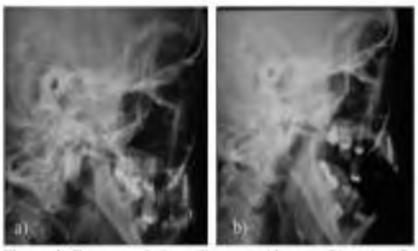


Figure 4. Contact technique (Parma incidence) of imaging the TMJ: mouth-closed (a), mouth-opened (b).

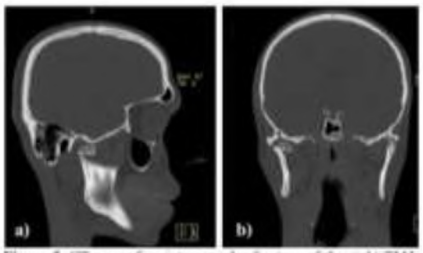


Figure 5. CT scan of an intracapsular fracture of the right TMJ. Sagittal plane (a), coronal plane (b).

Autopsy studies performed for the assessment of condylar abnormalities showed better results for CT than MRI [27]. Wesetesson et al. [28] found a sensitivity of 75 % and a specificity of 100% for the diagnosis of condylar bony changes. Regarding the visualization of the soft tissues of TMJ (disc, synovial membrane, ligaments, lateral pterygoid muscle), CT is not used as a primary diagnostic method. The disc could be visualized on CT scans only with injection of contrast media in the joint (arthrography). Arthrography is a dynamic investigation, but was never widely used, due to its invasiveness, pain and allergic reactions [29]. TMJ disc pathology and lateral pterygoid muscle pathology is better assessed with MRI. On CT scans, the position and the shape of the mandibular condyle in the glenoid fossa is well seen, though some authors suggest that this reference is not a precise sign of disc pathology [16-18,30].

The main disadvantage of CT, compared to other radiological methods, is the high cost and the radiation exposure. Being introduced in TMJ evaluation in 1990s, cone beam CT (Figures 6 and 7) is widely available now and provides high-resolution multiplanar reconstruction of the TMJ [31,32]. The main advantage of cone beam CT, compared to CT, is the lower radiation dose to the patient [33-35]. The spatial resolution of cone beam CT is higher than that of conventional CT [36,37]. Studies developed by Hintze et al. [38] found no significant differences between conventional tomography and cone beam CT in the detection of morphological TMJ changes. Cone beam CT performs better than conventional radiography and is as good as conventional CT, allowing to depict early bony changes of TMJ [39,40]. A review published by Silvia Caruso et al [41] pointed out the main contributions of cone beam CT in the field of TMJ:

- allows the calculation of volume and surface of the condyle;
- improves qualitative analyses of condylar surface and allows detecting the mandibular condyle shape;
- improves the accuracy of linear measurements of mandibular condyle;
- clarifies that, in case of facial asymmetry, the condyles are often symmetric, while joint space can change between the two sides;
- clarifies the position of the condyle in the fossa.

Although CT provides important information regarding the osseous components of TMJ, it has several limitations, like the artefact which can appear due to the patient's accidental movement during examination (especially in children). Also, a decrease in radiation dose (for cone beam CT) can affect the image quality [32-38].

Magnetic resonance imaging (MRI)

MRI is currently considered the reference method for imaging the soft tissue structures of the TMJ (articular disc, synovial membrane, lateral pterygoid muscle) and has been pointed out as the best imaging modality in diagnosing disc displacements [15,24,42-45]. MRI could also detect the early signs of TMJ dysfunction, like thickening of anterior or posterior band, rupture of retrodiscal tissue, changes in shape of the disc, joint effusion [46].

Images can be obtained in all planes (sagittal, axial, coronal). In most scanning sequences, T1 weighted, T2 weighted and proton-density (PD) images are obtained. The PD images serve to visualize the disc-condyle relationship (Figure 8), while T2-weighted images are used in diagnosing inflammation in the joint [47,48]. The slice thickness is important for image quality. The most frequent used section thickness is 3 mm. Reducing the slice thickness improves the quality of the images, but requires longer scanning time [45].

An axial localizing image is used to direct the long axis of the condyle in the closed-mouth position. Sagittal images are obtained perpendicular to the long axis of the condyle, and coronal images are obtained parallel to the long axis [49].

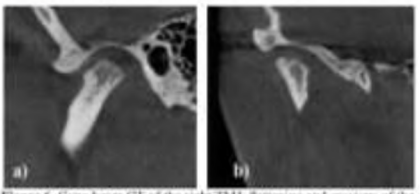


Figure 6. Cone beam CT of the right TMJ: flattening and erosions of the mandibular condyle. Sagittal plane (a), coronal plane (b).

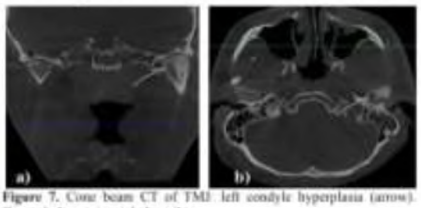


Figure 7. Cone beam CT of TMJ: left condyle hyperplasia (arrow). Coronal plane (a), axial plane (b).

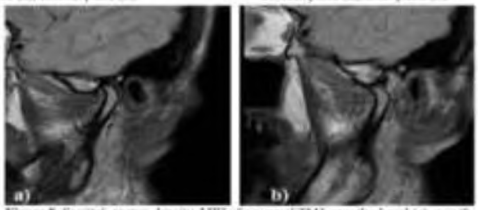


Figure 8. Sagittal, proton density, MRI of a normal TMJ: mouth-closed (a), mouth-opened (b). The disc (arrow) is in a correct position.

In MRI examination, a pathological condition is considered to be present relative to the intermediate zone of the meniscus (as a point of reference) and its interposition between the condyle and the temporal bone (Figure 9) [50]. Normal disc position, evaluated in the sagittal plane, is with the junction of posterior band aligned approximately at 12 o'clock, position relative to the condyle. Disc displacement is diagnosed when the posterior band sits in an anterior, posterior, medial or lateral position with regard to the condylar surface [51]. In the closed-mouth position, teeth should be in contact, whereas in the opened-mouth position, the jaw should be at the widest comfortable opening. This way, misinterpreted disc positions could be avoided [52].

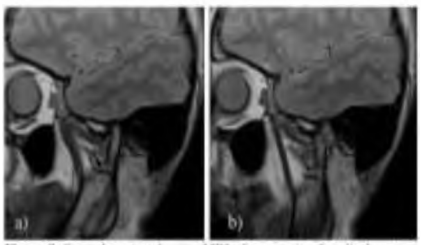


Figure 9. Sagittal, proton density, MRI of an anterior disc displacement with reduction: mouth-closed (a), mouth-opened (b). The displaced disc (arrow) returns to its normal position at maximal mouth opening.

Being a synovial joint, synovitis is a common situation and it is characterized by swelling due to hypertrophy of the synovia and overproduction of synovial fluid. Synovitis can be clearly visualized on MRI images [53]. Synovial inflammation could lead to joint effusion, defined as an increase in the volume of intra-articular fluid (Figure 10).

Figure 10. Sagittal, T2 weighted, MRI of a TMJ effusion.

Some studies have investigated the relationship between the articular eminence morphology and disc patterns in patients with disc displacements. The results showed that changes in the morphology of articular eminence (flattened) and disc could contribute to the appearance of disc displacement without reduction on that side [54]. Other studies also found changes in disc shape and dimension in cases of TMJ disc displacement [55].

Among the disadvantages of the MRI investigation, the following can be mentioned:

- it is costly and time consuming;
- restricted use in patients with claustrophobia;
- there is a possibility of missing the portion of condyle having a pseudo cyst [56];
- may miss different bone conditions and soft tissue calcifications with inflammatory diseases or tumors; in these cases, CT is the preferable imaging modality [57].

High-resolution ultrasonography

High-resolution ultrasonography (US) was first used for TMJ exploration in 1991, by Nabeih et al, using a 3.5 MHz transducer [58]. Although it is a non-invasive, dynamic, inexpensive procedure, it is not commonly used in TMJ exploration. Being a real time investigation, it provides information about disc position, during mouth opening [59]. In the literature, contradictory levels of sensitivity and specificity were reported. These variable levels of sensitivity and specificity reported by the articles may be due to the different equipment used (different US frequencies). The use of high-resolution US (transducer at least 7.5 MHz or higher) significantly increases the diagnostic value of this technique [60,61].

US examination is useful in depicting disc displacement and effusion. Normally, the disc is situated between two hyperechoic lines represented by the mandibular condyle and the articular eminence. If the disc is displaced in the closed-mouth position, the diagnosis is disc displacement. If the disc returns to its normal position during opening, the diagnosis is disc displacement with reduction (Figure 11). If not, the diagnosis is disc displacement without reduction (Figure 12) [59,62-64]. Regarding degenerative changes of the TMJ, US is still not recommended [65]. One difficulty of US is the possibility to obtain clear images, especially in the opened-mouth position, due to the overlying osseous structures. Another limitation of US is that the medial part of the disc cannot be visualized [59-65].

The diagnostic value of high-resolution US is strictly dependent on the examiner's skills and on the equipment used. Therefore, there is a continuous need for trained and experienced radiologists in this field.

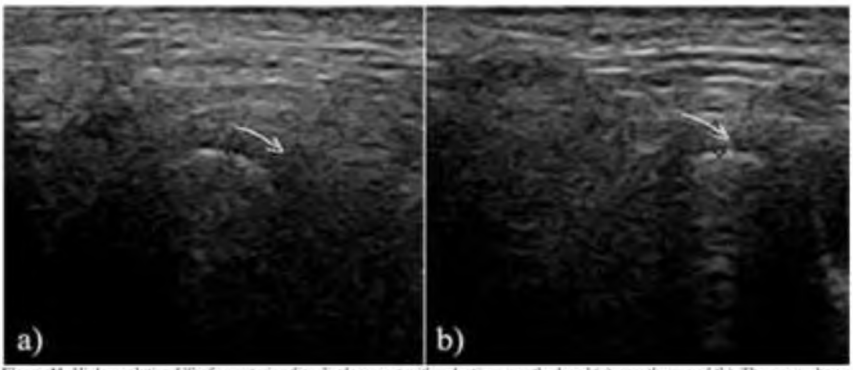


Figure 11. High-resolution US of an anterior disc displacement with reduction: mouth-closed (a), mouth-opened (b). The arrow shows the displaced disc.

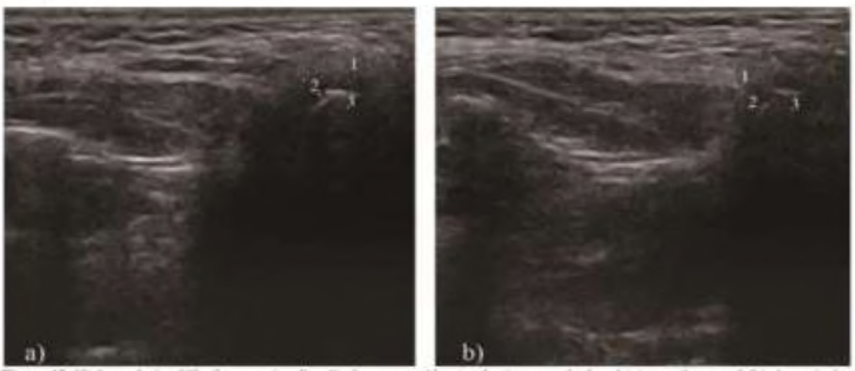


Figure 12. High-resolution US of an anterior disc displacement without reduction: mouth-closed (a), mouth-opened (b). 1 - articular eminence; 2 – articular disc; 3 - mandibular condyle.

Conclusions

The selection of the proper radiological technique for TMJ, as well as of the patient, must be carefully made by the practitioner, in correlation with the clinical signs and symptoms. The purpose of the chosen radiological investigation must improve the diagnosis and the treatment outcome according to each imaging examination's specific indications and varying degrees of sensitivity and specificity. CT and MRI are, nowadays, the most used imaging techniques. CT is the most efficient examination in detecting the osseous changes, whereas MRI remains the gold standard for the articular disc examination. High-resolution ultrasonography is a potential promising imaging diagnostic technique in assessing the TMJ disc position.

Acknowledgements

We would like to thank dr. Medeea Talmaceanu for the drawing of the temporomandibular joint anatomy.

References

1. Okeson JP. Management of temporomandibular disorders and occlusion. 6th ed. St. Louis: Mosby; 2008, pp 5-21.
2. Shaffer SM, Brismée JM, Sizer PS, Courtney CA. Temporomandibular disorders. Part 1: anatomy and examination/ diagnosis. J Man Manip Ther. 2014;22:2-12.
3. Slavicek R. The masticatory organ: functions and dysfunctions. Gamma Meidizinisch-wissenschaftliche Fortbildungs- GmbH, Klosterburg, 2006, pp 60-66.
4. Alomar X, Medrano J, Cabratosa J, Clavero JA, Lorente M, Serra I, et al. Anatomy of the temporomandibular joint. Semin

Ultrasound CT MR. 2007;28(3):170-183.
5. De Leeuw R, Klasser G. Orofacial Pain: Guidelines for assessment, diagnosis and management. 5th ed. Chicago: Quintessence Publishing Co., Inc. 2013, pp 127-137.
6. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Group†. J Oral Facial Pain Headache. 2014;28:6–27.
7. Droter JR. An orthopaedic approach to the diagnosis and treatment of disorders of the temporomandibular joint. Dent Today. 2005;24(11):82, 84-88; quiz 88.
8. Ahmad M, Hollender L, Anderson Q, Kartha K, Ohrbach R, Truelove EL, et al. Research diagnostic criteria for temporomandibular disorders (RDC/TMD): development of image analysis criteria and examiner reliability for image analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(6):844-860.
9. Poveda-Roda R, Bagan J, Carbonell E, Margaix M. Diagnostic validity (sensitivity and specificity) of panoramic X-rays in osteoarthrosis of the temporomandibular joint. Cranio. 2015;33(3):189-194.
10. Epstein JB, Caldwell J, Black G. The utility of panoramic imaging of the temporomandibular joint in patients with temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2001;92(2):236-239.
11. Brooks SL, Westesson PL, Eriksson L, Hansson LG, Barsotti JB. Prevalence of osseous changes in the temporomandibular joint of asymptomatic persons without internal derangement. Oral Surg Oral Med Oral Pathol. 1992;73(1):118-122.
12. Crow HC, Parks E, Campbell JH, Stucki DS, Daggy J. The utility of panoramic radiography in temporomandibular joint assessment. Dentomaxillofac Radiol. 2005;34(2):91-95.
13. Ruf S, Pancherz H. Is orthopantomography reliable for TMJ diagnosis? An experimental study on a dry skull. J Orofac Pain. 1995;9(4):365-374.
14. Dahlström L, Lindvall AM. Assessment of temporomandibular joint disease by panoramic radiography: reliability and validity in relation to tomography. Dentomaxillofac Radiol. 1996;25(4):197-201.
15. Brooks SL, Brand JW, Gibbs SJ, Hollender L, Lurie AG, Omnell KA, et al. Imaging of the temporomandibular joint: a position paper of the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1997;83(5):609-618.
16. Pullinger AG, Hollender L, Solberg WK, Petersson A. A tomographic study of mandibular condyle position in an asymptomatic population. J Prosthet Dent. 1985;53:706-713.
17. Blaschke DD, Blaschke TJ. Normal TMJ bony relationship in centric occlusion. J Dent Res. 1981;60:98-104.
18. Paknahad M, Shahidi S, Iranpour S, Mirhadi S, Paknahad M. Cone-Beam Computed Tomographic Assessment of Mandibular Condylar Position in Patients with Temporomandibular Joint Dysfunction and in Healthy Subjects. Int J Dent. 2015;2015:301796. doi: 10.1155/2015/301796.
19. Paknahad M, Shahidi S. Association between mandibular condylar position and clinical dysfunction index. J Craniomaxillofac Surg. 2015;43(4):432-436.
20. Al-Rawi NH, Uthman AT, Sodeify SM. Spatial analysis of mandibular condyles in patients with temporomandibular disorders and normal controls using cone beam computed tomography. Eur J Dent. 2017;11(1):99-105.
21. Kurita H, Ohtsuka A, Kobayashi H, Hurashina K. A study of the relationship between the position of the condylar head and the displacement of the temporomandibular joint disk. Dentomaxillofac Radiol. 2001;30:162-165.
22. Ozawa S, Boering G, Kawata T, Tanimoto K, Tanne K. Reconsideration of the TMJ condylar position during internal derangement: comparison between condylar position on tomogram and degree of disk displacement on MRI. Cranio. 1999;17(2):93-100.
23. Smith SR, Matteson SR, Phillips C, Tyndall DA. Quantitative and subjective analysis of temporomandibular joint radiographs. J Prosthet Dent. 1989;62:456-463.
24. Baba IA, Najmuddin M, Shah AF, Yousuf A. TMJ Imaging: A review. International Journal of Contemporary Medical Research. 2016;3(8):2253-2256.
25. Sano T, Westesson PL, Larheim TA, Takagi R. The association of temporomandibular joint pain with abnormal bone marrow in the mandibular condyle. J Oral Maxillofac Surg. 2000;58:254-257.
26. Bertram S, Rudisch A, Innerhofer K, Pümpel E, Grubwieser G, Emshoff R. Diagnosing TMJ internal derangement and osteoarthritis with magnetic resonance imaging. J Am Dent Assoc. 2001;132:753-761.
27. Tanimoto K, Petersson A, Rohlin M, Hansson LG, Johansen CC. Comparison of computed with conventional tomography in the evaluation of temporomandibular joint disease: a study of autopsy specimens. Dentomaxillofac Radiol. 1990;19:21-27.
28. Westesson PL, Katzberg RW, Tallents RH, Sanchez-Woodworth RE, Svensson SA. CT and MR of the temporomandibular joint: comparison with autopsy specimens. AJR Am J Roentgenol. 1987;148:1165-1171.
29. Maffe MF, Heffez L, Campos M, Backus P, Kahen HL, Langer BG, et al. Temporomandibular joint: role of direct sagittal CT air-contrast arthrogram and MRI. Otorynogol Clin North Am. 1988;21:575-588.
30. Bonilla-Aragon H, Tallents RH, Katzberg RW, Kyrkanides S, Moss ME. Condyle position as a predictor of temporomandibular joint internal derangement. J Prosthet Dent. 1999;82(2):205-208.
31. Larheim TA, Abrahamsson AK, Kristensen M, Arvidsson LZ. Temporomandibular joint diagnostics using CBCT. Dentomaxillofac Radiol. 2015;44(1):20140235. doi: 10.1259/dmfr.20140235.
32. Talaat W, Al Bayatti S, Al Kawas S. CBCT analysis of bony changes associated with temporomandibular disorders. Cranio. 2016;34(2):88-94.
33. Hedesiu M, Baciut M, Baciut G, Nackaerts O, Jacobs R; SEDENTEXCT Consortium. Comparison of cone beam CT device and field of view for the detection of simulated periapical bone lesions. Dentomaxillofac Radiol. 2012;41(7):548-552.
34. Oenning AC, Jacobs R, Pauwels R, Stratis A, Hedesiu M, Salmon B; DIMITRA Research Group, http://www.dimitra.be. Cone-beam CT in paediatric dentistry: DIMITRA project position statement. Pediatr Radiol. 2017 Nov 15. doi: 10.1007/s00247-017-4012-9. [Epub ahead of print]
35. Almăşan OC, Băciuţ M, Hedeşiu M, Bran S, Almăşan H, Băciuţ G. Posteroanterior cephalometric changes in subjects with temporomandibular joint disorders. Dentomaxillofac Radiol. 2013;42(1):20120039. doi: 10.1259/dmfr.20120039.
36. Barghan S, Tetradis S, Mallya S. Application of cone beam

computed tomography for assessment of the temporomandibular joints. Aust Dent J. 2012;57 Suppl 1:109-118.
37. Krishnamoorthy B, Mamatha NS, Kumar VA. TMJ imaging by CBCT: Current scenario. Ann Maxillofac Surg. 2013;3(1): 80–83.
38. Hintze H, Wiese M, Wenzel A. Cone beam CT and conventional tomography for the detection of morphological temporomandibular joint changes. Dentomaxillofac Radiol. 2007;36:192-197.
39. Honda K, Larheim TA, Maruhashi K, Matsumoto K, Iwai K. Osseous abnormalities of the mandibular condyle: diagnostic reliability of cone beam computed tomography compared with helical computed tomography based on an autopsy material. Dentomaxillofac Radiol. 2006;35:152–157.
40. Honey OB, Scarfe WC, Hilgers MJ, Klueber K, Silveira AM, Haskell BS, et al. Accuracy of cone-beam computed tomography imaging of the temporomandibular joint: comparisons with panoramic radiology and linear tomography. Am J Orthod Dentofacial Orthop. 2007;132:429–438.
41. Caruso S, Storti E, Nota A, Ehsani S, Gatto R. Temporomandibular Joint Anatomy Assessed by CBCT Images. Biomed Res Int. 2017;2017:2916953. doi: 10.1155/2017/2916953.
42. Liedberg J, Panmekiate S, Petersson A, Rohlin M. Evidence-based evaluation of three imaging methods for the temporomandibular disc. Dentomaxillofac Radiol. 1996;25:234-241.
43. Petersson A. What you can and cannot see in TMJ imaging--an overview related to the RDC/TMD diagnostic system. J Oral Rehabil. 2010;37(10):771-778.
44. Petscavage-Thomas JM, Walker EA. Unlocking the jaw: advanced imaging of the temporomandibular joint. AJR Am J Roentgenol. 2014;203(5):1047-1058.
45. Bag AK, Gaddikeri S, Singhal A, Hardin S, Tran BD, Medina JA, et al. Imaging of the temporomandibular joint: An update. World J Radiol. 2014;6(8):567-582.
46. Tomas X, Pomes J, Berenguer J, Quinto L, Nicolau C, Mercader JM, et al. MR imaging of temporomandibular joint dysfunction: a pictorial review. Radiographics. 2006;26(3):765-781.
47. Kober C, Hayakawa Y, Kinzinger G, Gallo G, Yamamoto M, Sano T, et al. 3D-visualization of the temporomandibular joint with focus on the articular disc based on clinical T1-, T2-, and proton density weighted MR images. International Journal of Computer Assisted Radiology and Surgery 2007;2:203–210.
48. Sano T, Widmalm SE, Yamamoto M, Sakuma K, Araki K, Matsuda Y, et al. Usefulness of proton density and T2-weighted vs. T1-weighted MRI in diagnoses of TMJ disk status. Cranio. 2003;21(4):253–258.
49. Salé H, Bryndahl F, Isberg A. Temporomandibular joints in asymptomatic and symptomatic nonpatient volunteers: a prospective 15-year follow-up clinical and MR imaging study. Radiology. 2013;267:183–194.
50. Helms CA, Kaplan P. Diagnostic imaging of the temporomandibular joint: recommendations for use of the various techniques. AJR Am J Roentgenol. 1990;154:319–322.
51. Drace JE, Enzmann DR. Defining the normal temporomandibular joint: closed-, partially open-, and open-mouth MR imaging of asymptomatic subjects. Radiology. 1990;177:67-71.
52. Gibbs SJ, Simmons HC 3rd. A protocol for magnetic resonance imaging of the temporomandibular joints. Cranio. 1998;16(4):236-241.
53. Rocabado M. Arthrokinematics of the temporomandibular joint. Dent Clin North Am. 1983;27(3):573-594.
54. Hirata FH, Guimarães AS, Oliveira JX, Moreira CR, Ferreira ET, Cavalcanti MG. Evaluation of TMJ articular eminence morphology and disc patterns in patients with disc displacement in MRI. Braz Oral Res. 2007;21(3):265-271.
55. Almăşan OC, Hedeşiu M, Băciuţ G, Leucuţa DC, Băciuţ M. Disk and joint morphology variations on coronal and sagittal MRI in temporomandibular joint disorders. Clin Oral Investig. 2013;17(4):1243-1250.
56. Sinha VP, Pradhan H, Gupta H, Mohammad S, Singh RK, Mehrotra D, et al. Efficacy of plain radiographs, CT scan, MRI and ultra sonography in temporomandibular joint disorders. Natl J Maxillofac Surg. 2012;3(1):2–9.
57. Larheim TA. Current trends in temporomandibular joint imaging. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995;80(5):555-576.
58. Nabeih YB, Speculand B. Ultrasonography as a diagnostic aid in temporomandibular joint dysfunction. A preliminary investigation. Int J Oral Maxillofac Surg. 1991;20:182-186.
59. Talmaceanu D, Lenghel LM, Bolog N, Popa Stanila R, Buduru S, Leucuta DC, et al. High-resolution ultrasonography in assessing temporomandibular joint disc position. Med Ultrason. 2018;20(1):64-70.
60. Manfredini D, Guarda-Nardini L. Ultrasonography of the temporomandibular joint: a literature review. Int J Oral Maxillofac Surg. 2009;38:1229-1236.
61. Kundu H, Basavaraj P, Kote S, Singla A, Singh S. Assessment of TMJ disorders using ultrasonography as a diagnostic tool: a review. J Clin Diagn Res. 2013;7:3116-3120.
62. Jank S, Rudisch A, Bodner G, Brandlmaier I, Gerhard S, Emshoff R. High-resolution ultrasonography of the TMJ: helpful diagnostic approach for patients with TMJ disorders? J Craniomaxillofac Surg. 2001;29:366-371.
63. Jank S, Emshoff R, Norer B, Missmann M, Nicasi A, Strobl H, et al. Diagnostic quality of dynamic high-resolution ultrasonography of the TMJ--a pilot study. Int J Oral Maxillofac Surg. 2005;34:132-137.
64. Habashi H, Eran A, Blumenfeld I, Gaitini D. Dynamic high-resolution sonography compared to magnetic resonance imaging for diagnosis of temporomandibular joint disk displacement. J Ultrasound Med. 2015;34:75-82.
65. Emshoff R, Brandlmaier I, Bodner G, Rudisch A. Condylar erosion and disc displacement: detection with high-resolution ultrasonography. J Oral Maxillofac Surg. 2003;61:877-881.

Lampiran 3

World Journal of Radiology

Submit a Manuscript: http://www.wjgnet.com/esps/
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
DOI: 10.4329/wjr.v6.i8.567

World J Radiol 2014 August 28; 6(8): 567-582
ISSN 1949-8470 (online)

REVIEW

Imaging of the temporomandibular joint: An update

Asim K Bag, Santhosh Gaddikeri, Aparna Singhal, Simms Hardin, Benson D Tran, Josue A Medina, Joel K Curé

Asim K Bag, Aparna Singhal, Simms Hardin, Benson D Tran, Josue A Medina, Joel K Curé, Section of Neuroradiology, The Department of Radiology, School of Medicine, The University of Alabama at Birmingham, Birmingham, AL 35249-6830, United States

Santhosh Gaddikeri, Department of Radiology, University of Washington, SS-202 Seattle, WA 98195-7117, United States

Author contributions: Bag AK contributed to the arthritis, images and overall integrity, manuscript revision and final approval the manuscript; Gaddikeri S contributed to the internal derangement and manuscript revision; Singhal A contributed to the normal joint anatomy, anatomic variation and manuscript revision; Hardin S contributed to the anatomic variation and manuscript revision; Tran BD contributed to the deposition diseases and tumors, manuscript revision; Medina JA contributed to the imaging techniques, manuscript revision; Curé JK contributed to the images, overall integrity, manuscript revision and final approval.

Correspondence to: Asim K Bag, Assistant Professor, Section of Neuroradiology, The Department of Radiology, School of Medicine, The University of Alabama at Birmingham, JT N432, 619 19th Street South, Birmingham, AL 35249-6830, United States. absg@uabmc.edu
Telephone: +1-205-9349952 Fax: +1-205-9759262

Received: December 28, 2013 Revised: February 27, 2014
Accepted: June 20, 2014
Published online: August 28, 2014

Abstract

Imaging of the temporomandibular joint (TMJ) is continuously evolving with advancement of imaging technologies. Many different imaging modalities are currently used to evaluate the TMJ. Magnetic resonance imaging is commonly used for evaluation of the TMJ due to its superior contrast resolution and its ability to acquire dynamic imaging for demonstration of the functionality of the joint. Computed tomography and ultrasound imaging have specific indication in imaging of the TMJ. This article focuses on state of the art imaging of the temporomandibular joint. Relevant normal anatomy and biomechanics of movement of the TMJ are discussed for better understanding of many TMJ pathologies. Imaging of internal derangements is discussed in detail. Different arthropathies and common tumors are also discussed in this article.

Key words: Temporomandibular joint; Magnetic resonance imaging; Imaging; Computed tomography; Anatomy; Pathologies

Core tip: "Imaging of the temporomandibular joint: An update" is a thorough review of the imaging techniques and imaging appearances of normal anatomy, anatomic variation and pathologies of the temporomandibular joint (TMJ). Numerous images are appropriately used for illustration of the key concepts of TMJ imaging. Nice blend of exquisite details and beautiful illustrative images is the main feature of this article. The purpose of this article is easy understanding of many difficult aspects of imaging of the TMJ.

Bag AK, Gaddikeri S, Singhal A, Hardin S, Tran BD, Medina JA, Curé JK. Imaging of the temporomandibular joint: An update. *World J Radiol* 2014; 6(8): 567-582 Available from: URL: http://www.wjgnet.com/1949-8470/full/v6/i8/567.htm DOI: http://dx.doi.org/10.4329/wjr.v6.i8.567

INTRODUCTION

Pain related to the temporomandibular joint (TMJ) is common in the general population. Only about 3%-7% of the patients with pain related to TMJ seek medical attention[1,2]. Although TMJ disorders or dysfunctions are the most common clinical conditions for imaging referrals, pathologies specific to the bone and the joints are also common. Different imaging modalities are available to image the TMJ, each with inherent strengths and weaknesses. Magnetic resonance imaging (MRI) is the most widely used and is diagnostic technique of choice. In this article, we review the imaging techniques, anatomy pathology involving the TMJ with special emphasis on MRI findings.

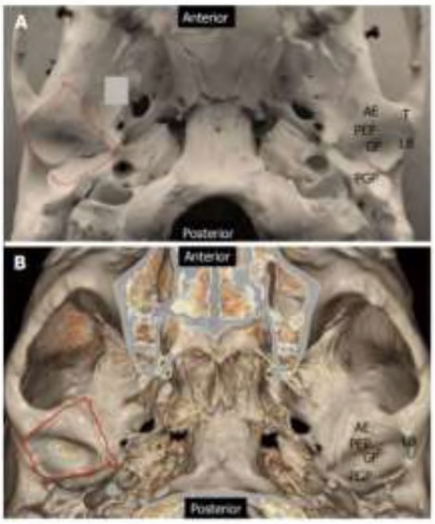


Figure 1 Anatomy of the cranial component of temporomandibular joint. A: Photograph of skull specimen; B: 3-D volume rendered image obtained from a temporal bone Redline demonstrates the capsular attachment. AE: Articular eminence; GF: Glenoid fossa; LB: Lateral border; PEP: Preglenoid plane; PGP: Postglenoid plane; T: Tubercle.

Embryology and development of TMJ

The TMJ is one of the last diarthrodial joints to appear in utero and does not emerge in the craniofacial region until the 8th week of gestation. The maxilla, mandible, muscles of mastication, and biconcave disc develop embryologically from the first branchial arch through the 14th week of gestation. The TMJ is considerably underdeveloped at birth in comparison to other diarthrodial joints making it susceptible to perinatal and postnatal insults. The joint continues developing in the early childhood years as the jaw is utilized for sucking motions and eventually chewing.

ANATOMY OF TMJ

The TMJ is a ginglymoarthrodial synovial joint (latin:ginglymus = hinge joint) that allows both backward and forward translation as well as a gliding motion[1]. Similar to the other synovial joints in the body, the TMJ has a disk, articular surfaces, fibrous capsule, synovial fluid, synovial membrane, and ligaments. What makes this joint unique is the articular surfaces are covered by fibrocartilage instead of hyaline cartilage. The articular surfaces of the TMJ are formed inferiorly by the mandibular condyle and superiorly by the glenoid fossa (also known as mandibular fossa) and articular eminence of the temporal bone.

Articular surfaces

The mandibular component consists of the ovoid condylar process that is 15-20 mm wide in the transverse dimension and 8-10 mm wide in the antero-posterior dimension[7]. The appearance of the mandibular condyle is extremely variable between patients and in different age groups.

The cranial component of the TMJ lies below the squamous portion of the temporal bone anterior to tympanic plate. The articular fossa is formed entirely by the squamous portion of the temporal bone. The posterior part of the articular fossa is elevated to form the posterior articular ridge. In most individuals the posterior articular ridge becomes thicker on the lateral aspect and forms a cone shaped projection known as postglenoid process (PGP). The tympanosquamosal fissure lies at the posterior and lateral part of the glenoid fossa, between the squamous and tympanic portion of the petrous bone and separates the articular surface form the nonarticular surface of the glenoid fossa. Along the medial aspect of the glenoid fossa is the petrotympanic fissure anteriorly and the petrosquamous fissure posteriorly. The articular eminence (AE) forms the anterior boundary of the glenoid fossa. The AE is a transverse bony bar anterior to the glenoid fossa and medial to the posterior margin of the zygomatic process. The anterior slope of the AE is known as the preglenoid plane (PEP) and rises gently from the infratemporal surface of the squamous bone. The mandibular condyle and the articular disk travel anteriorly to the summit of the AE and onto PEP during wide mouth opening. The gentle anterior slope facilitates smooth backward movement of the condyle and disk from the anterior position back to neutral position. The articular tubercle is a small bony knob at the lateral aspect of the AE where the lateral collateral ligament attaches. The lateral border of glenoid fossa is slightly raised from the fossa joining the anterior tubercle with the PGP (Figure 1).

Articular disk

The articular disk is round or oval, biconcave, avascular fibrocartilage between the condyle and glenoid fossa. The disk is considerably thinner centrally in the intermediate zone. The triangular anterior band is approximately 2 mm in thickness and blends with the joint capsule. The posterior band is approximately 3 mm in thickness and continues as bilaminar zone (also known as retrodiscal region and posterior attachment), which consists of superior fibroelastic layer (also known as temporal lamina) that attaches to PGP and an inferior fibrous layer (also known as the inferior lamina) that attaches to the posterior condylar neck. The superior layer prevents slipping of the disk during wide mouth opening and the inferior layer prevents excessive rotation of the disk over the condyle. Both the lamina are separated by loose elastic fibers with blood vessels and nerves. These fibers attach to the posterior joint capsule and augments disk retraction during mouth closing. The bands are longer in the mediolateral dimension than in the antero-posterior dimension[9]. The smaller anterior band attaches anteriorly to the joint

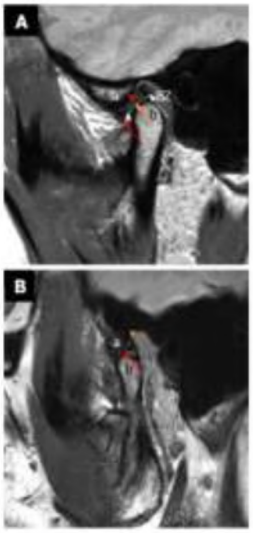


Figure 2 Normal anatomy. Sagittal proton density weighted closed mouth and open mouth view of magnetic resonance imaging. A: On the closed mouth view, the disk is located posterior to the articular eminence (the letter, a). It can be noted that the "bow-tie" shape of the disk: Thicker anterior band (red arrow) and posterior band (white arrow) with a thinner central zone (orange arrow). Bilaminar zone (BZ) is located posterior to the posterior band. It can also be noted that the inferior joint compartment (white arrowhead) between the disk and the mandibular condyle (the letter, b) and superior joint compartment (red arrowhead) between the articular eminence and the disk; B: On the open mouth view (in a different patient), the thinner intermediate zone (red arrow) of the disk is interposed between the articular eminence (the letter, a) and the condylar head (the letter, b) in a "bow-tie" fashion. Orange arrowhead demonstrates temporal lamina and black arrowhead indicate inferior lamina.

capsule, condylar head, and AE. Some patients have an additional antero-medial attachment to the superior belly of the lateral pterygoid muscle. Unlike its anterior and posterior attachments, the disk is not attached to the joint capsule medially and laterally. Instead, the disk is firmly attached to the medial and lateral poles of the mandibular condyle. This allows simultaneous movements of the disk and the condyle (Figure 2).

Muscles

The muscles of mastication (medial and lateral pterygoids, masseter, and temporalis) in addition to other accessory muscles help opening and closing of the jaw[24-31]. The lateral pterygoid in conjunction to the stylohyoid, mylohyoid and geniohyoid muscles is used to open the jaw. The temporalis, medial pterygoid, and masseter muscles close the jaw. The lateral pterygoid, part of the masseter muscle and the medial pterygoid assist in the anterior translation of the mandible. The protrusive muscles (helping forward movement) are used alternately to move the jaw laterally from side to side. Individual muscle origins and attachments are listed below[24-31].

Jaw-closing muscles/adductors

The masseter is the strongest muscle of mastication and has two parts that blend together anteriorly. The superficial part originates from the anterior two-thirds of the zygomatic arch and inserts on the lower one-third of the lateral surface of the mandibular ramus. The deep part originates from the entire zygomatic arch and inserts on the upper two-thirds of the ramus.

The medial pterygoid courses parallel to the masseter along the medial aspect of the mandible. The anterior part arises from the lateral surface of the palatine pyramidal process and the maxillary tuberosity. The posterior part originates from the pterygoid fossa and the medial surface of the lateral pterygoid plate. The medial pterygoid inserts on the inferomedial surface of the mandibular ramus.

The temporalis muscle originates from the temporalis fossa and inserts on the coronoid process and inner side of the mandibular ramus. The fibers also attach directly to the medial side of the coronoid process and ramus.

Jaw-opening muscles/abductors

The lateral pterygoid muscle has two bellies. The superior belly originates from the infratemporal surface of the greater wing of sphenoid. The inferior belly originates from the lateral surface of the lateral pterygoid plate. There is a wide gap between the two heads of the lateral pterygoid muscle that come together anterior to the TMJ. The fibers from the superior head primarily attach to the anteromedial surface of the mandibular neck at the pterygoid fovea. Additionally, in some patients part of the superior head directly attaches to the superomedial aspect of the joint capsule and extends to the anteromedial aspect of the articular surface. All of the fibers of the inferior head attach to the pterygoid fovea. Variability in the attachment of the lateral pterygoid muscle is reported with insertions of the muscle described only to the condyle or to the condyle, capsule, and the disk[27-29].

The superior belly helps maintain the physiologic position of the disk in the open mouth position. This is accomplished by pulling the disk forward with a combined translation and rotation while exerting forward pressure on both the condyle and the disk thus stabilizing their relationship to each other. The inferior belly pulls the condyle forward out of the fossa. When the inferior belly alternately contracts, this produces lateral movement of the jaw.

The digastric muscle has a posterior and an anterior belly united by an conjoined tendon. The posterior belly is attached to the mastoid process of the temporal bone and extends to the hyoid bone becoming continuous with the intermediate tendon. A fibrous loop attached to the hyoid holds the tendon in place. The anterior belly extends from the tendon to the digastric fossa on the lower aspect of mandible near the symphysis. Contraction of the digastric muscles pulls the symphysis menti backwards producing the retrusive and opening movements of the mandible.

The geniohyoid, mylohyoid, stylohyoid and infra-

hyoid muscles also have supportive role in mandibular movements that are beyond the scope of this review.

Biomechanics of TMJ movements

Jaw movement involves a high level of interaction and coordination between bilateral mandibular condyles, disk, muscles, and ligaments of the joints. The functional interactions within the TMJ are complex and incompletely understood[10,11]. A simplistic view of the complex interactions in open and closed mouth positions is described below.

In a normal joint, the thin intermediate zone of the disk is always interposed between the condyle and the temporal bone in both the closed-mouth and open-mouth positions. This is for the prevention of articular damage.

In the closed mouth position, the condyle is centered in the glenoid fossa. The disk is interposed between the condyle inferiorly and the glenoid fossa superiorly. The articular eminence is anterior to the disk (Figure 2). The normal disk is positioned such that the anterior band is in front of the condyle and the junction of the posterior band and bilaminar zone lie immediately above the condylar head near the 12 o'clock position[1,3,4,9,12-14]. However, some controversy exists over the range of normal position of the disk[2,3,4,14-16]. Drace *et al*[13] suggest that the junction of the posterior band and bilaminar zone should fall within 10 degree of vertical to be within 95 percentile of normal. There is significant variation in relationship of the posterior band and bilaminar zone in normal population, resulting in inappropriate classification of anterior disk displacement[14,16]. Rammelsberg *et al*[17] suggest that disk positions of up to +30° from the vertical be considered normal. Many other authors have proposed that the intermediate zone be the point of reference so that in a normal joint it is interposed between the condyle and the temporal bone in all joint positions[4,15,20]. Comparing to the different disk positions of 12, 11 and 10 o'clock, Orsini *et al*[15] found the intermediate zone criterion for disk displacement to be more stringent. Recently Provenzano Mde *et al*[20] have suggested similar conclusions (Figure 2).

IMAGING TECHNIQUES

A variety of modalities can be used to image the TMJ. This includes non-invasive imaging modalities such as conventional radiographs, ultrasound, Computed tomography (CT) and MRI to more invasive imaging such as arthrography. Each imaging modality has its uses.

Conventional radiographs have a limited role in evaluation of the TMJ. They can be used to evaluate only the bony elements of the TMJ. They do not give useful information when it comes to the non-bony elements such as cartilage or adjacent soft tissues. They also do not give useful information concerning joint effusions, which are commonly associated with pain and disc displacements. Another disadvantage concerning conventional radiographs is the problem of superimposition of adjacent structures. Many different views such as the submentovertex, transmaxillary, and the transcranial are used to reduce superimposition.

Ultrasound is a less expensive and easily performed imaging modality that can be used to evaluate the TMJ. This is simple way to look for the presence of a joint effusion[21]. Ultrasound is also used to evaluate cartilage as well as disk displacement with both open and closed mouth imaging[22]. It is used for image-guided injections for both diagnostic and therapeutic purposes[23]. Typically, a linear transducer of 8 MHz or higher is ideal. The patient should be lying supine with the transducer placed parallel to a line extending from the tragus of the ear to the lateral surface of the nose over the TMJ.

CT is useful to evaluate the bony elements of the TMJ as well as the adjacent soft tissues. CT is ideal for the evaluation of fractures, degenerative changes, erosions, infection, invasion by tumor, as well as congenital anomalies[23]. A typical imaging protocol is: 120 kV, 100 mA, 1 mm collimation, 1 mm/rotation (pitch), and imaged with a closed mouth. CT also allows 3D reconstructions, which can be used for evaluating congenital anomalies and fractures[23]. CT is predominantly done when there is suspicion of bony involvement from the MRI and if primary bony pathologies are suspected clinically. Relative advantages of CT over MRI include, exquisite bone details and 3D assessment of congenital, traumatic and postsurgical conditions.

Clinical evaluation of the TMJ can be nonspecific due to overlap of symptoms between internal derangement and myofacial pain dysfunction[9]. MRI should be part of the standard evaluation when an internal structural joint abnormality is suspected because MRI provides high resolution and great tissue contrast. This allows for a detailed evaluation of the anatomy was well as biomechanics of the joint through open and closed mouth imaging[9].

For optimal imaging of the TMJ, small bilateral surface coils with small field of view are used to achieve higher signal to noise ratio and simultaneous bilateral acquisition. Closed mouth coronal and axial T1 sequences are needed to evaluate the overall anatomy and bone marrow as well as the adjacent soft tissues to exclude other adjacent pathology. In our institution, axial T1 is obtained as a localizer[24]. Bilateral closed mouth and open mouth T2, proton density (PD) and dynamic sequences are obtained in a oblique sagittal plane. In our institution, dynamic images are obtained as rapid acquisition of static images using a single shot fast spin echo (SSFSE) proton density sequence during progressive opening and closing of the mouth. These images are displayed sequentially as a cine loop. Mouth opening devices such as Burnett opening devices may be used for incremental opening of the mouth controlled by the patient. It can be argued that passive mouth opening with a Burnet device might not reproduce the physiologic conditions occurring during mouth opening given the possible role of the lateral pterygoid muscle in disc stabilization during mouth opening. Oblique imaging entails 30° medial

Table 1 Temporomandibular joint magnetic resonance imaging protocol

Plane	Sequence	Slice thickness	TR	TE	Mouth open/closed
Axial	T1	2 mm, 0 skip	500	Minimal	Closed
Coronal	T1	3 mm, 0.5 skip	500	Minimal	Closed
Bilateral Sag Oblq	T2 and PD	3 mm	3500	Min and 85	Closed and open
Bilateral Sag Oblq	T2	3 mm	1180-2000	64	Dynamic cine

PD: Proton density; TE: Echo time; TR: Repetition time.

from the true sagittal plane[7]. Please see the table for specific MRI protocol[7]. A total of 8 sequences will need to be performed (Table 1).

Arthrography is an invasive imaging technique to evaluate the TMJ. This imaging modality requires injection of radiopaque contrast into the TMJ under fluoroscopic guidance. Once the contrast is injected, the joint can be evaluated for adhesions, disk dysfunction, as well as disk perforation based on how contrast flows in the joint. This modality is rarely used today because MRI can be used to evaluate the TMJ without being invasive, exposing the patient to a possibility of allergic reaction from the contrast, possibility of infection, or using radiation.

IMAGING APPEARANCE OF NORMAL TMJ

MRI

On MRI, marrow fat in the condyle has a high T1 signal intensity. The cortical bone and the disk have low signal intensity on both T1 and T2 weighted images because of low proton density and short T2[1,8]. Sometimes high T2 and PD signal intensity can be seen in the central portion of the disk similar to a centrally hydrated vertebral disk[1,4]. The disk is otherwise homogeneous, hypointense and biconcave in shape. The center of the posterior band may be slightly hyperintense due to presence of loose areolar tissue (Figure 2).

The disk's posterior attachment has higher signal intensity than muscle on proton density and T1 weighted images secondary to fatty tissue. The bilaminar zone is visible as intermediate signal intensity structures.

In closed mouth position, the junction of the posterior band and posterior attachment normally lies above the condylar head near the 12 o'clock position. The posterior band and retrodiskal tissue are best depicted in the open mouth position. In open mouth position, the intermediate zone lies between the condyle and the articular eminence and the posterior band is against the posterior surface of the condyle[1,8] (Figure 2).

The superior belly of lateral pterygoid attaches to the anterior band of the disk. The inferior belly of the lateral pterygoid attaches to the anterior surface of the condylar neck with a thin linear hypointense fibrous band. This band is seen just inferior to the position of the disk, and can sometimes be mistaken for the disk, particularly when the disk is medially or laterally displaced[1,8].

In the coronal plane, the disk is crescent shaped and its medial and lateral borders are attached to the respective aspects of the condylar head and joint capsule. The lateral and medial capsules do not demonstrate any outward bulges beyond the borders in normal condition[11,22].

PATHOLOGIES RELATED TO ANATOMIC VARIATIONS

Anatomic variations in the TMJ can be symptomatic and/or have implications during arthroscopy and surgery. There can also be several variations in the appearance of the mandibular condyles including intra-individual variations between the two sides. The disease processes can be developmental, due to remodeling related to malocclusion, trauma or other secondary developmental abnormalities[13].

Bifid condyle

A bi-lobed or duplicated mandibular head is an infrequently encountered incidental imaging finding. While the etiology is unknown, theories include reminiscence of congenital fibrous septum and peripartum or early childhood trauma. The duplicated heads may lie in either an antero-posterior or transverse orientation. Dennison *et al*[23] have suggested that the term "bifid condyle" should be reserved for describing multiple condyles in the sagittal plane only. No treatment is required for asymptomatic patients. However surgery may be performed if there is displacement of the disc or ankylosis of the joint space (Figure 3).

Foramen of Huschke

In some individuals there may be persistence of a developmental defect in the tympanic plate. The tympanic plate is present as an incomplete U-shaped cartilaginous ring at birth. Over time the ossification proceeds laterally and posteriorly leaving a defect in the floor of the external meatus, called the foramen tympanicum (foramen of Huschke). With growth of the mastoid process, this defect changes in position from inferior to anterior and usually closes by the 5th year of life. Rarely, a 3-4 mm defect persists and is found to be located at the antero-inferior aspect of the external auditory canal and posteromedial to the TMJ. These patients can present with a defect or polyp on the anterior wall of the external auditory canal (EAC) or with salivary otorrhea during mastication. TMJ tissue may also herniate into the EAC during mastication[24,25]. During arthroscopy, there can be inadvertent

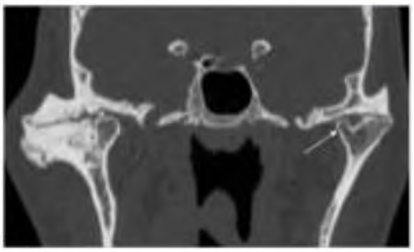


Figure 3 Bifid condyle. Coronal reformatted computed tomography image through the temporomandibular joint (TMJ) demonstrates bifid left mandibular condyle. It can be noted that one of the condyles (arrow) is smaller than the other. Advanced degenerative changes are noted in bilateral TMJ.

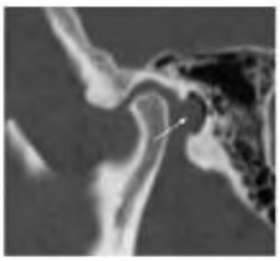


Figure 4 Foramen of Huschke. Sagittal reformatted computed tomography image through the temporomandibular joint demonstrates a focal defect (arrow) in the tympanic plate.

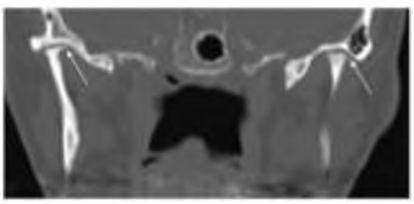


Figure 5 Idiopathic condylar resorption. Coronal reformatted computed tomography image through the temporomandibular joint of a young patient demonstrates bilateral severe condylar resorption (arrows) without any evidence of degenerative changes within the joint.

passage into the EAC resulting in otologic complications. This foramen also can act as a path of communication between the EAC and TMJ or infratemporal fossa allowing the spread of infection, inflammation or tumor[24,25] (Figure 4).

Condylar hypoplasia

Aplasia and hypoplasia of the mandibular condyle is secondary to non-development or underdevelopment of the condyle and can be congenital or acquired. Congenital aplasia or hypoplasia of the mandibular condyles is a rare anomaly and usually occurs as a part of more widespread 1st and 2nd branchial arch anomalies (*e.g.*, Treacher-Collins syndrome). Acquired condylar hypoplasia may be secondary to local factors (trauma, infection, radiation) or systemic factors (toxic agents, rheumatoid arthritis, mucopolysaccharoidosis)[26]. Traumatic vaginal delivery has been implicated as a cause of hypoplasia[27]. Hypoplasia may involve one or both of the condyles. Unilateral disease produces mandibular rotation or tilt and associated facial asymmetry. The diagnosis of bilateral condylar hypoplasia may be delayed secondary to facial symmetry. Hypoplastic condyles are frequently complicated with ankylosis[28].

Idiopathic condylar resorption

Idiopathic condylar resorption (also known as condylysis or "cheerleader syndrome") is primarily a disease of TMJ affecting teenage girls. There is rapidly progressive condylar erosion resulting in widening of the joint space with the chin becoming less prominent from retrognathia[29]. Many causes have been hypothesized including estrogen influence on osteogenesis, avascular necrosis, and TMJ internal derangement. Orthognathic surgery has been implicated as a cause of the disease but also is one of the corrective approaches for idiopathic condylar resorption (Figure 5).

Condylar hyperplasia

Condylar hyperplasia is a rare disorder characterized by increased volume of the mandibular condyle, and is frequently associated with increased volume of the ramus and mandibular body[29]. Condylar hyperplasia is usually a unilateral process. This disease presents in the second and third decades of life during brisk periods of osteogenesis suggesting a hormonal influence upon the growth disturbance. Trauma has also been implicated in asymmetric condylar hyperplasia due to hypervascularity during healing producing inducing excessive osteogenesis. The hyperplasia produces facial asymmetry with the chin rotating away from the affected side[30]. Resection of the hyperplastic condyle causes the abnormal growth to cease and restores facial symmetry (Figure 6).

Extensive pneumatization

Extensive pneumatization of the mastoid bone can involve the glenoid fossa and articular eminence. Knowledge of extensive pneumatization is necessary prior to surgery to prevent perforations. Complications can occur during TMJ surgery due to forceful flap retraction, dissection or with placement of screws in cases where fossa-eminence prostheses are required[31,32]. Pneumatization can also provide a path of minimal resistance and facilitate the spread of pathological tumors, inflammation, infection or fracture into the joint. For these reasons, a CT must be performed prior to TMJ surgery when ex-

Figure 6 Condylar hyperplasia. Panoramic reformation of the source computed tomography data including both the temporomandibular joints of a young patient demonstrates hyperplasia of the left condyle (arrowhead) in comparison to the right side. Associated hypertrophy of the ramus and the neck (arrow) of the left hemi-mandible is also noted.

Figure 7 Extensive pneumatization. Coronal reformatted computed tomography image through the right temporomandibular joint demonstrates almost complete pneumatization of the glenoid fossa except the central part.

tensive pneumatization is detected in the panoramic radiographs[71,72] (Figure 7).

INTERNAL DERANGEMENT OF TMJ

Internal derangement (ID) is defined as a mechanical fault of the joint that interferes with smooth joint function. This is attributed to abnormal interaction of the articular disc, condyle and articular eminence. Associated clinical features include articular pain and articular noises[73]. Disc displacement is the most common cause of ID, though not all displaced discs are associated with derangement and not all derangements are caused by disc displacement[74]. Additionally, it is not clear whether the displaced disk is related to onset, progression or cessation of the pain. Loose bodies and adhesions in the joint can also result in derangement. Up to 34% of asymptomatic volunteers can have anterior disc displacement and 23% of patients with derangement can have normal disc position[16]. In most large MRI series approximately 80% of patients referred for diagnostic imaging of the TMJ demonstrate some form of disk displacement[75-77]. MRI is the imaging modality of choice for the diagnosis of internal derangement with an accuracy of 95% in assessing the disc position and form and 93% accuracy in assessing the osseous changes[78].

Disc displacement

The disc displacement is categorized based on the relation of the displaced disc with mandibular condyle. The displacement can be anterior, anterolateral, anteromedial, lateral, medial and posterior[79]. The most common pattern of disc displacement are either anterior and anterolateral accounting for more than 80% of the causes[77]. The disc displacement can be subclassified as anterior displacement with reduction (ADR) or anterior displacement with no reduction (ADNR) based on restoration of a normal relationship between the condyle and the disc on mouth opening (Figures 8 and 9). The disc displacement can be either complete or partial[79]. If the entire mediolateral dimension of the disc is displaced, it is referred to as complete displacement. On the other hand if only the medial or lateral portion of the disc is displaced, it is referred to as partial displacement. Partial disc displacement is commonly seen with ADR. Frequently the lateral part of the disc is displaced anteriorly while the medial part of the disc remains in normal position (rotational disk displacement)[80].

In ADR, the anteriorly displaced disc returns to the normal position on mouth opening producing a "reciprocal click" (Figure 9). In ADNR, there is limited mouth opening and deviation of the jaw to the affected side (closed lock). Over time, stretching or perforation of the retrodiscal tissue causes deformation of the disk leading to an improvement in jaw excursion and reduced lateral deviation during mouth opening (Figure 10A). The posterior band of the disc remains anterior to the condyle even with mouth opening[81]. There is increased association of degenerative changes in the TMJ with the ADNR. Although TMJ disorder with ADR and normal condylar cortical bone may be stable for decades, it will eventually progress to ADNR. In a study with 55 patients, de Leeuw *et al*[82] have demonstrated 75% of the patients with long history (approximately 30 years) of TMJ internal derangement have ADNR.

The exact mechanism for a disc displacement is unknown although trauma with injury to the posterior disc attachment is considered to be the most likely cause. Unenhanced MRI is the imaging modality of choice for evaluation of ID. During the early stage of ID the disc retains its normal shape, but over time it becomes deformed by thickening of the posterior band and thinning of the anterior band. This produces in a biconvex, teardrop shaped or a rounded disc. The disc maintains a normal biconcave shape as long as it remains on top of the condyle during mouth opening[83]. Hence, presence of an irregular and rounded disc almost always indicates disc disease[83]. Other MRI findings that suggest disc disease include disc flattening, decrease in the normal intermediate to high signal intensity of the disc[84] and presence of tear or perforation in the chronic stage.

Posterior disc displacement is a rare entity and acco-

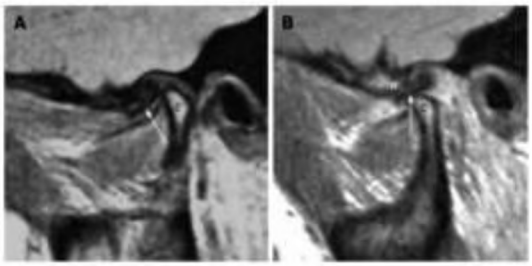


Figure 8 Anterior displacement with reduction. A: Sagittal proton density weighted magnetic resonance imaging (MRI) in the closed mouth position demonstrates anterior displacement of the disk (arrow) in front of the mandibular condyle (the letter, c); B: Sagittal proton density weighted MRI in the open mouth position demonstrates reduction of the disk (arrow) between the articular eminence (the letter, a) and the mandibular condyle (the letter, c).

Figure 9 Anterior displacement with no reduction. A: Sagittal proton density weighted magnetic resonance imaging (MRI) in the closed mouth position demonstrates anterior displacement of the disk (arrow) related to the articular eminence (the letter, a) and anterior to the mandibular condyle (the letter c); B: Sagittal proton density weighted MRI in the open mouth position demonstrates no reduction of the disk (arrow) between the articular eminence (the letter, a) and the mandibular condyle (the letter, c).

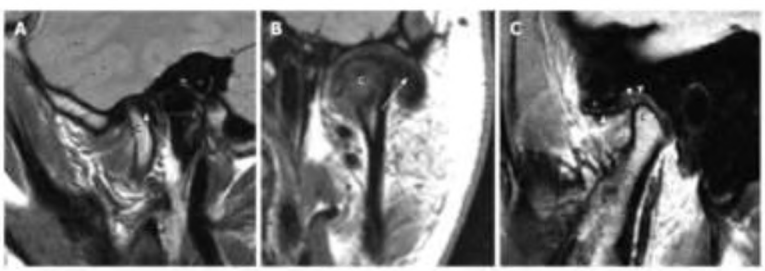


Figure 10 Other types of disk displacement. A: Posterior disk displacement. Sagittal proton density weighted magnetic resonance imaging (MRI) in the closed mouth position demonstrates posterior displacement of the disk (arrow) in relation to the mandibular condyle (the letter, c); B: Lateral disk displacement. Coronal proton density weighted demonstrates lateral displacement of the disk (arrow) in relation to the mandibular condyle (the letter, c); C: Pseudodisk. Sagittal proton density weighted MRI in the closed mouth position demonstrates anterior displacement of the disk (arrow) in front of the mandibular condyle (the letter, c). The thickening of the posterior attachments (arrowheads) superior to the mandibular condyle is seen as "pseudodisk".

unts for only 0.01% to 0.001% of all disc displacements[89]. The major clinical sign is a sudden onset of locked jaw in open position. MRI is helpful in the diagnosis by demonstrating displacement of the posterior band beyond 1[st] clock position[79] (Figure 10A). Review of patient's clinical information is important before image interpretation as previous posterior disk plication can be mistaken for an acquired posterior disk displacement.

Anterolateral and antero-medial disk displacements are grouped under rotational displacements while the

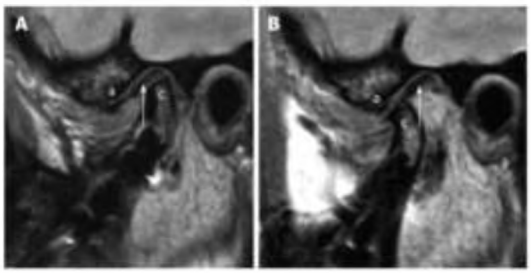


Figure 11 Stuck disk. A: Sagittal proton density weighted magnetic resonance imaging (MRI) in the closed mouth position demonstrates apparently normal position of the disk (arrow) in relation to the mandibular condyle (the letter, c). The letter "a" demonstrates the articular eminence. B: Sagittal proton density weighted MRI in the open mouth position demonstrates no anterior movement of the disk (arrow) with the mandibular condyle (the letter, c). *i.e.*, "stuck" to the glenoid fossa. The articular eminence is denoted with letter "a".

pure lateral and medial displacements are grouped under sideways displacement[80]. Isolated lateral displacement is rare (Figure 10B). Again these rotational and sideways displacements can be complete or partial and with or without disc reduction. Anterolateral displacement is the most common pattern[75].

Pseudodisk

A pseudo-disk is present in some patients with an anteriorly displaced disk. This has been postulated as an adaptive reaction to anterior disk displacement within the posterior disk attachment followed by subsequent connective tissue hyalinization that[47] appears as a band-like structure of low signal intensity replacing the normally bright signal of the posterior disk attachment[20,21] (Figure 10C).

Stuck disc

The "stuck disc" is a pathologic condition characterized by an immobile disc in relation to the glenoid fossa and the articular eminence. This is present in both open and closed mouth positions[9] and is likely related to the adhesions. It can occur with or without disc displacement and can be associated with pain and joint dysfunction due to limitation of condylar translation[40,41]. This diagnosis can be missed unless the TMJ is imaged in both open and closed mouth positions (Figure 11). Sagittal oblique cine imaging is particularly useful in evaluation of stuck disk.

Perforated disc

Disc perforation is reported in 5% to 15% of deranged joints disc displacements[59]. It is more common in patients with ADNR than in ADR[51,52] and is usually seen in patients with advanced arthrosis. The prevalence of a perforated disc is higher in women than in men and prevalent in individuals over 80 years of age[75]. MRI findings of disc perforation include disc deformity (100%), disc displacement (81%), condylar bony changes (68%), joint effusion (23%) and non-visualization of temporal posterior attachment (TPA) of the disc (65%-68%)[59]. Conventional and MR arthrogram can be helpful in the diagnosis of a disc perforation by demonstrating opacification of both the joint compartments from a single lower compartment injection. If the disk perforation is suspected a fat suppressed T2 weighted MRI can be obtained in sagittal and coronal plane[59]. Absence of stretching/straightening of the posterior temporal disk attachment on mouth opening also suggests disk perforation.

Joint effusion

Joint effusion represents an abnormally large accumulation of intra-articular fluid and is commonly seen in symptomatic patients. A small amount of joint fluid can be seen in asymptomatic patients[56]. An effusion is more prevalent in painful than in non-painful joints[75]. Although not all patients with joint pain have effusion, patients with large effusions commonly experience pain and disc displacement[57].

T2 weighted MR sequence is the best sequence for the assessment of joint effusion. An early joint effusion is commonly seen surrounding the anterior band but larger effusions can occupy both superior and inferior joint space. A large effusion may have diagnostic value as it outlines the disc and sometimes even the disc perforation as well as retrodiscal tissue producing "arthrographic effect"[57]. Gadolinium enhanced T1 weighted imaging can be helpful in distinguishing a plain joint effusion from synovial proliferation. In patients with inflammatory arthropathies with associated synovial proliferation, the proliferating synovium enhances while the effusion does not[59].

Thickening of lateral pterygoid muscle attachment (double disk sign)

The exact role of lateral pterygoid muscle (LPM) in the TMJ function is still controversial although its suggested role is in generation of side-to-side and protrusive jaw forces[59]. There are electromyographic studies showing hyperactivity in the inferior attachment of the LPM in patients with TMJ internal derangement[59]. Several mor-

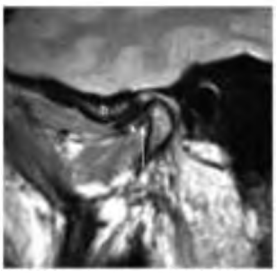


Figure 12 Double disk sign (thickening of the lateral pterygoid muscle). Sagittal closed mouth proton density image demonstrates anterior displacement of the disk (arrow head). The thickened lateral pterygoid muscle near the mandibular condylar (the letter, a) attachment appear as linear hyperintense structure (white arrow) inferior to the disk in the same orientation giving the appearance of "double disk". The articular eminence is denoted with letter "b".

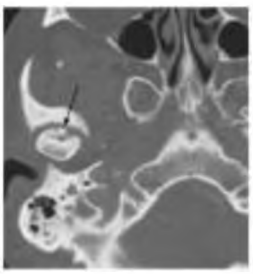


Figure 13 Osteochondritis dessicans. Axial computed tomography scan through the level of the temporomandibular joint demonstrates a tiny bone fragment (arrow) at the anterior aspect of the disk. It can be noted that there are linear lucency surrounding the bone fragment.

Figure 14 Loose bodies. Sagittal reformation of the axial dataset demonstrates multiple "loose bodies" in the joint cavities, anteroinferior to the articular eminence (black arrow) and immediately posterior to the mandibular condyle (white arrow).

phologic changes to the superior and inferior bellies of the LPM on MRI have been described. These include hypertrophy, atrophy and contractures in patients with ADNR of the TMJ with these morphologic changes having a significant association with the clinical symptoms of pain or restricted jaw opening[69]. It is suggested that there is significant association between the anterior disc displacement and attachment of the superior LPM to the disc alone and not to the condyle[67]. The interpreting radiologist should be aware of a potential pitfall of mistaking the thickened inferior LPM to an anteriorly displaced disc ("double disc sign")[70] (Figure 12).

Osteochondritis dissecans and avascular necrosis

Osteochondritis dissecans (OCD) and avascular necrosis (AVN) of the mandibular condyle are similar pathologic entities likely represent a spectrum of the same pathophysiology[63]. Common clinical features of OCD/AVN of the mandibular condyle include pain and joint disability[8,9]. Pain is commonly over the joint and along the third division of the trigeminal nerve. Other symptoms include ipsilateral headache, earache and spasm of masticator muscles. These can occur with or without limitation of joint movements[8,9].

MRI is the modality of choice for assessment of OCD/AVN of the mandibular condyle[8,9]. There is decreased marrow signal on T1 weighted sequences in cases of AVN. T2 weighted sequences demonstrate variable signal characteristics with early AVN, healing and OCD. Early AVN consistently exhibits high signal on T2WI and acute OCD typically demonstrated a hypointense central fragment surrounded by a zone of higher signal on both T1W and T2W sequences[8,9]. Although MRI is 78% sensitive and 84% specific for the diagnosis of AVN, the positive predictive value is only 54% because condylar sclerosis secondary to advanced TMJ degenerative changes have similar MRI appearances[64]. Radiologic changes of OCD and AVN of the mandibular condyle are frequently associated with joint effusion and internal derangement of the disc[8,9] (Figure 13).

Loose bodies

Loose bodies in a synovial joint can be due to primary or secondary synovial chondromatosis. The primary type is associated with spontaneous cartilaginous metaplasia in the synovium, while the secondary type is due to incorporation of osteocartilaginous loose bodies in the synovium in the setting of degenerative joint disease[60]. Common clinical symptoms associated with loose bodies include pain, periauricular swelling, decreased range of jaw motion, crepitation and unilateral deviation of the jaw during mouth opening[67].

Panoramic radiographs of the TMJ may or may not demonstrate loose bodies[68]. High resolution CT[69,71] or MRI[70] can demonstrate small loose bodies within the TM joint space (Figure 14).

Hypermobility

Patients with a hypermobile TMJ can present with an inability to close the jaw (open lock) after wide opening of the jaw. This occurs as a result of translation of the

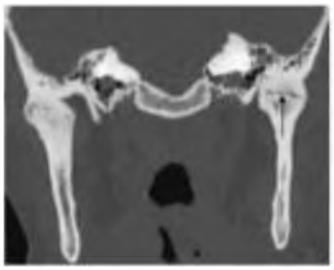


Figure 15 Ankylosis. Coronal reformation of the axial dataset demonstrates complete ankylosis of the right temporomandibular joint (TMJ) and near complete ankylosis of the left TMJ with subtle residual joint space at the center (black arrow).

condyle beyond the margins of the anterior attachment of the TMJ capsule. Entrapment of the condyle along the anterior slope of the articular eminence results due to various biomechanical constraints, particularly masticator muscle activity[71].

In acute cases, there is little need for imaging studies as the open lock is clinically evident with a relevant clinical history of wide jaw opening or trauma. In chronic cases MRI can give information about the height and steepness of the articular eminences as well as the shape and position of the disc[72].

Ankylosis

Ankylosis of the TMJ can be due to fibrous adhesions or a bony fusion resulting in the restriction of jaw motion. It can occur as a sequel of previous infection, trauma surgery[73] and in patients with juvenile idiopathic arthritis or bifid mandibular condyles. MR arthrography is useful for the evaluation of fibrous adhesions and three-dimensional CT scan is necessary for surgical planning when bony fusion is suspected (Figure 15).

TMJ ARTHRITIS

Similar to other synovial joints in body, the TMJ is frequently involved in different inflammatory arthritides. Degenerative arthritis and arthritis secondary to crystalline deposition disease are also common in TMJ. Arthritis secondary to infection or trauma can occur at the TMJ. Arthritis of TMJ is discussed based on the pathophysiologic mechanism.

Inflammatory arthritis

Juvenile idiopathic arthritis: Juvenile idiopathic arthritis (JIA) is the most common rheumatic disease in childhood affecting girls more frequently than boys. The disease predominantly affects synovial joints. There are two peaks of onset, first being between the ages of 1 and 3 years and the second peak between 8 and 12 years[74]. The TMJ is involved in 17% to 87% of patients with JIA[74]. JIA can be systemic, polyarticular and pauciarticular. The TMJ is more commonly involved in patients with polyarticular joint involvement[75]. The typical presentation of TMJ involvement includes pain, joint tenderness, crepitation, stiffness and decreased range of motion. Bony ankylosis can develop in some patients as a late disease manifestation.

Orthopantomogram, CT, MRI and ultrasound have been used to evaluate TMJ JIA. Orthopantomogram and CT predominantly identify the bony erosions secondary to TMJ involvement. Both these techniques involve radiation exposure to young patients. MRI and ultrasound have gained popularity in evaluation of the TMJ in patients with JIA because these techniques have better soft tissue resolution allowing earlier diagnosis of TMJ involvement without any ionizing radiation. Acute TMJ arthritis typically demonstrates joint effusion and synovial thickening on T2 weighted imaging without any bony changes[76]. Enhancement of the joint or periarticular tissue is not a specific sign of acute TMJ arthritis because abnormal joint enhancement can be present even in healthy patients[76]. Condylar resorption can be better evaluated on non-fat suppressed T1 weighted sequence and suggests a more chronic TMJ arthritis[76] (Figure 16).

Rheumatoid arthritis: Rheumatoid arthritis (RA) is a chronic inflammatory disorder that predominantly affects the periarticular tissue such as synovial membrane, joint capsules, tendon, tendon sheaths and ligaments. Internal joint components are secondarily involved. The prevalence of RA in the general population is approximately 2%-2.5% with female predominance. The peak onset of disease is 40-60 years and approximately 50%-75% of patients with RA have TMJ involvement[77].

RA is a slowly progressive disease of insidious onset with progressive destruction of the articular/periarticular soft tissue and the adjacent bones resulting in joint deformity. The TMJ is involved at a later stage of disease. TMJ involvement causes deep, dull aching pain in the preauricular area, especially during chewing. Limited range of motion and morning stiffness can be present[78]. The mandibular condyle gradually resorbs as the disease progresses.

Radiographic features of RA include loss of joint space, condylar destruction, flattening with anterior positioning of the condyle. There may be flattening of the articular eminence and erosion of the glenoid fossa. Synovial proliferation is an early process in RA and can distinguish it from other types of arthritis[79]. Synovial proliferation is readily seen on MRI and can be seen in all patients[79]. A joint effusion is also comparatively more common in RA.

Degenerative (osteo)arthritis

Osteoarthritis (OA) is a chronic degenerative disease that characteristically affects the articular cartilage of synovial joints and is associated with simultaneous remodeling of the underlying subchondral bone with secondary involvement of the synovium. Osteoarthritis is the most

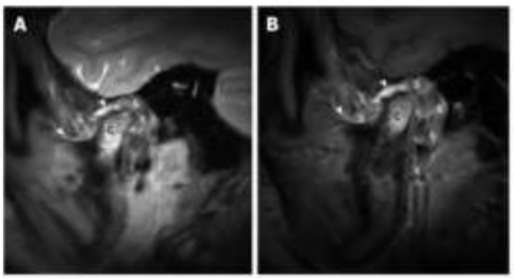


Figure 16 Juvenile idiopathic arthritis. A: Sagittal proton density weighted magnetic resonance imaging (MRI) in the closed mouth position demonstrates increased signal at the mandibular condyle (the letter, c), extensive thickening of the synovium (the letter, s) in the retrodiscal regions. It can be noted that the thickening and increased signal of the synovium at other places (arrowheads); B: Sagittal fat suppressed post contrast T1 weighted MRI in the closed mouth position demonstrates enhancement of signal at the mandibular condyle (the letter, c), enhancement and extensive thickening of the synovium (the letter, s) in the retrodiscal regions. There is thickening and enhancement of the synovium at other places (arrowheads).

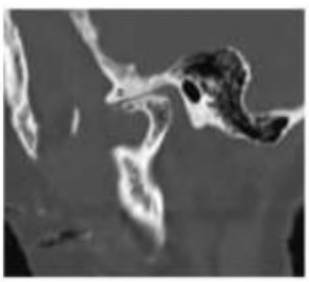


Figure 17 Degenerative changes. Sagittal reformation of the axial dataset demonstrates deformity of the mandibular condyle (the letter, c), extensive sclerosis of the articular eminence (the letter, a) and severe loss of joint space.

common joint pathology affecting the TMJ[39]. There is a clear disparity between radiographic evidence of OA and symptoms. Population based studies demonstrate that minimal condylar flattening is present in up to 35% of asymptomatic patients while approximately 11% of patients have TMJ OA-related symptoms[39].

The most common symptom of TMJ OA is pain during chewing. The pain usually starts in the periarticular soft tissue and the masticator muscles that are in protective reflex spasm. Fatigue of masticator muscles, trismus, decreased range of motion, difficulty opening the mouth and joint crepitations are other common symptoms.

Radiologic hallmarks of TMJ OA are articular surface cortical bone irregularity, erosion and osteophyte formation[61]. Erosion is radiologically defined as focal area of decreased density at the cortical margin of the articular surface of the mandibular condyle and the subchondral region. Osteophyte formation typically occurs at a later stage in the disease and can stabilize and broaden the surface area of the joint in an attempt to better withstand axial loading forces. Different imaging modalities have been used with varying degree of success. There is still no general consensus as to which imaging modality should be the gold standard[39] (Figure 17).

Metabolic arthritis/crystalline arthropathies

Calcium pyrophosphate dehydrate deposition disease: Calcium pyrophosphate dehydrate deposition disease (CPPD) is a metabolic arthropathy caused by the deposition of calcium pyrophosphate dehydrate crystals in and around joints, especially within the articular cartilage and fibrocartilage[62].

The spectrum of TMJ involvement ranges from asymptomatic disk calcification to a marked destruction of the joint with erosive changes in the mandibular condyle and the adjacent skull base. Common symptoms include pain and preauricular swelling with occasional hearing loss. Chewing can exacerbate the pain. Other less common symptoms include TMJ clicking, tinnitus, and malocclusion.

The radiographic appearance of CPPD is variable. Computed tomography demonstrates calcium deposition in the disk or periarticular tissue. On MRI, CPP deposits typically appear as hypointense material both on T1 and T2 weighted sequences. CT and MRI show erosions near both the condyle and fossa with adjacent CPPD deposits[62]. The erosions may extend into the skull base and into the middle cranial fossa. Involvement of other joints with chondrocalcinosis is a clue to the diagnosis. The differential diagnosis includes synovial chondromatosis, synovial osteochondroma, and osteosarcoma (Figure 18).

Infectious arthritis

TMJ infection is usually secondary to direct extension of infection from the adjacent tissue into the joint. Systemic infections such as tuberculosis and syphilis can rarely involve the TMJ. TMJ infection is more common in the setting of immunosuppression and presence of other systematic diseases such as diabetes mellitus, rheumatoid arthritis and intravenous drug use, *etc*.

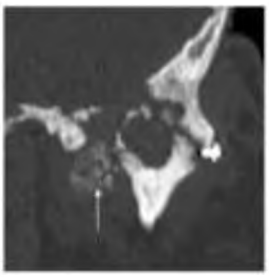


Figure 18 Calcium pyrophosphate dehydrate deposition disease. Coronal reformation of the axial dataset demonstrates destruction of the left temporomandibular joint with erosion and deformity of both the mandibular condyle and the glenoid fossa. There is extensive extensive calcium pyrophosphate dehydrate deposition disease medial to the joint space (arrow).

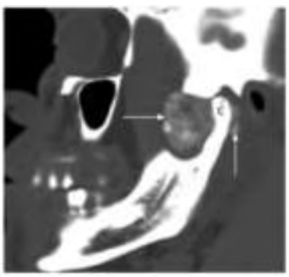


Figure 19 Synovial chondromatosis. Sagittal reformation of the axial dataset demonstrates extensive cloud-like calcification (arrows) filling and expanding the joint space anterior to the mandibular condyle (the letter, c). Calcification is also present posterior to the mandibular condyle.

TUMORS AND TUMOR-LIKE CONDITIONS OF THE TMJ

Tumors and tumor-like conditions can affect the TMJ. These conditions may have similar presentations such as pain, swelling, and limitation of motion.

Synovial chondromatosis

Synovial chondromatosis (SC) is a benign condition with chondrometaplasia of the synovial membrane and formation of cartilaginous nodules. These nodules can become detached and form loose bodies which later calcify. Synovial chondromatosis typically involves large joints, such as the knee, hip, and elbow. It is uncommon for the temporomandibular joint to be affected by SC. SC typically involves the superior compartment of TMJ while involvement of the inferior compartment is rare and secondary to perforation of the articular disc. Uncommon findings include erosion of the mandibular condylar head, temporal skull base, and intracranial extension.

Patients typically present with preauricular pain, swelling, inflammation, limitation of motion, and articular noises. Some patients also report neurologic dysfunction, such as headache and hearing loss.

The diagnosis of TMJ synovial chondromatosis is difficult since it is a rare disease and can have similar findings to more common diseases, such as chondrocalcinosis, osteoarthritis, and chondrosarcoma. The radiologic findings of SC include calcified loose bodies, soft tissue swelling, widening of the joint space, irregularities of the joint surface, and sclerosis of the glenoid fossa and/or mandibular condyle. CT typically shows calcified nodules surrounding the mandibular condyle with degenerative changes of the condyle[85]. MRI typically shows mixed solid and fluid signal related to the metaplasia of the synovial tissue and the fluid component of the accumulated synovial secretions. The calcified nodules are T1/T2 hypointense with a surrounding T2 hyperintense effusion and proliferative synovium, which enhances after contrast administration. MRI is preferred in evaluation of SC over CT because of the ability to detect non-calcified loose bodies, lack of radiation, and visualization of the articular disc[86] (Figure 19).

Treatment is surgical removal of the loose bodies and excision of the metaplastic synovium. In end stage SC without synovial metaplastic activity, the treatment is often non-surgical with therapy aimed towards symptom relief.

Pigmented villonodular synovitis

Pigmented villonodular synovitis (PVNS) is a benign, non-neoplastic proliferative disorder of the synovial membranes of joints, bursae, and tendon sheaths. The disease is typically monoarticular and can involve any joint but is most often seen in the knee. Primary PVNS of the TMJ is rare. There are two forms of PVNS: nodular and diffuse. The most common nodular patterns of PVNS include giant cell tumor, xanthoma, xanthogranuloma, and mycloplaxoma, which affect a focal part of the synovium[85]. Diffuse PVNS affects nearly the entire synovium.

The exact etiology of PVNS is unclear. It was originally postulated to be an inflammatory response to an unknown stimulus. Other theories attribute it to repetitive intra-articular hemorrhage from trauma, altered lipid metabolism, or a benign neoplastic proliferation.

PVNS commonly presents as a slowly growing and non-tender swelling of the affected joint. Patients with involvement of the TMJ, can present with a preauricular mass with swelling, pain, tenderness, clicking, otalgia, and hearing loss.

The most sensitive method for the detection of PVNS is by MRI demonstrating T1/T2 hypointensity and blooming on the GRE sequences from paramagnetic hemosiderin deposition[86]. There may be moderate to intense inhomogeneous enhancement of the synovium. CT findings are usually nonspecific with bone erosion, subchondral cysts, and a soft tissue mass[87]. A joint effusion may be dense from the hemosiderin. The differential diagnosis of PVNS on MRI includes synovial chondrom-

atosis, rheumatoid arthritis, synovial sarcoma, hemophilia, and synovial hemangioma.

Primary and secondary neoplasms, and other lesions

Osteochondroma is the second most common neoplastic lesion affecting the TMJ. Osteochondroma, osteoma, and condylar hyperplasia are often difficult to differentiate both clinically and on imaging. MR and CT may delineate the exact extent of the tumor and its relationship to anatomic structures within the TMJ.

Synovial cysts, ganglion cysts and simple bone cysts may also occur. Many benign primary bone neoplasms, such as chondroblastoma, osteoma, osteoid osteoma, osteoblastoma, ossifying fibroma and aneurysmal bone cyst can also involve the TMJ. Malignant primary bone neoplasms are extremely rare in TMJ but include chondrosarcoma and osteogenic sarcoma. There also can be extension of tumors from adjacent structures into the TMJ. Tumors from the external ear and parotid gland can extend into the TMJ. Less than 1% of all tumors metastasize into the maxillofacial region. Adenocarcinoma is the most common metastatic tumor of the jaw, making up about 70% of cases. Reported metastasis to TMJ includes breast, renal, lung, colon, prostate, thyroid, and testicular primary.

CONCLUSION

Imaging of TMJ should be performed on a case by case basis depending upon clinical signs and symptoms. MRI is the diagnostic study of choice for evaluation of disk position and internal derangement of the joint. CT scan for evaluation of TMJ is indicated if bony involvement is suspected and should be judiciously considered because of radiation risk. Understanding of the TMJ anatomy, biomechanics, and the imaging manifestations of diseases is important to accurately recognize and manage these various pathologies.

REFERENCES

1 **Aiken A**, Bouloux G, Hudgins P. MR imaging of the temporomandibular joint. *Magn Reson Imaging Clin N Am* 2012; **20**: 397-412 [PMID: 22877948 DOI: 10.1016/j.mric.2012.05.002]
2 **Guralnick W**, Kaban LB, Merrill RG. Temporomandibular-joint afflictions. *N Engl J Med* 1978; **299**: 123-129 [PMID: 661872 DOI: 10.1056/NEJM197807202990304]
3 **Alomar X**, Medrano J, Cabratosa J, Clavero JA, Lorente M, Serra I, Monill JM, Salvador A. Anatomy of the temporomandibular joint. *Semin Ultrasound CT MR* 2007; **28**: 170-183 [PMID: 17571700 DOI: 10.1053/j.sult.2007.02.002]
4 **Sommer OJ**, Aigner F, Rudisch A, Gruber H, Fritsch H, Millesi W, Stiskal M. Cross-sectional and functional imaging of the temporomandibular joint: radiology, pathology, and basic biomechanics of the jaw. *Radiographics* 2003; **23**: e14 [PMID: 12920179 DOI: 10.1148/rg.e14]
5 **Sava A**, Scutariu M. Functional anatomy of the temporomandibular joint (II). *Rev Med Chir Soc Med Nat Iasi* 2012; **116**: 1213-1217 [PMID: 23700914]
6 **Van Eijden TM**, Korfage JA, Brugman P. Architecture of the human jaw-closing and jaw-opening muscles. *Anat Rec* 1997; **248**: 464-474 [PMID: 9214565 DOI: 10.1002/(SICI)1097-0185(199707)248:3<464::AID-AR20>3.0.CO;2-M]
7 **Imanimoghaddam M**, Madani AS, Hashemi FM. The evaluation of lateral pterygoid muscle pathologic changes and insertion patterns in temporomandibular joints with or without disc displacement using magnetic resonance imaging. *Int J Oral Maxillofac Surg* 2013; **42**: 1116-1120 [PMID: 23746672 DOI: 10.1016/j.ijom.2013.01.022]
8 **Tomas X**, Pomes J, Berenguer J, Mercader JM, Pons F, Donoso L. Temporomandibular joint soft-tissue pathology, II: Nondisc abnormalities. *Semin Ultrasound CT MR* 2007; **28**: 205-212 [PMID: 17571703 DOI: 10.1053/j.sult.2007.02.005]
9 **Tomas X**, Pomes J, Berenguer J, Quinto L, Nicolau C, Mercader JM, Castro V. MR imaging of temporomandibular joint dysfunction: a pictorial review. *Radiographics* 2006; **26**: 765-781 [PMID: 16702453 DOI: 10.1148/rg.263055091]
10 **Koolstra JH**. Dynamics of the human masticatory system. *Crit Rev Oral Biol Med* 2002; **13**: 366-376 [PMID: 12191962 DOI: 10.1177/154411130201300406]
11 **Lobbezoo F**, Drangsholt M, Peck C, Sato H, Kopp S, Svensson P. Topical review: new insights into the pathology and diagnosis of disorders of the temporomandibular joint. *J Orofac Pain* 2004; **18**: 181-191 [PMID: 15508997]
12 **Harms SE**, Wilk RM. Magnetic resonance imaging of the temporomandibular joint. *Radiographics* 1987; **7**: 521-542 [PMID: 3448646 DOI: 10.1148/radiographics.7.3.3448646]
13 **Katzberg RW**. Temporomandibular joint imaging. *Radiology* 1989; **170**: 297-307 [PMID: 2643133]
14 **Rao VM**, Bacelar MT. MR imaging of the temporomandibular joint. *Magn Reson Imaging Clin N Am* 2002; **10**: 615-630 [PMID: 12685497 DOI: 10.1016/S1064-9689(02)00011-9]
15 **Drace JE**, Enzmann DR. Defining the normal temporomandibular joint: closed-, partially open-, and open-mouth MR imaging of asymptomatic subjects. *Radiology* 1990; **177**: 67-71 [PMID: 2399340]
16 **Katzberg RW**, Westesson PL, Tallents RH, Drake CM. Anatomic disorders of the temporomandibular joint disc in asymptomatic subjects. *J Oral Maxillofac Surg* 1996; **54**: 147-153; discussion 153-155 [PMID: 8604061 DOI: 10.1016/S0278-2391(96)90435-8]
17 **Rammelsberg P**, Pospiech PR, Jäger L, Pho Duc JM, Böhm AO, Gernet W. Variability of disk position in asymptomatic volunteers and patients with internal derangements of the TMJ. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997; **83**: 393-399 [PMID: 9084204 DOI: 10.1016/S1079-2104(97)90248-1]
18 **Tallents RH**, Katzberg RW, Murphy W, Proskin H. Magnetic resonance imaging findings in asymptomatic volunteers and symptomatic patients with temporomandibular disorders. *J Prosthet Dent* 1996; **75**: 529-533 [PMID: 8709019 DOI: 10.1016/S0022-3913(96)90458-8]
19 **Orsini MG**, Kuboki T, Terada S, Matsuka Y, Yamashita A, Clark GT. Diagnostic value of 4 criteria to interpret temporomandibular joint normal disk position on magnetic resonance images. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998; **86**: 489-497 [PMID: 9798238 DOI: 10.1016/S1079-2104(98)90380-8]
20 **Provenzano Mde M**, Chilvarquer I, Fenyo-Pereira M. How should the articular disk position be analyzed? *J Oral Maxillofac Surg* 2012; **70**: 1534-1539 [PMID: 22079066 DOI: 10.1016/j.joms.2011.08.004]
21 **Vilanova JC**, Barceló J, Puig J, Remollo S, Nicolau C, Bru C. Diagnostic imaging: magnetic resonance imaging, computed tomography, and ultrasound. *Semin Ultrasound CT MR* 2007; **28**: 184-191 [PMID: 17571701 DOI: 10.1053/j.sult.2007.02.003]
22 **Westesson PL**, **O-YM**, Sano T, Okano T. Anatomy, Pathology, and Imaging of the Temporomandibular Joint. In: Som PM, Curtin HD, ed. Head and Neck Imaging-2 Volume Set, 5th Edition. St. Louis: Mosby, 2011: 1547-613
23 **Dennison J**, Mahoney P, Herbison P, Dias G. The false and the true bifid condyles. *Homo* 2008; **59**: 149-159 [PMID:

18417126 DOI: 10.1016/j.jchb.2008.02.001]
24 **Lacout A**, Marsot-Dupuch K, Smoker WR, Lasjaunias P. Foramen tympanicum, or foramen of Huschke: pathologic cases and anatomic CT study. *AJNR Am J Neuroradiol* 2005; **26**: 1317-1323 [PMID: 15956489]
25 **Tozoglu U**, Caglayan F, Harorli A. Foramen tympanicum or foramen of Huschke: anatomical cone beam CT study. *Dentomaxillofac Radiol* 2012; **41**: 294-297 [PMID: 22517996]
26 **Tank W**, Wright D, Iizuka T. Unilateral dysplasia of the mandibular condyle: report of a case. *J Oral Maxillofac Surg* 1998; **56**: 765-769 [PMID: 9632337]
27 **Berger SS**, Stewart RE. Mandibular hypoplasia secondary to perinatal trauma: report of case. *J Oral Surg* 1977; **35**: 578-582 [PMID: 267174]
28 **Kaneyama K**, Segami N, Hatta T. Congenital deformities and developmental abnormalities of the mandibular condyle in the temporomandibular joint. *Congenit Anom* (Kyoto) 2008; **48**: 118-125 [PMID: 18778456 DOI: 10.1111/j.1741-4520.2008.00191.x]
29 **Wolford LM**. Idiopathic condylar resorption of the temporomandibular joint in teenage girls (cheerleaders syndrome). *Proc* (Bayl Univ Med Cent) 2001; **14**: 246-252 [PMID: 16369629]
30 **Angiero F**, Farronato G, Benedicenti S, Vinci R, Farronato D, Magistro S, Stefani M. Mandibular condylar hyperplasia: clinical, histopathological, and treatment considerations. *Cranio* 2009; **27**: 24-32 [PMID: 19241796]
31 **Ladeira DB**, Barbosa GL, Nascimento MC, Cruz AD, Freitas DQ, Almeida SM. Prevalence and characteristics of pneumatization of the temporal bone evaluated by cone beam computed tomography. *Int J Oral Maxillofac Surg* 2013; **42**: 771-775 [PMID: 23290566]
32 **Miloglu O**, Yilmaz AB, Yildirim E, Akgul HM. Pneumatization of the articular eminence on cone beam computed tomography: prevalence, characteristics and a review of the literature. *Dentomaxillofac Radiol* 2011; **40**: 110-114 [PMID: 21239574]
33 **Rudisch A**, Innerhofer K, Bertram S, Emshoff R. Magnetic resonance imaging findings of internal derangement and effusion in patients with unilateral temporomandibular joint pain. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001; **92**: 566-571 [PMID: 11709695 DOI: 10.1067/moe.2001.116817]
34 **Cholitgul W**, Nishiyama H, Sasai T, Uchiyama Y, Fuchihata H, Rohlin M. Clinical and magnetic resonance imaging findings in temporomandibular joint disc displacement. *Dentomaxillofac Radiol* 1997; **26**: 183-188 [PMID: 9442605 DOI: 10.1038/sj.dmfr.4600239]
35 **Larheim TA**, Westesson P, Sano T. Temporomandibular joint disk displacement: comparison in asymptomatic volunteers and patients. *Radiology* 2001; **218**: 428-432 [PMID: 11161157 DOI: 10.1148/radiology.218.2.r01fe11428]
36 **Ribeiro RF**, Tallents RH, Katzberg RW, Murphy WC, Moss ME, Magalhaes AC, Tavano O. The prevalence of disc displacement in symptomatic and asymptomatic volunteers aged 6 to 25 years. *J Orofac Pain* 1997; **11**: 37-47 [PMID: 10332309]
37 **Paesani D**, Westesson PL, Hatala M, Tallents RH, Kurita K. Prevalence of temporomandibular joint internal derangement in patients with craniomandibular disorders. *Am J Orthod Dentofacial Orthop* 1992; **101**: 41-47 [PMID: 1731487]
38 **Tasaki MM**, Westesson PL, Raubertas RF. Observer variation in interpretation of magnetic resonance images of the temporomandibular joint. *Oral Surg Oral Med Oral Pathol* 1993; **76**: 231-234 [PMID: 8361737]
39 **Tasaki MM**, Westesson PL, Isberg AM, Ren YF, Tallents RH. Classification and prevalence of temporomandibular joint disk displacement in patients and symptom-free volunteers. *Am J Orthod Dentofacial Orthop* 1996; **109**: 249-262 [PMID: 8607470]
40 **Sano T**, Yamamoto M, Okano T. Temporomandibular joint MR imaging. *Neuroimaging Clin N Am* 2003; **13**: 583-595 [PMID: 14631692]
41 **Som PM**, Bergeron RT. Head and neck imaging. 2nd ed. St. Louis: Mosby Year Book, 1991
42 **de Leeuw R**, Boering G, Stegenga B, de Bont LG. TMJ articular disc position and configuration 30 years after initial diagnosis of internal derangement. *J Oral Maxillofac Surg* 1995; **53**: 234-241; discussion 241-242 [PMID: 7861272]
43 **Suenaga S**, Hamamoto S, Kawano K, Higashida Y, Noikura T. Dynamic MR imaging of the temporomandibular joint in patients with arthrosis: relationship between contrast enhancement of the posterior disk attachment and joint pain. *AJR Am J Roentgenol* 1996; **166**: 1475-1481 [PMID: 8633468 DOI: 10.2214/ajr.166.6.8633468]
44 **Helms CA**, Kaban LB, McNeill C, Dodson T. Temporomandibular joint: morphology and signal intensity characteristics of the disk at MR imaging. *Radiology* 1989; **172**: 817-820 [PMID: 2772194]
45 **Chossegros C**, Cheynet F, Guyot L, Bellot-Samson V, Blanc JL. Posterior disk displacement of the TMJ: MRI evidence in two cases. *Cranio* 2001; **19**: 289-293 [PMID: 11725853]
46 **Katzberg RW**, Westesson PL, Tallents RH, Anderson R, Kurita K, Manzione JV, Totterman S. Temporomandibular joint: MR assessment of rotational and sideways disk displacements. *Radiology* 1988; **169**: 741-748 [PMID: 3186996]
47 **Konttinen YT**, Ainola M, Valleala H, Ma J, Ida H, Mandelin J, Kinne RW, Santavirta S, Sorsa T, López-Otin C, Takagi M. Analysis of 16 different matrix metalloproteinases (MMP-1 to MMP-20) in the synovial membrane: different profiles in trauma and rheumatoid arthritis. *Ann Rheum Dis* 1999; **58**: 691-697 [PMID: 10531073]
48 **Schellhas KP**, Wilkes CH. Temporomandibular joint inflammation: comparison of MR fast scanning with T1- and T2-weighted imaging techniques. *AJR Am J Roentgenol* 1989; **153**: 93-98 [PMID: 2735304 DOI: 10.2214/ajr.153.1.93]
49 **Roberts D**, Schenck J, Joseph P, Foster T, Hart H, Pettigrew J, Kundel HL, Edelstein W, Haber B. Temporomandibular joint: magnetic resonance imaging. *Radiology* 1985; **154**: 829-830 [PMID: 3969490]
50 **Katzberg RW**, Westesson P-L. Diagnosis of the temporomandibular joint, 1e. Philadelphia: W. B. Saunders Co., 1993
51 **Cholitgul W**, Petersson A, Rohlin M, Akerman S. Clinical and radiological findings in temporomandibular joints with disc perforation. *Int J Oral Maxillofac Surg* 1990; **19**: 220-225 [PMID: 2120363]
52 **Kondoh T**, Westesson PL, Takahashi T, Seto K. Prevalence of morphological changes in the surfaces of the temporomandibular joint disc associated with internal derangement. *J Oral Maxillofac Surg* 1998; **56**: 339-343; discussion 343-344 [PMID: 9496846]
53 **Widmalm SE**, Westesson PL, Kim IK, Pereira FJ, Lundh H, Tasaki MM. Temporomandibular joint pathosis related to sex, age, and dentition in autopsy material. *Oral Surg Oral Med Oral Pathol* 1994; **78**: 416-425 [PMID: 7800370]
54 **Kuribayashi A**, Okochi K, Kobayashi K, Kurabayashi T. MRI findings of temporomandibular joints with disk perforation. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008; **106**: 419-425 [PMID: 18504154 DOI: 10.1016/j.tripleo.2007.11.020]
55 **Yura S**, Nobata K, Shima T. Diagnostic accuracy of fat-saturated T2-weighted magnetic resonance imaging in the diagnosis of perforation of the articular disc of the temporomandibular joint. *Br J Oral Maxillofac Surg* 2012; **50**: 363-368 [PMID: 21723011 DOI: 10.1016/j.bjoms.2011.05.017]
56 **Larheim TA**, Katzberg RW, Westesson PL, Tallents RH, Moss ME. MR evidence of temporomandibular joint fluid and condyle marrow alterations: occurrence in asymptomatic volunteers and symptomatic patients. *Int J Oral Maxillofac Surg* 2001; **30**: 113-117 [PMID: 11405445 DOI: 10.1054/ijom.2000.0018]
57 **Westesson PL**, Brooks SL. Temporomandibular joint: rela-

tionship between MR evidence of effusion and the presence of pain and disk displacement. *AJR Am J Roentgenol* 1992; **159**: 559-563 [PMID: 1503025 DOI: 10.2214/ajr.159.3.1503025]
58 **Smith HJ**, Larheim TA, Aspestrand F. Rheumatic and non-rheumatic disease in the temporomandibular joint: gadolinium-enhanced MR imaging. *Radiology* 1992; **185**: 229-234 [PMID: 1523314 DOI: 10.1148/radiology.185.1.1523314]
59 **Lafrenière CM**, Lamontagne M, el-Sawy R. The role of the lateral pterygoid muscles in TMJ disorders during static conditions. *Cranio* 1997; **15**: 38-52 [PMID: 9586487]
60 **Yang X**, Pernu H, Pyhtinen J, Tiilikainen PA, Oikarinen KS, Raustia AM. MR abnormalities of the lateral pterygoid muscle in patients with nonreducing disk displacement of the TMJ. *Cranio* 2002; **20**: 209-221 [PMID: 12150268]
61 **Taskaya-Yilmaz N**, Ceylan G, Incesu L, Muglali M. A possible etiology of the internal derangement of the temporomandibular joint based on the MRI observations of the lateral pterygoid muscle. *Surg Radiol Anat* 2005; **27**: 19-24 [PMID: 15750717 DOI: 10.1007/s00276-004-0267-6]
62 **Schellhas KP**, Wilkes CH, Fritts HM, Omlie MR, Heithoff KB, Jahn JA. Temporomandibular joint: MR imaging of internal derangements and postoperative changes. *AJR Am J Roentgenol* 1988; **150**: 381-389 [PMID: 3257330 DOI: 10.2214/ajr.150.2.381]
63 **Schellhas KP**, Wilkes CH, Fritts HM, Omlie MR, Lagrotteria LB. MR of osteochondritis dissecans and avascular necrosis of the mandibular condyle. *AJR Am J Roentgenol* 1989; **152**: 551-560 [PMID: 2783809 DOI: 10.2214/ajr.152.3.551]
64 **Larheim TA**, Westesson PL, Hicks DG, Eriksson L, Brown DA. Osteonecrosis of the temporomandibular joint: correlation of magnetic resonance imaging and histology. *J Oral Maxillofac Surg* 1999; **57**: 888-898; discussion 899 [PMID: 10437715]
65 **Mesgarzadeh M**, Sapega AA, Bonakdarpour A, Revesz G, Moyer RA, Maurer AH, Alburger PD. Osteochondritis dissecans: analysis of mechanical stability with radiography, scintigraphy, and MR imaging. *Radiology* 1987; **165**: 775-780 [PMID: 3685359 DOI: 10.1148/radiology.165.3.3685359]
66 **Xiang S**, Rebellato J, Inwards CY, Keller EE. Malocclusion associated with osteocartilaginous loose bodies of the temporomandibular joint. *J Am Dent Assoc* 2005; **136**: 484-489 [PMID: 15884318]
67 **Von Arx DP**, Simpson MT, Batman P. Synovial chondromatosis of the temporomandibular joint. *Br J Oral Maxillofac Surg* 1988; **26**: 297-305 [PMID: 3048377]
68 **Norman JE**, Stevenson AR, Painter DM, Sykes DG, Feain LA. Synovial osteochondromatosis of the temporomandibular joint. An historical review with presentation of 3 cases. *J Craniomaxillofac Surg* 1988; **16**: 212-220 [PMID: 3042809]
69 **Boccardi A**. CT evaluation of chondromatosis of the temporomandibular joint. *J Comput Assist Tomogr* 1991; **15**: 826-828 [PMID: 1885803]
70 **van Ingen JM**, de Man K, Bakri I. CT diagnosis of synovial chondromatosis of the temporomandibular joint. *Br J Oral Maxillofac Surg* 1990; **28**: 164-167 [PMID: 2135654]
71 **Nitzan DW**. Temporomandibular joint "open lock" versus condylar dislocation: signs and symptoms, imaging, treatment, and pathogenesis. *J Oral Maxillofac Surg* 2002; **60**: 506-11; discussion 512-3 [PMID: 11988925]
72 **DaSilva AF**, Shaefer J, Keith DA. The temporomandibular joint: clinical and surgical aspects. *Neuroimaging Clin N Am* 2003; **13**: 573-582 [PMID: 14631691]
73 **Güven O**. A clinical study on temporomandibular joint ankylosis. *Auris Nasus Larynx* 2000; **27**: 27-33 [PMID: 10648065]
74 **Cannizzaro E**, Schroeder S, Müller LM, Kellenberger CJ, Saurenmann RK. Temporomandibular joint involvement in children with juvenile idiopathic arthritis. *J Rheumatol* 2011; **38**: 510-515 [PMID: 21159837 DOI: 10.3899/jrheum.100325]
75 **Twilt M**, Mobers SM, Arends LR, ten Cate R, van Suijlekom-Smit L. Temporomandibular involvement in juvenile idiopathic arthritis. *J Rheumatol* 2004; **31**: 1418-1422 [PMID: 15229986]
76 **Weiss PF**, Arabshahi B, Johnson A, Bilaniuk LT, Zarnow D, Cahill AM, Feudtner C, Cron RQ. High prevalence of temporomandibular joint arthritis at disease onset in children with juvenile idiopathic arthritis, as detected by magnetic resonance imaging but not by ultrasound. *Arthritis Rheum* 2008; **58**: 1189-1196 [PMID: 18383394 DOI: 10.1002/art.23401]
77 **Koh ET**, Yap AU, Koh CK, Chee TS, Chan SP, Boudville IC. Temporomandibular disorders in rheumatoid arthritis. *J Rheumatol* 1999; **26**: 1918-1922 [PMID: 10493669]
78 **Yoshida A**, Higuchi Y, Kondo M, Tabata O, Ohishi M. Range of motion of the temporomandibular joint in rheumatoid arthritis: relationship to the severity of disease. *Cranio* 1998; **16**: 162-167 [PMID: 9852809]
79 **Kretapirom K**, Okochi K, Nakamura S, Tetsumura A, Ohbayashi N, Yoshino N, Kurabayashi T. MRI characteristics of rheumatoid arthritis in the temporomandibular joint. *Dentomaxillofac Radiol* 2013; **42**: 31627230 [PMID: 22842633 DOI: 10.1259/dmfr/31627230]
80 **Tanaka E**, Detamore MS, Mercuri LG. Degenerative disorders of the temporomandibular joint: etiology, diagnosis, and treatment. *J Dent Res* 2008; **87**: 296-307 [PMID: 18362309]
81 **Hussain AM**, Packota G, Major PW, Flores-Mir C. Role of different imaging modalities in assessment of temporomandibular joint erosions and osteophytes: a systematic review. *Dentomaxillofac Radiol* 2008; **37**: 63-71 [PMID: 18239033 DOI: 10.1259/dmfr/16932758]
82 **Matsumura Y**, Nomura J, Nakanishi K, Yanase S, Kato H, Tagawa T. Synovial chondromatosis of the temporomandibular joint with calcium pyrophosphate dihydrate crystal deposition disease (pseudogout). *Dentomaxillofac Radiol* 2012; **41**: 703-707 [PMID: 23166363 DOI: 10.1259/dmfr/24183821]
83 **Kahraman AS**, Kahraman B, Dogan M, Firat C, Samdanci E, Celik T. Synovial chondromatosis of the temporomandibular joint: radiologic and histopathologic findings. *J Craniofac Surg* 2012; **23**: 1211-1213 [PMID: 22801131 DOI: 10.1097/SCS.0b013e3182564a6e]
84 **Wang P**, Tian Z, Yang J, Yu Q. Synovial chondromatosis of the temporomandibular joint: MRI findings with pathological comparison. *Dentomaxillofac Radiol* 2012; **41**: 110-116 [PMID: 22116129 DOI: 10.1259/dmfr/36144602]
85 **Giannakopoulos H**, Chou JC, Quinn PD. Pigmented villonodular synovitis of the temporomandibular joint. *Ear Nose Throat J* 2013; **92**: E10-E13 [PMID: 23904309]
86 **Kim KW**, Han MH, Park SW, Kim SH, Lee HJ, Jae HJ, Kang JW, Chang KH. Pigmented villonodular synovitis of the temporomandibular joint: MR findings in four cases. *Eur J Radiol* 2004; **49**: 229-234 [PMID: 14962652 DOI: 10.1016/S0720-048X(03)00099-8]
87 **Le WJ**, Li MH, Yu Q, Shi HM. Pigmented villonodular synovitis of the temporomandibular joint: CT imaging findings. *Clin Imaging* 2014; **38**: 6-10 [PMID: 24100118 DOI: 10.1016/j.clinimag.2013.08.011]

P- Reviewer: Franco AL, Rattan V, Ramirez Aristeguieta LM
S- Editor: Ji FF **L- Editor**: A **E- Editor**: Liu SQ

Published by **Baishideng Publishing Group Inc**
8226 Regency Drive, Pleasanton, CA 94588, USA
Telephone: +1-925-223-8242
Fax: +1-925-223-8243
E-mail: bpgoffice@wjgnet.com
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
http://www.wjgnet.com

Lampiran 4

Braz J Otorhinolaryngol. 2016;82(3):341–352

Brazilian Journal of
OTORHINOLARYNGOLOGY
www.bjorl.org

REVIEW ARTICLE

Diagnosis of temporomandibular joint disorders: indication of imaging exams☆

Luciano Ambrosio Ferreira[a,b,c,d,*], Eduardo Grossmann[e,f,g], Eduardo Januzzi[h], Marcos Vinicius Queiroz de Paula[i,j], Antonio Carlos Pires Carvalho[d]

[a] Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora, MG, Brazil
[b] Faculdade Sete Lagoas (FACSETE), Sete Lagoas, MG, Brazil
[c] Hospital Maternidade Therezinha de Jesus-HMTJ/JF, Suprema-Faculdade de Ciências Médicas e da Saúde, Juiz de Fora, MG, Brazil
[d] Department of Radiology, Faculdade de Medicina, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil
[e] Pontifícia Universidade Católica do Rio Grande do Sul (PUC-RS), Porto Alegre, RS, Brazil
[f] Universidade Estadual de Maringá, Maringá, PR, Brazil
[g] Department of Morphology, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil
[h] Postgraduate Course in Temporomandibular Joint Dysfunction and Orofacial Pain, Faculdade Sete Lagoas (FACSETE), Sete Lagoas, MG, Brazil
[i] Discipline of Propaedeutic and Dental Radiology, Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora, MG, Brazil
[j] Postgraduate Course in Dental Radiology and Imagenology, Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora, MG, Brazil

Received 23 October 2014; accepted 16 June 2015
Available online 8 January 2016

KEYWORDS
Temporomandibular joint disorders;
Diagnostic imaging;
Temporomandibular joint;
Magnetic resonance imaging;
X-ray computed tomography;
Radiography

Abstract
Introduction: Knowledge of the different imaging tests and their appropriate indications is crucial to establish the diagnosis of temporomandibular disorders, especially in patients with overlapping signs and symptoms.
Objective: To present and assess the main diagnostic imaging tests for temporomandibular disorders and rationally discuss their indication criteria, advantages, and disadvantages.
Methods: Literature review in the Web of Knowledge, PubMed and SciELO databases, as well as manual search for relevant publications in reference lists of the selected articles.
Results: Computed tomography and magnetic resonance imaging were considered the gold standard assessments for the temporomandibular joint to evaluate hard and soft tissues, respectively. Each diagnostic method exhibited distinct sensitivity and specificity for the different subtypes of joint dysfunction.

☆ Please cite this article as: Ferreira LA, Grossmann E, Januzzi E, de Paula MVQ, Carvalho ACP. Diagnosis of temporomandibular joint disorders: indication of imaging exams. Braz J Otorhinolaryngol. 2016;82:341–52.

* Corresponding author.
E-mail: lucianoaf369@gmail.com (L.A. Ferreira).

http://dx.doi.org/10.1016/j.bjorl.2015.06.010

Lampiran 4

Conclusion: Selecting an evaluation examination based on its accuracy, safety, and clinical relevance is a rational decision that can help lead to an accurate diagnosis and an optimum treatment plan.

PALAVRAS-CHAVE
Transtornos da articulação temporomandibular;
Diagnóstico por imagem;
Articulação temporomandibular;
Imagem por ressonância magnética;
Tomografia computadorizada por raios X;
Radiografia

Diagnóstico das disfunções da articulação temporomandibular: indicação dos exames por imagem

Resumo
Introdução: O conhecimento dos distintos exames de imagem e sua correta indicação é fundamental para elaboração do diagnóstico das disfunções temporomandibulares, principalmente em pacientes com grande sobreposição de sinais e sintomas.
Objetivo: Apresentar e avaliar os principais exames de diagnóstico por imagem das disfunções temporomandibulares, além de discutir racionalmente os seus critérios de indicação, vantagens e desvantagens.
Método: Revisão da literatura nas bases de dados Web of Knowledge, PubMed e SciELO, além de busca manual por publicações relevantes nas listas de referências dos artigos selecionados.
Resultado: Os exames de tomografia computadorizada e ressonância magnética foram considerados "padrão-ouro" para a avaliação dos tecidos duros e moles, respectivamente, da articulação temporomandibular. Cada método de diagnóstico pesquisado apresentou sensibilidade e especificidade distintas para os diferentes subtipos de disfunção da articulação.
Conclusão: Considera-se como racional a indicação fundamentada na acurácia, segurança e relevância clínica do exame a ser solicitado, o que implica na adequada determinação do diagnóstico e do plano de tratamento.

Introduction

The temporomandibular joint (TMJ) is a composite ginglymus-arthrodial joint, whose components are the condyle, glenoid cavity and articular tubercle, articular disc, retrodiscal tissue, synovial membrane, and joint capsule.[1] It is the most frequently used joint of the human body and has simultaneous bilateral capacity to move the mandible.[2,3]

Its components often undergo remodeling and adaptation processes. In the presence of temporomandibular disorders (TMD), structural alterations and functional disorders are commonly observed.[2,3]

In most cases, symptoms are diffuse and imprecisely manifested as masticatory myalgia, arthralgia, headache, otalgia, and neck pain, among others.[4–8] Pain in more than one area is common and often leads patients to seek evaluation from various medical and dental specialists, including otorhinolaryngologists.[6,8]

For instructional purposes, the American Academy of Orofacial Pain (AAOP) has classified TMD into two major groups: muscle and joint pain.[9] It is estimated that temporomandibular joint disorders (TMJD) affect approximately 30% of the population in asymptomatic form, as internal joint derangement, comprising disc dislocation and structural changes resulting from osteoarthritis and osteoarthrosis.[1,10,11] The diagnostic subtypes TMJD can be seen in Table 1.

The etiology of TMJD is not fully understood[6,8,12] and is related to the presence of risk factors such as trauma, parafunctional habits, postural condition, occlusal microtrauma, systemic predisposition, sleep disorders, and deleterious psychosocial alterations.[6–8,11,13]

The diagnosis of TMJD is achieved by evaluating the medical history and by physical examination.[6,8,14] However, diagnostic TMJ imaging methods are used to assess the integrity of its components and their functional association, to confirm the extent or progression of an existing disease, and to assess and document the effects of an already established treatment.[9,15] They are essential for assessment in cases of trauma, occlusal alterations and sudden limitation of mouth opening, presence of joint noises, systemic joint diseases, infection and failure of conservative treatments.[13]

Objectives

This study discusses the main imaging techniques for the assessment of TMJ and adjacent structures and their indications for the diagnosis of joint alterations, rationally evaluating their advantages and disadvantages.

Method

Using the ISI Web of Knowledge, PubMed, and SciELO databases, a search was carried out for literature articles published and made available in the years 2004–2014,

Lampiran 4

Table 1 Diagnostic classification proposed by the AAOP.[1]

Congenital or developmental disorders	Hyperplasia
Acquired disorders	Dysplasia
Disorders of disc derangement	Neoplasias
TMJ displacement (dislocation)	Disc displacement with reduction
Inflammatory disorders	Disc displacement without reduction
Non-inflammatory disorders	Synovitis and capsulitis
Ankylosis	Polyarthritis
Fracture (condylar process)	Primary osteoarthritis
Aplasia	Secondary osteoarthritis
Hypoplasia	

AAOP, American Academy of Orofacial Pain.

in English or Portuguese, that contained the keywords "temporomandibular joint disorder" and "diagnostic imaging test."

There were 51 articles found in the ISI Web of Knowledge database, 117 in PubMed, and 25 in SciELO. *Basic research* experimental articles, letters to the editor, and isolated case reports were excluded. A total of 23 articles, characterized as clinical trials, comparative studies, reviews, and case group studies comprised the first stage of the research.

Then, based on the same inclusion criteria, a literature search was performed in the five most frequently cited radiology journals for the years 2004–2014. In this search, six new references were found in addition to the previously selected articles. Four other relevant publications cited in the selected articles' lists of references were added, including historical ones dated prior to 2004.

According to the requirements defined in CNS Resolution 196/96, this study was submitted to the Research Ethics Committee, approved under No. 133/2009, designed to demonstrate the major changes in the TMJ as disclosed by imaging tests.

Temporomandibular joint imaging assessment

Radiographic examinations

TMJ radiographs provide information on the morphological characteristics of osseus components of the joint and certain functional associations between the condyle, articular tubercle and fossa, but are inefficient for evaluating the soft tissues.[1,14,16]

Several anatomical and technical factors can prevent a clear and unobstructed radiographic image of the TMJ.[16,17] When choosing TMJ radiography, one needs to consider the identification of boney structural details, the specific suspected clinical disorder, the amount of symptomatic information clinically available for the diagnosis, the cost of these examinations, and their radiation dose.[3,14] The radiographic techniques most often used in the routine management of TMJD are panoramic radiography, planigraphy, and transcranial radiography[1,3,13,15] (Fig. 1).

Panoramic radiography

As it provides a maxillary overview, it is useful in the differential diagnosis of odontogenic alterations whose symptoms overlap with TMJD.[13,18] It can reveal advanced bone alterations in the condyle, such as asymmetries, erosions, osteophytes, fractures, changes in size and shape, degenerative and inflammatory processes, growth alterations, maxillary tumors, metastases, and ankylosis.[1,13,15,16] However, it does not provide functional information on condylar excursion.[14] Also, only gross alterations in the articular tubercle morphology can be seen because of the superimposition of images of the skull base and the zygomatic arch.[3,14,16,18] This technique is useful as a screening tool, as it allows the initial diagnosis and assessment of TMJ alterations that are not so subtle.[15] It is also indicated when the patient has reduced mouth opening and the differential diagnosis of fracture is considered.[1,3]

Planigraphy (or panoramic radiography with programs for TMJ)

This method provides considerable accuracy and produces images without much overlap. It visualizes the articular boney detail and reveals any anatomical abnormalities in structures adjacent to the TMJ, such as the styloid process, mastoid process, and zygomatic arch.[1,15] It can be obtained in the sagittal and coronal planes, documenting the relationship of the condyle with the articular fossa in maximum habitual intercuspation (MHI) and the excursion extension during maximal mouth opening (MMO). It provides a direct comparison of both sides regarding the hypo-, normo-, or hyperexcursion of the condyle, which is useful in confirming a clinical suspicion of hypermobility.[1,3]

In spite of the relative identification of the TMJ boney structures, it does exhibit some magnification that is inherent to the technique. However, it is useful for functional assessment of mouth opening, evaluation of morphological alteration and the joint spaces, analysis of dimension, fractures, and ankylosis.[3]

Transcranial radiography

Similarly to the planigraphy, this evaluation provides good anatomical assessment of the condyle, fossa, and articular tubercle.[1,14,17] In this technique, an X-ray beam is obliquely directed through the skull to the contralateral TMJ, producing a sagittal view.[17] Thus, the central and medial portions of the condyle are projected inferiorly and only the lateral joint contour is displayed.[17] It is useful to identify bone

Lampiran 4

Figure 1 Radiographic assessments of different TMDs. (a–c) Close-up in panoramic image showing mandibular condyle hypoplasia (a), horizontal impaction of the third molar (a, b) fracture line in the region of gonial angle (b) and elongated styloid process. The transcranial images (d–f) show the presence of osteophytes (d), preservation of joint spaces in maximum habitual intercuspation (MHI) (e) and the identification of condylar hyperexcursion (f). The planography techniques (g–j) demonstrate: mandibular neck fracture and ankylosis (g) elongated styloid process (h), advanced remodeling process, superior-anterior flattening, cortical irregularities, and osteophyte formation (i) in addition to mandibular head hyperexcursion, defining TMJ hypermobility (j).

alterations and displaced fractures of the head and neck of the mandibular condyle, as well as to assess excursion and to determine radiographic joint spaces.[3,14,17]

This type of projection is limited by the fact that it produces an image with a large overlap of the skull bones; it also requires the use of a specific cephalostat for standardization, usually requiring complex positioning.[3,13,14,17]

Arthrography

Arthrography is a variant of the radiographic technique for TMJ, which aims to assess the TMJ soft tissues. In the 1970s and 1980s, arthrography was the method of choice for the identification of disc displacement.[14,15,19] Disc morphology, positioning, and function were indirectly identified by contrast injection into the superior and/or inferior joint spaces.[14] After the injection, dynamic images were obtained, recording mandibular movements.[20]

Even though it is useful for disc position identification, arthrography is not currently recommended as it is an invasive procedure and carries a risk of iatrogenic disc perforation and facial nerve damage.[14] There are also the risks of radiation to radiosensitive structures (crystalline and thyroid), pain and limitation of movement after the injections, infections, allergies to the injected dye,

and it is an examination that is considered difficult to perform.[1,14,15,20]

Other combined radiographic techniques

Due to the two-dimensional radiographic visualization of the TMJ, the combined use of different techniques is necessary to provide an accurate diagnosis and location of the alterations. The evaluation of the structures in different planes illuminates fracture extension, degenerative joint disease, postoperative status, ankylosis, and neoplasms.[3] Additionally, the anatomic relations of areas adjacent to the lesion can be studied with greater diagnostic accuracy, providing more efficient surgical and therapeutic planning.[15] The main combined views are submental (or submento-vertex), transpharyngeal, transmaxillary, reverse Towne, posterior–anterior, and lateral teleradiography.[3,13,15]

Despite their lower cost, technical simplicity, and lower levels of radiation, the use of combined radiographic images has become less common due to increasing use and availability of accurate images such as cone-beam computed tomography, which assess hard tissues in the three anatomical planes and are widely used in dental diagnosis.[13,15]

Computed tomography (CT)

CT comprises a set of images obtained through a sophisticated and highly accurate technique, compared to plane radiographs.[2] Recently, cone-beam computed tomography (CBCT) technology has been used for dental diagnosis due to its specific use for the maxillofacial region.[3,21] Its main advantage is the observation of boney joint structures in the sagittal, coronal, and axial planes,[1,21] in addition to the possible image manipulation at different depths and three-dimensional reconstruction[14,21] through specific software. The examination time varies between 10 and 70 s, and the radiation dose is much lower compared to the helical technique.[1,21]

The main indications of CBCT include structural assessment of bone components of the TMJ, which precisely determines the location and extent of boney alterations: fractures, neoplasms, and ankylosis; erosive degenerative, pseudocystic, and osteophytic alterations; presence of asymptomatic bone remodeling; evaluation of post-surgical conditions; hyperplasia of condylar, coronoid, and styloid processes; persistent foramen of Huschke; as well as intraarticular calcification derived from synovial chondromatosis or metabolic arthritis.[2,14,15]

Hard tissues, teeth, and bones are well demonstrated and measured in their real morphological condition, with minimal noise and artifacts.[1,18,22] However, few details are provided on soft tissue and it is not possible to evaluate the joint disc.[3,22]

Significant disadvantages are the cost of the examination and exposure to significant levels of radiation compared to conventional radiographic techniques.[1,14,15,18]

Fig. 2 shows morphological alterations in joint bone components diagnosed by the CBCT technique.

Magnetic resonance imaging (MRI)

MRI has been the method of choice to study disease processes involving the TMJ soft tissues,[2,20,23] such as the articular disc, ligaments, retrodiscal tissues, intracapsular synovial content, adjacent masticatory muscles, as well as cortical and medullary integrity of bone components.[1,2,15,22]

The technique allows three-dimensional analysis in the axial, coronal, and sagittal planes. It is considered the gold standard for assessing disc position and is highly sensitive for intraarticular degenerative alterations.[3,20,23]

The clinical conditions that suggest its use include persistent symptoms of joint or pre-auricular pain, presence of clicking and crepitation noises, functional alterations such as lateral projections of the condyle during mouth opening, frequent subluxations and dislocations, limited mouth opening movement with terminal stiffness, suspected neoplastic processes, and presence of osteoarthritic symptoms or asymptomatic osteoarthrosis.[1,2,13,15]

This diagnostic test protocols usually include the recording in the MHI and MMO position, using weighted T1, T2, and proton density (PD), in the sagittal and coronal planes.[15] With T1-weighted images, it is possible to obtain excellent anatomic detail; proton density results in satisfactory spatial resolution of joint disc injuries, and is an excellent choice for the evaluation of medial and lateral disc displacements.[20] T2-weighted images record the presence of joint effusion and medullary bone edema.[2,3,20]

The main advantages include detecting soft tissue alterations, necrosis, edema, presence or absence of invasion, and lack of exposure to ionizing radiation.[2,3,15,16,20]

MRI is also indicated for the assessment of the integrity and anatomical relation of neural structures, which, when compressed by tumor or vascular processes, can produce orofacial pain by demyelination and deafferentation.[2,3,13,14,16]

Its disadvantages are related to the high cost and the need for sophisticated facilities. It is contraindicated in claustrophobic patients, those with pacemakers and metallic heart valves, ferromagnetic foreign bodies, and pregnant women.[14,15,23]

Fig. 3 illustrates morphological joint disc and bone structures alterations diagnosed by MRI.

Other imaging techniques

Ultrasonography (US)

The use of US examination, especially by high-resolution imaging equipment, can be a useful option in the assessment of disc position in internal TMJ disorders.[4,23] Although it has considerable diagnostic sensitivity, it has insufficient specificity to identify osteoarthrosis. The findings related to morphological alterations show that the method still does not have accuracy for the cortical and articular disc morphological diagnosis.[24] However, the method is able to identify effusion in patients with inflammatory condition associated with pain, verified by MRI.[23,24]

Even with limitations, it can become a useful option for the initial study of the internal dysfunctions of the

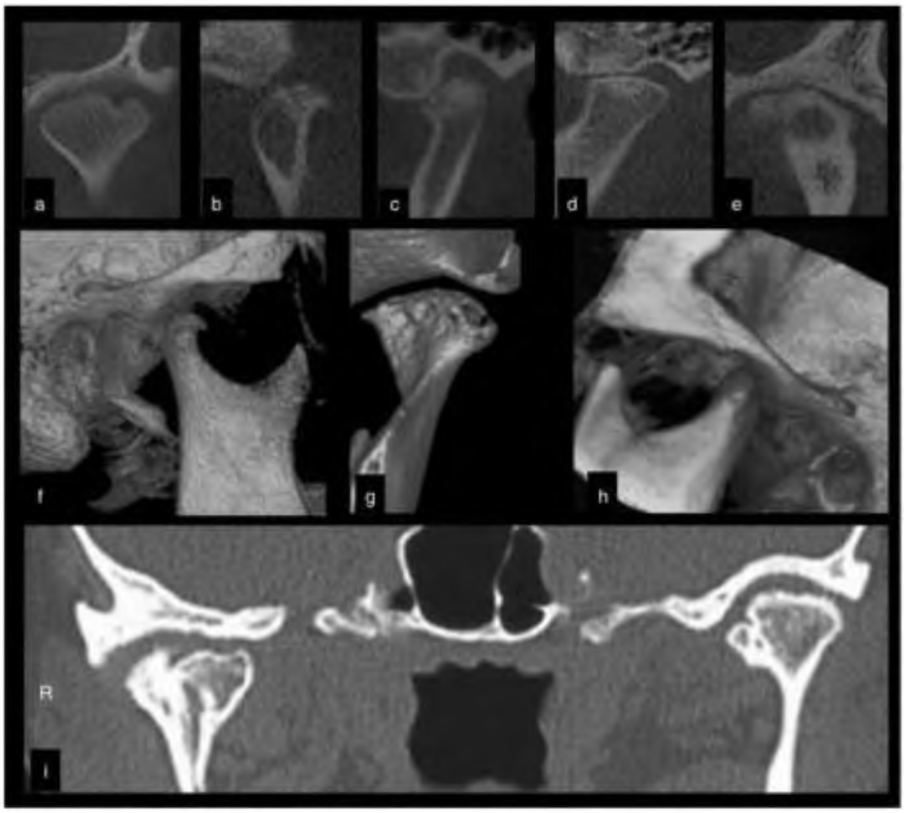


Figure 2 Cone-beam computed tomography (CBCT) assessment of different TMJs in the coronal (a, e) and parasagittal (b–d) views. (a) Coronal view showing extensive erosion. Note the presence of bone sclerosis, cortical irregularities, and osteophytic formation in (b), (c), and (e). The presence of subchondral cysts can be observed in (c) and (e). Advanced flattening of bone components and decreased joint space are recorded in (d). Advanced degenerative osteoarthritis alteration is observed in e. Three-dimensional reconstructions (f–h) show osteophytes (f, g), advanced erosion (g) and hyperexcursion of the mandibular condyle (h). (i) The coronal view of the right and left TMJ shows alteration of the mandibular condyle and hyperdense images in the joint spaces compatible with synovial chondromatosis.

TMJ,[15,22] particularly in patients with contraindications to MRI.[14] Moreover, it is less expensive, allows real-time visualization without the use of ionizing radiation, and is quick and comfortable.[4,22,24]

US assessment is commonly used in the differential diagnosis of glandular and adjacent structures alterations, such as the TMJ and the masseter muscle. The symptoms present in cases of sialadenitis and sialolithiasis can be mistaken for Eagle syndrome, TMD, myofascial pain, nerve pain, and other orofacial pain conditions.

Another indication of the US assessment is the correct location of joint spaces for infiltrative therapies, arthrocentesis, and viscosupplementation (Fig. 4a and b). It shows, dynamically and in realtime, the location of joint components, providing adequate lubrication and washing, which are verified by the increase in joint space after treatment.[25]

Nuclear medicine evaluation

Nuclear medicine facilitates establishing a diagnosis by detecting minute concentrations of radioactive pharmacological substances that determine osteometabolic alterations expressed in imaging exams.[29]

Bone scintigraphy is indicated to define neoplastic activity, metabolic disorders, and bone growth,[14,26,27] as well as

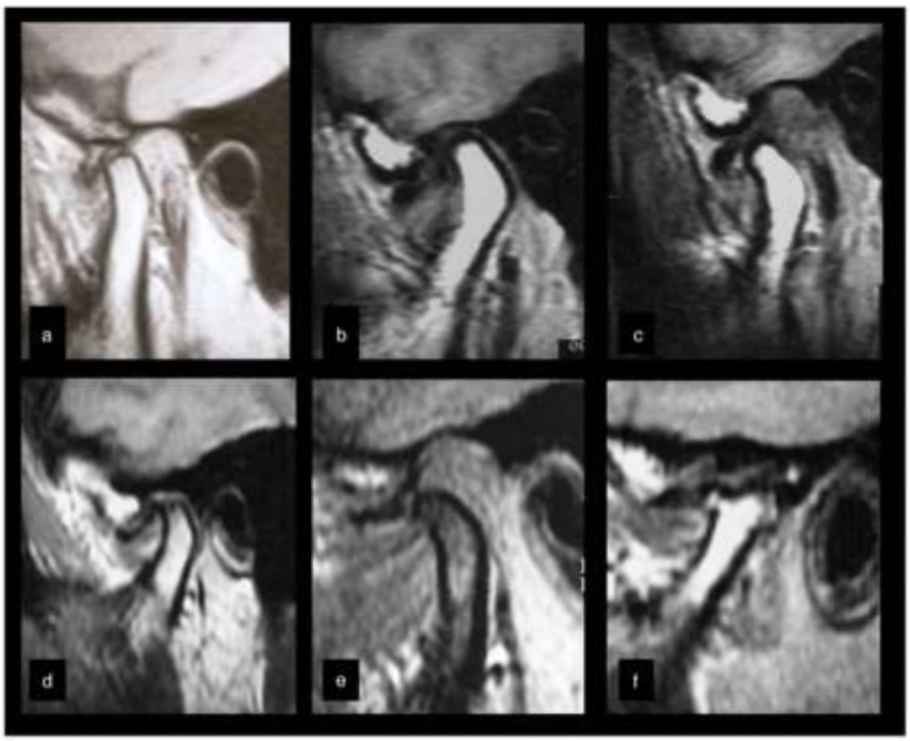


Figure 3 Different MRI assessments disclosing previous joint disc displacement, with no reduction in the parasagittal views. One can observe compressive deformation of the joint disc in (a), also during dynamic comparison of the mandibular condylar movement in (b) and (c). Osteophytic formations (d–f), subchondral cyst (d), and severe change in form (f) define the diagnosis of osteoarthritis degenerative alterations in bone components. The presence of hyperintense T2-weighted images defines the diagnosis of effusion in (b–f).

to evaluate synovitis and osteoarthritis.[18] It is an examination with considerable sensitivity, low invasiveness, and high organ specificity, with low levels of radiation.[27] It has some advantages over radiographies, conventional CT, and MRI because it provides an estimate of metabolic and inflammatory activity.[26,27] It can facilitate an early diagnosis and is less costly than CT and MRI. However, it does not differentiate among bone scar disorders, infections, osteoarthritic manifestations, or tumors.[13]

Positron-emission tomography (PET) is usually indicated for the assessment and staging of metastatic tumors. It is able to provide accurate functional, morphological, and metabolic information.[28] Three-dimensional images facilitate anatomical visualization and can significantly reduce the time required for diagnosis, in addition to properly direct treatments by ensuring that the therapies are appropriate.[15]

Currently, single photon emission computed tomography with technetium-99m methylene diphosphate (SPECT/CT with 99m Tc-MDP) is largely employed.[25] This technology allows for multiplane image acquisition and 3-D display. The radiotracer 99m Tc is able to reflect the local osteometabolic rate, while the anatomic mapping is obtained by tomographic technique.[25] As in the PET, anatomical and functional data are fused into a single image[28] (Fig. 4c and d). Its main advantage is its sensitivity and specificity.[26,28]

Nuclear medicine examinations differ by the radiotracers/radioisotopes used, image capture technique, radiation dose, sensitivity, and presentation of results.[15]

Imaging test indication criteria in the diagnosis of temporomandibular joint disorders

One of the failures in diagnosis and treatment planning is an incorrect or unnecessary selection of unsuitable diagnostic tests. This occurs because of a lack of knowledge on the

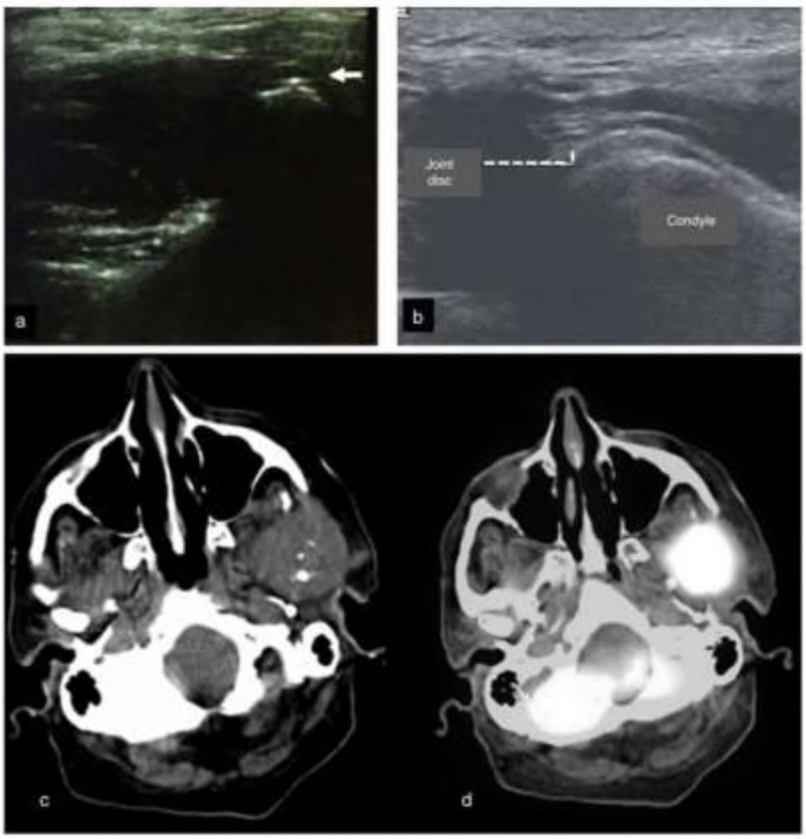


Figure 4 Other imaging techniques. (a) Ultrasound examination of the TMJ[73] used during the arthrocentesis assessment. Note the arthrocentesis needle as a hyperechoic point (white arrow). (b) Ultrasound examination of the TMJ showing the joint disc and condyle. (c) Tomographic axial view[28] showing mass of soft tissue growth in the left TMJ region extending to the ipsilateral pterygoid region. Infra-temporal space with absence of condylar process, the presence of hyperdense areas, swelling, and asymmetry. (d) PET/CT assessment in axial view[28] showing high metabolic activity in the left TMJ region. Images reproduced with permission of the authors' copyrights[25,28] by Elsevier.

part of the professionals regarding the indications of the applicable tests.[29]

The correct indication of an imaging study should be based on the patient's need for legal documentation, his/her individual complaints, and the identified clinical signs and symptoms obtained during history-taking and physical examination.[19,29,30] The basic principle that should guide the professional is that supplementary tests are only indicated when the clinical assessment is not sufficient to arrive at a diagnosis and devise a treatment plan.[31]

For TMJD, the physical examinations of palpation, measurement of movement, functional testing and evaluation of joint noises are instruments of great diagnostic validity when performed by trained and experienced professionals.[6] However, the overlapping of muscle and joint symptoms can impair diagnostic accuracy, as both conditions show functional impairment. In this case and in cases of non-specific symptoms (from, for example, inflammation, neoplasia, and trauma), complementary imaging tests are essential for diagnostic clarification and delineation of the appropriate therapy.[2,6]

Imaging tests, from the simplest to the most complex, have varying degrees of sensitivity and specificity, properties that give them their diagnostic power.[31]

Lampiran 4

Table 2 Indication of imaging tests to diagnose joint TMD and alterations in structures adjacent to the stomatognathic system.

Disorders	Assessed sign	Panoramic[1,3,13,14,16,18,29]	Transcranial[1,3,13,14,16–18,29]	Planigraphy[2,3,13,14,16,18,29]	Arthrography[1,3,13,14,16–18,20,29]
Congenital and developmental					
Aplasia	Absence of structure	b	c	c	a
Hypoplasia	Dimensional reduction	b	c	c	a
Hyperplasia	Dimensional increase	b	c	c	a
Dysplasia	Structural alteration	b	c	c	a
Acquired					
Neoplasias	Bone formation/destruction	b	c	c	a
	Soft tissue growth	–	–	–	–
	Metastasis	a	a	a	–
Disc derangement					
With reduction	Recapture in MMO	–	–	–	c
Without reduction	No recapture in MMO	–	–	–	c
TMJ displacement	Open locking, clinical diagnosis	a	c	c	a
Inflammatory disorders					
Synovitis/capsulitis	Effusion, inflammation, capsular edema	–	–	–	–
Polyarthritis	Polyarticular, cortical alteration, remodeling	b	b	b	a
Non-inflammatory disorders/primary or secondary osteoarthritis	Uni-/bilateral, cortical alteration, remodeling	b	b	b	a
Ankylosis	Bone formation, impaired excursion	c	c	c	b
Fracture (condylar process)	Asymmetry, fracture line	c	b	c	b
Odontogenic conditions	Cists, tumors, periapical disease	c	–	–	–
Of the styloid process	Elongation calcification	c	–	c	–
Of the major salivary glands	Sialolithiasis, inflammation	a	–	–	–
Of the condylar excursion (hypo/hyper)	Condylar x mandibular tubercle ratio in MMO	–	c	c	b
Of the joint disc form	TMJ disc form alteration and perforation	–	–	–	d
Of the adjacent bone structures	Alterations in coronoid and mastoid processes	c	–	c	–
Of adjacent soft tissues	Alterations in the ligaments, retrodiscal area, masticatory muscles	–	–	–	–

Lampiran 4

Table 2 (*Continued*)

Disorders	Assessed sign	CT[1,15,16,18,31–33,35,36]	MRI[1–3,12,14,15,19,32,34,35,37–39]	US[4,5,15,33–35,38,39]	Nuclear medicine[13,14,36,38]
Congenital and developmental					
Aplasia	Absence of structure	d	c	a	a
Hypoplasia	Dimensional reduction	d	c	a	a
Hyperplasia	Dimensional increase	d	c	a	a
Dysplasia	Structural alteration	d	c	a	a
Acquired					
Neoplasias	Bone formation/destruction	d	d	a	d
	Soft tissue growth	d	d	c	d
	Metastasis	c	c	a	d
Disc derangement					
With reduction	Recapture in MMO	–	d	c	–
Without reduction	No recapture in MMO	–	d	c	–
TMJ displacement	Open locking, clinical diagnosis	d	c	a	–
Inflammatory disorders					
Synovitis/capsulitis	Effusion, inflammation, capsular edema	–	d	c	a
Polyarthritis	Polyarticular, cortical alteration, remodeling	d	c	–	a
Non-inflammatory disorders/primary or secondary osteoarthritis	Uni-/bilateral, cortical alteration, remodeling	d	c	–	a
Ankylosis	Bone formation, impaired excursion	d	c	–	–
Fracture (condylar process)	Asymmetry, fracture line	d	c	–	–
Odontogenic conditions	Cists, tumors, periapical disease	d	a	a	c
Of the styloid process	Elongation calcification	d	b	–	–
Of the major salivary glands	Sialolithiasis, inflammation	b	d	d	–
Of the condylar excursion (hypo/hyper)	Condylar x mandibular tubercle ratio in MMO	d	c	–	–
Of the joint disc form	TMJ disc form alteration and perforation	–	c	–	–
Of the adjacent bone structures	Alterations in coronoid and mastoid processes	d	b	–	b
Of adjacent soft tissues	Alterations in the ligaments, retrodiscal area, masticatory muscles	–	d	c	a

[a] Occasional finding, not the diagnostic purpose of the examination. Other tests are required to confirm.
[b] Frequently diagnosed condition, but requires other more accurate tests.
[c] Accurate diagnosis is established.
[d] Gold standard diagnostic evaluation, measurement, staging, location, and treatment planning.
TMD, temporomandibular disorders; CT, computed tomography; MRI, magnetic resonance imaging. US, ultrasound; MMO, maximal mouth opening; TMJ, temporomandibular joint.

Lampiran 4

In general, MRI and CT are methods with higher accuracy when compared to conventional radiology, due to the higher anatomical resolution they provide. CT is considered the gold standard for the assessment of boney structures and the method of choice for facial trauma, whereas MRI is similarly regarded for the study of soft tissues.[1,2,14,21,29] The two methods often complement each other in the study of TMJ alterations, constituting important tools for muscle and joint differential diagnosis.[4] Although able to diagnose all bone alterations of the TMJ, MRI is considered limited when compared to the high accuracy of CT for hard tissue.[19,22]

However, low-technical-complexity tests may possess high diagnostic accuracy,[18] as in the case of radiographic records of condylar hyperexcursion in patients with the clinical presentation of terminal joint clicking. These characteristics suggest a diagnosis of joint hypermobility, verified by a simple transcranial or planigraphy image.[3] In this example, the image has great sensitivity, while clinical data confer specificity, ruling out other diagnostic possibilities.

Similarly, morphological alterations of the styloid, coronoid, and condylar processes can be evaluated with high diagnostic accuracy through low-cost and easy-to-perform radiographic examinations, such as planigraphy and panoramic X-rays,[29] even though the CT is the gold standard for assessment of these alterations.[2]

The decision in choosing the examination must consider its influence on the proposed diagnosis and therapy. If the clinical indication is a conservative therapy that can control symptoms in the short term, image requests can be considered.[1,15] Moreover, when conservative therapy has failed and an invasive therapy is indicated, highly sensitive diagnostic tests, such as CT and MRI are selected.[15,31]

Elaborate treatment plans also require complete and accurate images,[29,31] for example, suspected fractures, where the CT, in addition to establishing the diagnosis, illustrates the exact location and size, and allows for the selection of the appropriate surgical therapy.[2]

Similar reasoning is used for the assessment of neoplastic conditions. A study[32] that compared the accuracy of imaging tests for bone tumor detection showed that the nuclear medicine diagnostic tests had greater sensitivity and specificity than CT scans, MRI, and radiographic assessment, although the latter are useful in the initial clinical investigations.[26,28,29,32]

Especially for non-surgical joint conditions, one should consider the risk of injuries and the safety of diagnostic techniques.[15] Although arthrography can effectively determine disc position and perforation,[33] it is considered an invasive and potentially hazardous method. Thus, MRI has become the method of choice for such conditions.[7]

Similarly, recent studies[4,5,23–25,30] have recommended US as a safe, noninvasive diagnostic technique with considerable accuracy for joint disc positioning, especially for patients with contraindication to MRI or submitted to real-time interventions, such as arthrocentesis and viscosupplementation. In these techniques, the US examination is especially appropriate for the identification of the inferior joint space. Its precise identification and correct access are factors that contribute to the technique's success.[11]

Long-term risks and tissue damage should also be considered for radiation exposure. As in conventional radiographs, CT should only cautiously be chosen because of its higher radiation absorption,[15,29] although CBCT has shorter radiation exposure time when compared to helical CT.[21]

Even if they pose some risk, tests that use higher doses of radiation are needed for disease staging and are essential for defining the treatment plan. Nuclear medicine examinations, for instance, are indicated to assess metabolic alterations of growth and assessment of metastases.[26–28] However, they still require confirmation of the type of growth through specific tests, such as histopathological or immunohistochemical analysis.[15]

Table 2 lists and classifies information that can be obtained by several examination techniques through TMJ images, based on their indications, risks, and diagnostic power.

Conclusion

Individually, the several imaging tests have specific indications for the diagnosis of TMJD.

Despite their lower sensitivity, radiographic techniques have lower cost and employ lower radiation doses. They are indicated for the early assessment of less complex symptoms and the differential diagnosis between TMD and inflammatory dental-maxillofacial conditions.

Morphological, degenerative bone abnormalities, and fractures are precisely diagnosed, identified, and measured by CT. Mainly, CBCT has a lower radiation dose and artifact reduction, and is considered the gold standard for the assessment of maxillofacial hard tissues. Inflammatory alterations, joint disc position, and other soft tissue structures are clearly identified and evaluated by MRI, that is safer than arthrography.

US examination accurately identifies the joint disc, mainly when the MRI assessment is contraindicated. It is indicated for the differential diagnosis between TMD and painful conditions of major salivary glands, as well as pre- and post-evaluation of infiltration therapies, such as viscosupplementation and arthrocentesis.

Nuclear medicine assessments are primarily indicated for the assessment of metabolic and growth alterations, such as tumors and metastases.

Arthrography is an invasive intra-articular examination; its usual indication is the visualization of joint disc alterations. Due to the risk inherent to the technique, it has been replaced by MRI assessment.

Factors that need to be evaluated for the selection of TMJ imaging tests include the following: the need to determine the presence of the disease and its prognosis, the quality and quantity of available clinical information; uncertainty in the differential diagnosis; determining the stage of disease development; need for legal documentation; preoperative preparation; evaluation of treatment evolution; and the safety and accuracy of the proposed examination.

Conflicts of interest

The authors declare no conflicts of interest.

Lampiran 4

References

1. Mahl CRW, Silveira MW. Diagnóstico por imagens da articulação temporomandibular: técnicas e indicações. JBA. 2002;2: 327–32.
2. Garcia MM, Machado KFS, Mascarenhas MH. Ressonância magnética e tomografia computadorizada da articulação temporomandibular: além da disfunção. Radiol Bras. 2008;41:337–42.
3. Ferraz Júnior AML, Guimarães JP, Ferreira LA. Técnicas de obtenção de imagens da articulação temporomandibular. In: Guimarães JP, Ferreira LA, editors. Atlas de diagnóstico por imaginologia das desordens temporomandibulares. Juiz de Fora: Editora UFJF; 2012. p. 28–66.
4. Landes CA, Goral WA, Sader R, Mack M. 3D sonography for diagnosis of disc dislocation of the temporomandibular joint compared with MRI. Ultrasound Med Biol. 2006;32:633–9.
5. Cakir-Özkan N, Sarikaya B, Erkorkmaz U, Aktürk Y. Ultrasonographic evaluation of disc displacement of the temporomandibular joint compared with magnetic resonance imaging. J Oral Maxillofac Surg. 2010;68:1075–80.
6. Cunha SC, Nogueira RVB, Duarte AP, Vasconcelos BCE, Almeida RAC. Análise dos índices de Helkimo e craniomandibular para diagnóstico de desordens temporomandibulares em pacientes com artrite reumatoide. Braz J Otorhinolaryngol. 2007;73:19–26.
7. Ferreira LA, Oliveira RG, Guimarães JP, Carvalho ACP, Paula MVQ. Laser acupuncture in patients with temporomandibular dysfunction: a randomized controlled trial. Lasers Med Sci. 2013;28:1549–58.
8. Silveira AM, Feltrin PP, Zanetti RV, Mautoni MC. Prevalência de portadores de DTM em pacientes avaliados no setor de otorrinolaringologia. Braz J Otorhinolaryngol. 2007;73:528–32.
9. Leeuw R. Disfunção temporomandibular. In: Leeuw R, editor. Dor orofacial. São Paulo: Quintessence; 2010. p. 129–204.
10. Fujiwara M, Honda K, Hasegawa Y, Hasegawa M, Urade M. Comparison of joint pain in patients diagnosed with and without articular disc displacement without reduction based on the Research Diagnostic Criteria for Temporomandibular Disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2013;116:9–15.
11. Grossmann E, Januzzi E, Iwaki Filho L. O uso do hialuronato de sódio no tratamento das disfunções temporomandibulares articulares. Rev Dor. 2013;14:301–6.
12. Güler N, Uçkan S, Imirzalioğlu P, Açikgözoğlu S. Temporomandibular joint internal derangement: relationship between joint pain and MR grading of effusion and total protein concentration in the joint fluid. Dentomaxillofac Radiol. 2005;34:175–81.
13. Hunter A, Kalathingal S. Diagnostic imaging for temporomandibular disorders and orofacial pain. Dent Clin North Am. 2013;57:405–18.
14. Vasconcelos BCE, Silva EDO, Kelner N, Miranda KS, Silva AFC. Meios de diagnóstico das desordens temporomandibulares. Rev Cir Traumat Buco-Maxilo-Facial. 2002;1:49–57.
15. Lewis EL, Dolwick MF, Abramowicz S, Reeder SL. Contemporary imaging of the temporomandibular joint. Dent Clin North Am. 2008;52:875–90.
16. Cozzolino FA, Rapoport A, Franzi SA, Souza RP, Pereira CAB, Dedivitis RA. Correlação entre os achados clínicos e imaginológicos nas disfunções temporomandibulares. Radiol Bras. 2008;41:13–7.
17. Almeida SM, Böscolo FN, Pereira TCR. Estudo comparativo entre duas técnicas radiográficas transcranianas utilizando o cefalostato ACCURAD-200, nas posições padrão e corrigida, e confecção de gabaritos para delimitação dos espaços articulares. Rev Fac Odontol Univ São Paulo. 1997;11:51–60.
18. Hintze H, Wiese M, Wenzel A. Comparison of three radiographic methods for detection of morphological temporomandibular joint changes: panoramic, scanographic and tomographic examination. Dentomaxillofac Radiol. 2009;38:134–40.
19. Sano T. Recent developments in understanding temporomandibular joint disorders. Part 1: bone marrow abnormalities of the mandibular condyle. Dentomaxillofac Radiol. 2000;29:7–10.
20. Ramos ACA, Sarmento VA, Campos PSF, Gonzalez MOD. Articulação temporomandibular – aspectos normais e deslocamentos de disco: imagem por ressonância magnética. Radiol Bras. 2004;37:449–54.
21. Rodrigues MGS, Alarcón OMV, Carraro E, Rocha JF, Capelozza ALA. Tomografia computadorizada por feixe cônico: formação da imagem, indicação e critérios para prescrição. Odontol Clin-Cient. 2010;9:115–8.
22. Alkhader M, Ohbayashi N, Tetsumura A, Nakamura S, Okochi K, Momin MA, et al. Diagnostic performance of magnetic resonance imaging for detecting osseous abnormalities of the temporomandibular joint and its correlation with cone beam computed tomography. Dentomaxillofac Radiol. 2010;39:270–6.
23. Jank S, Zangerl A, Kloss F, Lalmer K, Missmann M, Schroeder D, et al. High resolution ultrasound investigation of the temporomandibular joint in patients with chronic polyarthritis. Int J Oral Maxillofac Surg. 2011;40:45–9.
24. Bas B, Yilmaz N, Gökce E, Akan H, Turkey S. Ultrasound assessment of increased capsular width in temporomandibular joint internal derangements: relationship with joint pain and magnetic resonance grading of joint effusion. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;112:112–7.
25. Dayisoylu EH, Cifci E, Uckan S. Ultrasound-guided arthrocentesis of the temporomandibular joint. Br J Oral Maxillofac Surg. 2013;51:667–8.
26. Coutinho A, Fenyo-Pereira M, Dib LL, Lima ENP. The role of SPECT/CT with ^{99m}Tc-MDP image fusion to diagnose temporomandibular dysfunction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;101:224–30.
27. Bittencourt LP, Souza SAL, Magnanini M, Fonseca LMB, Gutfilen B. Verificação da atividade condilar em pacientes com padrão esquelético classe III por intermédio da cintilografia óssea. Radiol Bras. 2005;38:273–7.
28. Shintaku WH, Venturin JS, Yepes JS. Application of advanced imaging modalities for the diagnosis of metastatic adenocarcinoma of the lungs in the temporomandibular joint. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107: 37–41.
29. Pharoah M. The prescription of diagnostic images for temporomandibular joint disorders. J Orofac Pain. 1999;13:251–4.
30. Bas B, Yilmaz N, Gökce E, Akan H. Diagnostic value of ultrasonography in temporomandibular disorders. J Oral Maxillofac Surg. 2011;69:1304–10.
31. Calderon PDS, Reis KR, Araujo CDRP, Rubo JH, Conti PCR. Ressonância magnética nos desarranjos internos da ATM: sensibilidade e especificidade. Rev Dent Press Ortodon Ortoped Facial. 2008;13:34–9.
32. Shintaku WH, Venturin JS, Langlais RP, Clark GT. Imaging modalities to access bony tumors and hyperplasic reactions of the temporomandibular joint. J Oral Maxillofac Surg. 2010;68:1911–21.
33. Liedberg J, Panmekiate S, Petersson A, Rohlin M. Evidence-based evaluation of three imaging methods for the temporomandibular disc. Dentomaxillofac Radiol. 1996;25:234–41.