Original Article - Evaluative Study

Role of Magnetic Resonance Imaging in Temporomandibular Joint Ankylosis - An Evaluative Study

Cheruvathur Prasad, M. Deepa, Palani Triveni, Kamalakaran Arunkumar

Department of Oral and Maxillofacial Surgery, Tamil Nadu Government Dental College and Hospital, Chennai, Tamil Nadu, India

Abstract

Introduction: Temporomandibular joint (TMJ) ankylosis is a pathologic condition where the mandible is fused to the fossa by bony or fibrotic tissues. Haemorrhage is one of the major complications during TMJ surgery especially in ankyloses due to altered anatomy. The aim of the study was to analyse the proximity of the vasculature to the TMJ region in TMJ ankylosis patients using magnetic resonance imaging (MRI). **Materials and Methods:** Noncontrast-enhanced MRI images of seven patients were assessed. The distance between maxillary artery and neck of condyle/ankylotic mass was measured using coronal sections and distance between the internal carotid artery (ICA), internal jugular vein (IJV) and medial edge of condyle/bony mass were measured using axial sections. **Results:** The mean distance of internal maxillary artery (IMA) to medial edge of ankylotic mass was 1 ± 0.57 mm and 2 ± 1.2 mm-left and right condylar regions respectively (range: 0–4 mm).The mean distance from lateral aspect of ankylotic mass to IMA was 8.2 ± 1.4 mm and 8.7 ± 2.8 mm–right and left condylar regions respectively (range: 3–11 mm).The mean distance from medial edge of condyle to ICA was 18.8 ± 1.3 mm and 18.2 ± 1.1 mm-right and left condylar regions respectively (range: 17 mm–20 mm).The mean distance from the medial edge of condyle to IJV was 16.4 ± 1.1 mm and 14.5 ± 2.9 mm-right and left condylar regions (range: 11 mm–19 mm). **Discussion:** These measurements were used as a guide to plan the steps during surgery in order to minimise the intraoperative haemorrhagic complications. Hence, MRI may be considered as a valuable tool in assessing the juxtaposition of vascular bed to TMJ region, though contrast MRI and a larger sample is needed to standardise.

Keywords: Internal carotid artery, internal jugular vein, internal maxillary artery, magnetic resonance imaging, proximity

Introduction

Temporomandibular joint (TMJ) ankylosis is a pathologic condition where the mandible is fused to the fossa by bony or fibrotic tissues.[1] The morphological characteristic of the condyle is altered due to the formation of the bony callus leading to bony fusion. The cause of TMJ ankylosis is multifactorial–ranging from trauma, arthritis, infection, previous TMJ surgery, congenital deformities, idiopathic factors, and iatrogenic causes.[2-11] The gold standard treatment of TMJ ankylosis is gap arthroplasty with or without interpositional graft.[12] Surgical management is complicated and one of the major complications faced during surgery of TMJ is haemorrhage especially in TMJ ankylosis where there is altered anatomy. Our experience over the years in surgery has shown the importance of understanding the anatomy of the vascular bed. Radiological assessment of vascular bed preoperatively will guide the surgeon immensely.

Access this article online

Quick Response Code:

Website: https://journals.lww.com/aoms/

DOI: 10.4103/ams.ams_77_22

In this study, magnetic resonance imaging (MRI) was done to understand the vascular bed in TMJ ankylosis patients operated for the first time as well as for re-ankylosis.

Earlier studies by El-Hakim and Metwalli[13] has demonstrated the distance between the internal carotid artery (ICA), internal jugular vein (IJV), the maxillary artery and the medial pole of the mandibular condyle to be decreased on the ankylotic side when compared to the normal side. El-Hakim *et al*.[13] have shown that the maxillary artery was inside the ankylotic mass

Address for correspondence: Dr. Cheruvathur Prasad, Greata Pearl, Flat No. 243, No. 206, Choolaimedu High Road, Chennai - 600 094, Tamil Nadu, India.
E-mail: prasaads07@gmail.com

Received: 26-03-2022 **Last Revised:** 18-06-2022
Accepted: 22-06-2022 **Published:** 16-08-2022

How to cite this article: Prasad C, Deepa M, Triveni P , Arunkumar K. Role of magnetic resonance imaging in temporomandibular joint ankylosis - An evaluative study. Ann Maxillofac Surg 2022;12:39-45.

sometimes or the distance between the maxillary artery and the medial pole of the condyle is less on the ankylotic side than on the normal side.

It was also shown that the ankylosed mass appeared fused to the base of the skull and there is extensive bone formation, especially from the medial aspect of the condyle to the extent that the ankylotic mass is in close relationship with the vital structures at the base of the skull such as the pterygoid plates, carotid and jugular foramina and foramen spinosum and that normal joint anatomy could not be defined from the radiograph.[14]

Clinical and radiographic studies of the vascularity of ankylotic and re-ankylotic patients are very few in the literature. This study was done on seven patients over a period of 3 years who attended outpatient department at the Department of Oral and Maxillofacial Surgery. In addition to traditional diagnostic methods like X-ray, computed tomography (CT), MRI was taken to thoroughly analyse the vascular changes to guide us during surgery.

Aim

The aim of the study was to assess the proximity of the major vascular structures to the TMJ region in TMJ ankylosis patients using MRI.

Materials and Methods

MRI scans of seven cases of TMJ ankylosis operated in the Department of Oral and Maxillofacial Surgery, over 3 years were assessed. T1 and T2 weighted noncontrast-enhanced MRI images of 3 mm slice thickness were taken. There were four female and three male patients in the age range of 16–47 years. Five out of seven were bilateral and two were unilateral TMJ ankylosis cases. Two out of seven were re-ankylosis both of which were bilateral and the remaining five were primary ankylosis. Totally 12 TMJs were analysed.

Ethical committee clearance reference number: 4/IERB/2021.

Inclusion criteria

Patients with unilateral or bilateral TMJ ankylosis (primary or recurrent)-Sawhney's classification-Type I, II, III and IV.[15,16]

Exclusion criteria

- Patients with ferromagnetic metallic implants
- Medical devices like cardiac pacemakers
- Cochlear implants
- Cerebral aneurysm clips
- Ferrous foreign objects in the eye, metal sutures, plates and screws, wire mesh
- MRI contrast poses a risk of allergic reaction to the dye in patients who are allergic or sensitive to medications, contrast dye, iodine or shellfish. It may have an effect on asthma, anaemia, hypotension and sickle cell disease
- Patients who do not give consent for MRI
- Contrast agents are avoided in patients who are pregnant or breast feeding.[17]

Methods

Axial, coronal and sagittal MRI sections were taken.

The distance between the maxillary artery and the neck of condyle/ankylotic mass was measured (in millimeters) using coronal sections of MRI scans which prominently showed the ankylotic mass and the maxillary artery [Figures 1 and 2].

The distance between the carotid canal ICA (Point I), jugular foramen IJV (Point J) and medial edge of the condyle/bony mass (Point E) were measured (in millimetres) using axial sections of the MRI scans which prominently showed the ankylotic mass and the carotid canal and jugular foramen [Figures 3 and 4].

The axial sections in which the ankylotic mass was diffuse and condyle margins could not be exactly identified, the condyle was considered to be in the horizontal line (EF) drawn from just in front of the ear (Point F) towards medially till the medial edge of the bony mass (Point E) [Figures 3 and 4].

The following points were considered for measuring the proximity of internal maxillary artery (IMA) [Figures 1 and 2]. Point A-The outermost soft tissue margin (Skin), Point B-The lateral most point on the outer edge of the IMA, Point C-The most prominent point on the medial edge of the inferior end of the ankylotic mass, Point D-The most prominent point on the lateral edge of the inferior end of the ankylotic mass.

The following points were considered for measuring the proximity of the ICA and IJV [Figures 3 and 4]. Point E-The most prominent point on the medial edge of the condyle or the bony mass, Point F-Point just in front of the ear on the outermost soft tissue margin. Horizontal line EF-drawn from just in front of the ear (Point F) towards medially till the most prominent point on the medial edge of the bony mass (Point E), Point I-The most anterolateral point on the outer edge of the carotid canal, Point J-The most anterolateral point on the outer edge of the jugular foramen.

The following distances were measured (in millimetres) for finding the proximity of IMA [Figure 2]. Distance AB-From the outermost soft tissue margin-Skin (Point A) to the lateral most point on the outer edge of the IMA (Point B). Distance CB-From the most prominent point on the medial edge of the inferior end of the ankylotic mass (Point C) to the lateral most point on the outer edge of the IMA (Point B). Distance DB-From the most prominent point on the lateral edge of the inferior end of the ankylotic mass (Point D) to the lateral most point on the outer edge of the IMA (Point B).

The following distances were measured (in millimetres) for finding the proximity of the ICA and IJV respectively [Figures 3 and 4]. Distance EI-The distance from the most prominent point on the medial edge of the condyle or the bony mass (Point E) to the most anterolateral point on the outer edge of the carotid canal (Point I). Distance EJ-The distance from the most prominent point on the medial edge of the condyle or

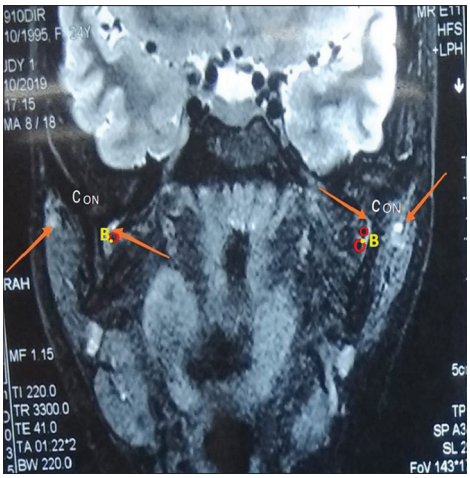

Figure 1: Coronal section of MRI with markings for condyle (CON-orange arrow) and internal maxillary artery (marked in RED) appears as a flow void medial to the condyle. Point B (Yellow dot). MRI: Magnetic resonance imaging

Figure 3: Axial section of MRI with markings for (ICA) Carotid canal (marked in deep red) and Jugular foramen (IJV) (marked in green), Point I and Point J. ICA: Internal carotid artery, IJV: Internal jugular vein, MRI: Magnetic resonance imaging

the bony mass (Point E) to the most anterolateral point on the outer edge of the jugular foramen (Point J) [Figures 3 and 4].

Results

The results of the study showed that the maximum and the minimum distances from the skin to the lateral most point of the internal maxillary artery(DISTANCE AB) were 27mm and 16mm with a mean of (21.6± SD4.15mm- Right side) and (23.7± SD2.05mm – Left side) (Table 1A and 1B and Chart 1a). The minimum distance of the IMA and the medial edge of the inferior end of the ankylotic mass (Distance CB) was 0 mm and the maximum distance was just 4 mm and an average of (1 ± standard deviation [SD] 0.57 mm on the left side) and (2 ± SD 1.2 mm on the right side) [Table 1A and 1B and Chart 1b].

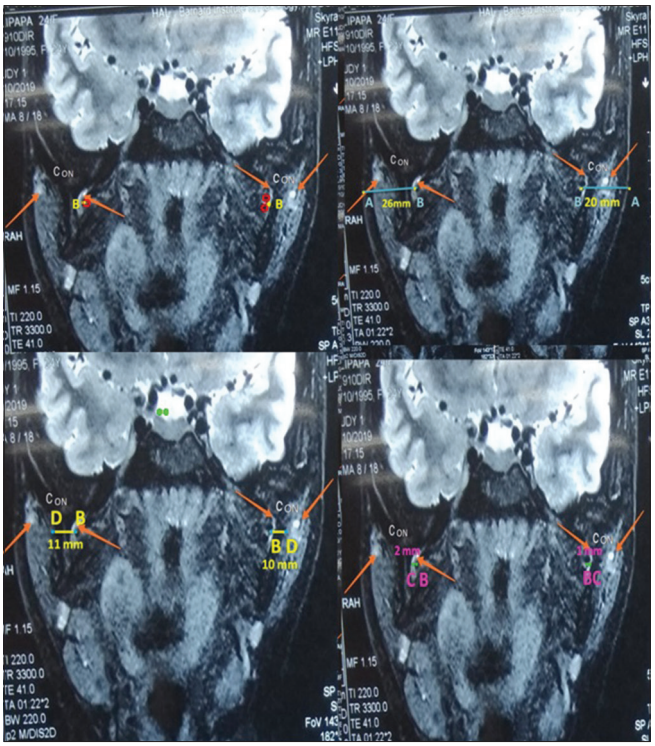

Figure 2: Coronal section of MRI Showing- B/L TMJ ankylosis-Right side and Left side Condyles (CON-Orange arrow). Point B, Distance AB-Blue line, Distance CB-Pink line and Distance DB-Yellow line, TMJ: Temporomandibular joint, MRI: Magnetic resonance imaging

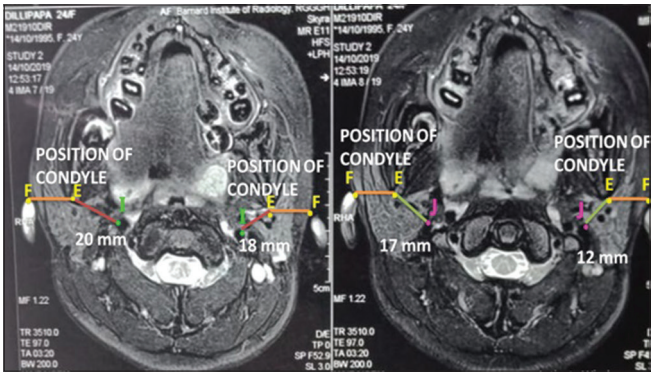

Figure 4: Axial section of MRI showing position of condyle (orange line-a horizontal line EF drawn from a point just in front of the ear (Point F), Distance EI-deep red line, Distance EJ – green line. MRI: Magnetic resonance imaging

The minimum distance from the lateral aspect of the inferior end of the ankylotic mass to the IMA (Distance DB) was just 3 mm and maximum being 11 mm. The average value was found to be (8.2 ± SD 1.4 mm on the right side) and (8.7 ± SD 2.8 mm on the left side) [Table 1A and 1B and Chart 1c].

The maximum and minimum distances [Table 1B] from the medial edge of the condyle to the ICA (Distance EI) were 20 mm and 17 mm respectively with a mean of (18.8 ± SD1.3 mm on the right side) and (18.2 ± SD 1.1 mm

on the left side) [Table 1A and Chart 2a] and maximum and minimum distances [Table 1B] from the medial edge of the condyle to the IJV (Distance EJ) were 19 mm and 11 mm respectively with a mean of (16.4 ± SD1.1 mm on the right side) and (14.5 ± SD 2.9 mm on the left side) [Table 1A and Chart 2b].

Discussion

The management goal in TMJ ankylosis is to increase the patient's mandibular function, correct associated facial deformity, decrease pain, and prevent reankylosis.[1]

Multiple surgical modalities have been proposed to manage TMJ ankylosis including gap arthroplasty, interpositional arthroplasty, and total joint reconstruction. Autogenous tissues such as ear cartilage, temporalis muscle flap, dermis, fat, and bone, have been used after gap arthroplasty.[18,19]

The most common management is gap arthroplasty with or without interposition graft. The most common complication is intraoperative haemorrhage due to injury to the adjacent vasculature.[20]

Haemorrhagic complications of TMJ surgeries may be intracranial/extracranial.[20-23,26-28]

Extracranial complications are likely to involve superficial temporal vessels, maxillary artery, middle meningeal artery and ICA.

Intracranial complications involve extradural haemorrhage due to rupture of the middle meningeal artery and are life-threatening.[20-23,26-28]

MRI provides images about muscles, vessels, nerves within the TMJ and masticator spaces which may be a useful guide to plan surgical approaches to the TMJ region due to the closeness of myriad vital structures within this limited space often complicating operative procedures.[17,24,29]

In our study osseous structures display clear hypointense signals on MRI and are differentiated from the adjacent soft tissue, allowing preoperative measurements to be made between bony anatomical landmarks.

The vascular structures near the TMJ appear hyperintense in the gradient echo T1 sequences with fat suppression and

Table 1A: Descriptive statistics

Variable	Side	Mean	SD	SEM
AB	Right	21.6000	4.15933	1.86011
	Left	23.7143	2.05866	0.77810
CB	Right	2.0000	1.22474	0.54772
	Left	1.0000	0.57735	0.21822
DB	Right	8.2000	1.48324	0.66332
	Left	8.7143	2.87021	1.08484
EI	Right	18.8000	1.30384	0.58310
	Left	18.2857	1.11270	0.42056
EJ	Right	16.4000	1.14018	0.50990
	Left	14.5714	2.99205	1.13089

SD: Standard deviation, SEM: Standard error mean,

Table 1B: Distances measured in each case

Cases	IMA (coronal sections) [Figure 1, 2] (mm)			ICA (axial sections) [Figure 3, 4] Distance EI (mm)		IJV (axial sections) [Figure 3, 4] Distance EJ (mm)	
	Distance (mm)	Right	Left	Right	Left	Right	Left
24/female	AB	20	26	20	18	17	12
Bilateral TMJ ankylosis (re-ankylosis)	CB	2	1				
	DB	10	11 (maximum)				
29/male	AB	16 (minimum)	20	18	20 (maximum)	16	11 (minimum)
Bilateral TMJ ankylosis (re-ankylosis)	CB	4 (maximum)	0 (minimum)				
	DB	6	3 (minimum)				
16/female	AB	-	24	-	17 (minimum)	-	13
Unilateral left TMJ ankylosis (primary)	CB	-	2				
	DB	-	10				
17/male	AB	-	25	-	19	-	14
Unilateral left TMJ ankylosis (primary)	CB	-	1				
	DB	-	9				
47/female	AB	24	22	19	17	18	15
Bilateral TMJ ankylosis (primary)	CB	1	1				
	DB	9	7				
17/male	AB	27 (maximum)	25	20	19	16	18
Bilateral TMJ ankylosis (primary)	CB	2	1				
	DB	8	10				
40/female	AB	21	24	17	18	15	19 (maximum)
Bilateral TMJ ankylosis (primary)	CB	1	1				
	DB	8	11				

TMJ: Temporomandibular joint, IMA: Internal maxillary artery, ICA: Internal carotid artery, IJV: Internal jugular vein

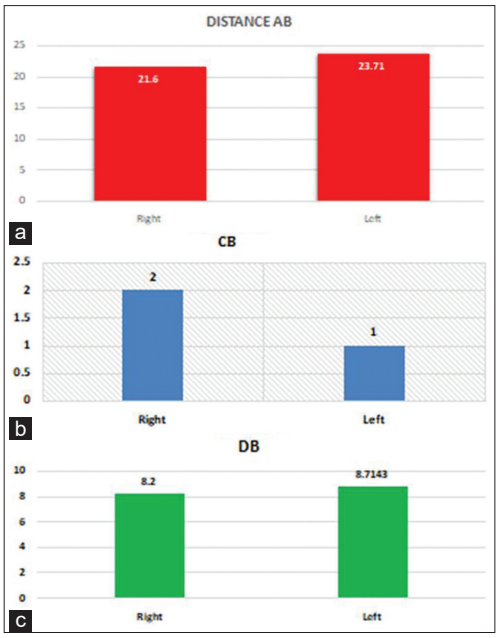

Chart 1: (a) Mean value of distance AB on the right side and the left side. (b) Mean value of distance CB on the right side and the left side. (c) Mean value of distance DB on the right side and the left side

hypointense in a T1 weighted scan and hyperintense in a T2 weighted MRI scan.[24] On coronal slices, the maxillary vessels appeared as flow voids on the medial side of the condyle and in the inferior region of the lateral pterygoid muscle. A flow void indicates a signal loss caused by rapid blood flow and hence act as natural contrasts and are a clinical focus of attention in the diagnosis of vascular abnormalities [Figures 1 and 2].[21]

On a noncontrast CT scan, the vessels may appear as a radiolucency traversing the radiopaque ankylotic mass suggesting the presence of the vessel within the mass. On a CT angiogram with contrast, it appears as a hypointense structure adjacent to the osseous structures.[21]

There are methods like CT angiography which can serve as an useful diagnostic aid that can help in super selective embolisation or modify the surgical plan based on the anatomy especially in patients who had undergone previous interventions due to which the anatomy of vasculature might have altered and obliterated nascent anatomic boundaries. Although CT angiography is an useful adjunct for managing haemorrhage during ankylotic release, it poses a well recognised risk of an allergic reaction to the dye or acute kidney injury from the volume of contrast administered.[22] The radiation exposure of multislice CT is 860–1500 μSv.[17]

Due to the noninvasiveness, no ionising radiation, and best resolution of soft tissues, noncontrast-MRI was preferred in our study.

In our study, CT was taken initially [Figure 5] followed by MRI to understand the vascular bed of each case to plan the surgical steps.

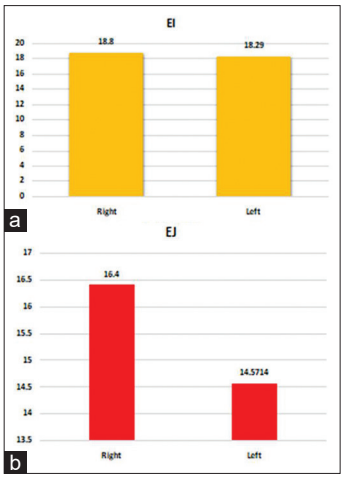

Chart 2: (a) Mean value of distance EI on the right side and the left side. (b) Mean value of distance EJ on the right side and the left side

In this study, the maxillary artery which appears as a flow void in the coronal section near the medial aspect of the condyle and the distances between skin to the maxillary artery (AB), medial edge of the condylar neck and the outer edge of maxillary artery (CB), lateral edge of the condyle to outer edge of maxillary artery (DB) were measured [Figures 1 and 2].

In the axial sections, the distance EI between the carotid canal ICA and medial edge of the condyle/bony mass and the distance EJ between jugular foramen IJV and medial edge of the condyle/bony mass were measured [Figures 3 and 4].

The IMA normally runs approximately 3 mm medial from the mid sigmoid notch.[25] In the present study, the minimum distance of the IMA and the medial edge of the inferior end of the ankylotic mass (Distance CB) is 0 mm suggesting that the artery lies on the ankylotic mass and the maximum distance is just 4 mm and an average of (1 ± SD 0.57 mm on the left side) and (2 ± SD1.2 mm on the right side) [Table 1A and Chart 1b].

The minimum distance from the lateral aspect of the inferior end of the ankylotic mass to the IMA (Distance DB) is just 3 mm suggesting hypotrophied condyle as this was found in a case of re-ankylosis and maximum being 11 mm. The average value was found to be (8.2 ± SD 1.4 mm on the right side) and (8.7 ± SD 2.8 mm on the left side) [Table 1A and Chart 1c] These minimum distances of IMA (CB = 0 mm, DB = 3 mm), IJV (11 mm) were found in one particular case of reankylosis.

In cases where the ankylotic mass is attached to the base of the skull, there is a risk of bleeding from the carotid arteries during ankylotic release due to base of skull fracture.[22,26,27] In our study, it was found that the maximum and minimum distances [Table 1B] from the medial edge of the condyle to the ICA (Distance EI) was 20 mm and 17 mm respectively with a mean of (18.8 ± SD1.3 mm on the right side) and (18.2 ± SD 1.1 mm on the left side) [Table 1A and Chart 2a] and maximum and minimum distances [Table 1B] from the medial edge of the condyle to the IJV (Distance EJ) was 19 mm and 11 mm respectively with a mean of (16.4 ± SD1.1 mm on the right

side) and (14.5 ± SD 2.9 mm on the left side) [Table 1A and Chart 2b].

Advantage of this study

The intra and inter-individual variations and closeness of osseous and vascular structures should be considered preoperatively when planning a surgery. Preoperative visualisation is useful when any vascular or bony aberrant anatomy is suspected during treatment planning as their identification would be difficult intraoperatively. These values convey a high risk of intraoperative haemorrhage and the need for careful manipulation of the surgical site in such cases thus suggesting preoperative MRI in TMJ ankylosis cases as a valuable tool in assessing the vascular proximity to the TMJ to prevent the dreaded complication of massive haemorrhage.

Our understanding of the nature of the vascular bed helped us to plan the surgical steps preoperatively which eventually reduced the haemorrhagic complications. The major drawback was the technique sensitivity in identifying the potential and prime source of haemorrhage [Figure 6]. In our study, out of 12 TMJs in seven patients assessed, none of them had haemorrhagic complications intraoperatively and postoperatively which may be attributed to the preoperative assessment of the proximity of vascular structures to the ankylotic mass using MRI.

Conclusion

This study of preoperative MRI in understanding the vascular bed in TMJ ankylosis has served as an important preoperative guidance in determining the proximity of the potential sources of bleeding to the TMJ region, which was found to be in close proximity or within the ankylotic mass-IMA approximately 0–4 mm medially and 3–11 mm laterally, ICA-17–20 mm and IJV 11–19 mm from the ankylotic mass. A preoperative MRI would persuade the surgeon to carefully explore the surgical site, avoid massive haemorrhage which would incur otherwise and thus reduce operating time. Hence, MRI is suggested as a valuable presurgical guiding tool in assessing the juxtaposition of the vascular bed to the TMJ region, though contrast MRI coupled with a larger sample is needed to standardize.

Acknowledgement

Dr. Cyril (Public Health Dentist) - For Technical Support and Statistics, Bernard Institute of Radiology - Rajiv Gandhi Government General Hospital, Chennai, Tamil Nadu, India.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

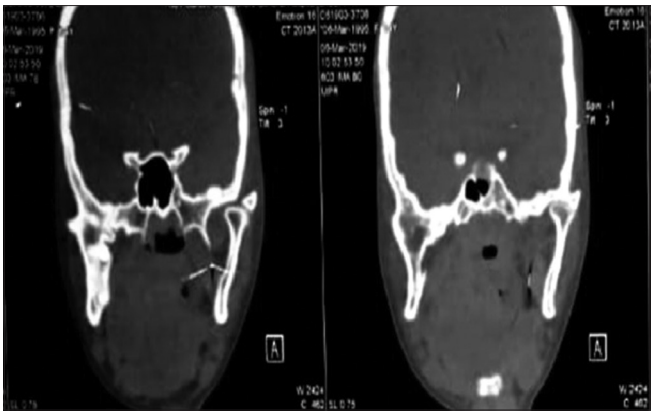

Figure 5: Coronal section of CT SCAN showing B/L TMJ ANKYLOSIS. CT: Computed tomography

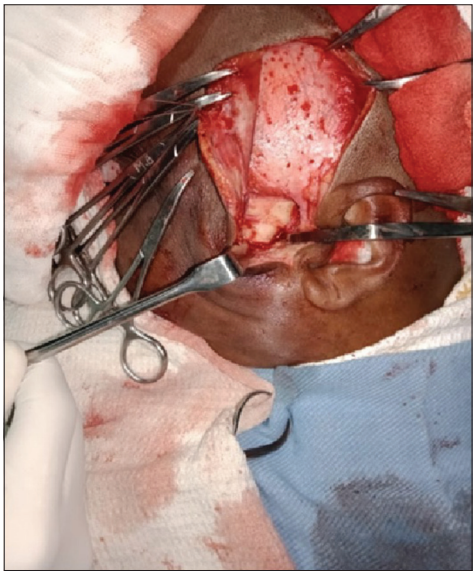

Figure 6: TMJ ANKYLOSIS-Intra operative image. TMJ: Temporomandibular joint

Conflicts of interest

There are no conflicts of interest.

References

1. Movahed R, Mercuri LG. Management of temporomandibular joint ankylosis. Oral Maxillofac Surg Clin North Am 2015;27:27-35.
2. Erol B, Tanrikulu R, Görgün B. A clinical study on ankylosis of the temporomandibular joint. J Craniomaxillofac Surg 2006;34:100-6.
3. Topazian RG. Etiology of ankylosis of temporomandibular joint: Analysis of 44 cases. J Oral Surg Anesth Hosp Dent Serv 1964;22:227-33.
4. Arakeri G, Kusanale A, Zaki GA, Brennan PA. Pathogenesis of post-traumatic ankylosis of the temporomandibular joint: A critical review. Br J Oral Maxillofac Surg 2012;50:8-12.
5. Kaban LB, Perrott DH, Fisher K. A protocol for management of temporomandibular joint ankylosis. J Oral Maxillofac Surg 1990;48:1145-51.
6. Guralnick WC, Kaban LB. Surgical treatment of mandibular hypomobility. J Oral Surg 1976;34:343-8.
7. Norman JE. Ankylosis of the temporomandibular joint. Aust Dent J 1978;23:56-66.

8. Howlader D, Vignesh U, Bhutia DP, Pandey R, Kumar S, Chandra T, *et al.* Hydroxyapatite collagen scaffold with autologous bone marrow aspirate for mandibular condylar reconstruction. J Craniomaxillofac Surg 2017;45:1566-72.
9. Shivakotee S, Menon CS, Sham ME, Kumar V, Archana S. TMJ ankylosis management: Our experience. J Maxillofac Oral Surg 2020;19:579-84.
10. Younis M, Shah A, Ahmed I. Viability and volumetric analysis of free autogenous dermis fat graft as interpositional material in TMJ ankylosis: A long-term MRI study. J Maxillofac Oral Surg 2021;20:304-9.
11. Bansal S, Verma DK, Rai M, Sorake A, Kaur C. Gap arthroplasty or interpositional arthroplasty for the management of TMJ ankylosis? A prospective randomized comparative multicenter clinical trial. J Maxillofac Oral Surg 2019;18:567-71.
12. Metwalli S. Computerized Tomography of the Temporal Bone in TMJ Ankylosis. MSc Thesis, Cairo University; 1993. p. 20-36.
13. El-Hakim IE, Metwalli SA. Imaging of temporomandibular joint ankylosis. A new radiographic classification. Dentomaxillofac Radiol 2002;31:19-23.
14. Sawhney CP. Bony ankylosis of the temporomandibular joint: Follow-up of 70 patients treated with arthroplasty and acrylic spacer interposition. Plast Reconstr Surg 1986;77:29-40.
15. Upadya VH, Bhat HK, Rao BH, Reddy SG. Classification and surgical management of temporomandibular joint ankylosis: A review. J Korean Assoc Oral Maxillofac Surg 2021;47:239-48.
16. Mallya S, Lam E. White and pharaoh, other imaging modalities. In: Oral Radiology-Text Book of Oral Radiology-Principles and Interpretation. India: Elsevier; 2019. p. 229-49.
17. Mittal N, Goyal M, Sardana D, Dua JS. Outcomes of surgical management of TMJ ankylosis: A systematic review and meta-analysis. J Craniomaxillofac Surg 2019;47:1120-33.
18. Santillan A, Hee Sur M, Schwarz J, Easthausen I, Behrman DA, Patsalides A. Endovascular preoperative embolization for temporomandibular joint replacement surgery. Interv Neuroradiol 2020;26:99-104.
19. Alderazi YJ, Shastri D, Wessel J, Mathew M, Kass-Hout T, Aziz SR, *et al.* Internal maxillary artery preoperative embolization using n-butyl cyanoacrylate and pushable coils for temporomandibular joint ankylosis surgery. World Neurosurg 2017;101:254-8.
20. Hossameldin RH, McCain JP, Dabus G. Prophylactic embolisation of the internal maxillary artery in patients with ankylosis of the temporomandibular joint. Br J Oral Maxillofac Surg 2017;55:584-8.
21. Lepić T, Lepić M, Mandić-Rajčević S. Ultrasonographic assessment of the maxillary artery and middle meningeal artery in the infratemporal fossa. J Clin Ultrasound 2019;47:405-11.
22. Schönegg D, Ferrari R, Ebner J, Blumer M, Lanzer M, Gander T. Proximity of the middle meningeal artery and maxillary artery to the mandibular head and mandibular neck as revealed by three-dimensional time-of-flight magnetic resonance angiography. Oral Maxillofac Surg 2022;26:139-46.
23. Susarla SM, Peacock ZS, Williams WB, Rabinov JD, Keith DA, Kaban LB. Role of computed tomographic angiography in treatment of patients with temporomandibular joint ankylosis. J Oral Maxillofac Surg 2014;72:267-76.
24. Anchlia S, Dhuvad J, Shah JC. Temporomandibular joint ankylosis release: 17 years of experience with 521 joints. J Maxillofac Oral Surg 2019;18:190-6.
25. Pedullà E, Meli GA, Garufi A, Cascone P, Mandalà ML, Deodato L, *et al.* Morphometric evaluation of the temporomandibular joint and the masticatory spaces: The role of high-definition MRI. Minerva Stomatol 2009;58:127-43.
26. Quinn PD. Atlas of Temporomandibular Joint Surgery. Wiley-Blackwell: UK. ISBN-13: 978-1-119-94985-5 / 2015.
27. Singh R, Bhalla AS, Manchanda S, Roychoudhury A. Multidetector computed tomography in preoperative planning for temporomandibular joint ankylosis: A pictorial review and proposed structured reporting format. Imaging Sci Dent 2021;51:313-21.
28. De Carvalho GM, Guimarães AC, Vega F, Iwakura C, Paschoal JR, Pfeilsticker LN. Surgical disaster in temporomandibular joint: Case report. Rev Esp Cirugía Oral Maxilofac 2014;36:113-8.
29. Gharavi SM, Qiao Y, Faghihimehr A, Vossen J. Imaging of the temporomandibular joint. Diagnostics (Basel) 2022;12:1006.