



Retrospective analysis of a TMJ ankylosis protocol with a 9 year follow up

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ABSTRACT

Objective: Temporomandibular joint ankylosis (TMJa) is a debilitating condition that causes difficulty in mastication, speech and mouth opening. Its treatment poses surgical and rehabilitative challenges along with a high incidence of reankylosis. This study was designed to assess the long-term outcomes with a new two phase physiotherapy protocol following conservative resection of the ankylotic mass.

Materials and methods: 143 patients who were treated for TMJa were initially recruited, among whom 98 were inducted into the study and retrospectively evaluated using clinical records and 3-dimensional computed tomography. All the patients underwent a minimal pre auricular incision and conservative interpositional gap arthroplasty with collagen membrane. This was followed by the new two phase physiotherapy protocol with the use of a bite block. The primary outcome measures were the maximum interincisal distance, vertical ramus height and complications. The patients were followed up at monthly intervals during the first year, quarterly intervals during the second year, and at intervals of 6 months during subsequent follow-up years. The mean follow up period was 6.38 ± 2.36 years after ankylotic release. Paired student t test was used for statistical analysis.

Results: The mean scores for mouth opening at T1, T2 and T3 were statistically significantly different at all intervals ($p < 0.0005$). The mean scores for ramal length were statistically significantly different at T1 and T2 interval ($p < 0.0005$) and insignificant at T2 and T3 interval. No reankylosis was observed in patients who followed the physiotherapy protocol.

Conclusions: In the management of TMJa, the success of the conservative surgical technique with interpositional arthroplasty is less dependent on the longevity and rigidity of the interpositional material but more indebted to the patient compliance in following the proposed physiotherapy protocol.

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1. Introduction

Temporomandibular joint ankylosis (TMJa) is a joint disorder which refers to bone or fibrous adhesion of the anatomic joint

components and the ensuing loss of function (Valentini et al., 2002). Ankylosis can result from trauma, as a result of local and systemic infections or due to systemic disease, such as ankylosing spondylitis, rheumatoid arthritis, and psoriasis. Ankylosis can also occur as a result of previous TMJ surgery (Matsuura et al., 2001; Kaban et al., 2009). TMJa is a very distressing structural condition that alters the patient's eating habits and speech ability. It also causes severe facial disfigurement that aggravates psychological stress and severely decreases the patient's quality of life. TMJa occurs in children and adults. Timely diagnosis of TMJa, especially in

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children, and early surgical intervention must be applied to prevent growth alterations and the subsequent emergence of a unilateral mandibular retrusion, a significant malocclusion, and/or facial asymmetry (Zhi et al., 2009). TMJa and its complications pose a significant challenge. Treatment for TMJa broadly aims at restoring joint function, refining the facial aesthetics, improving quality of life and preventing re-ankylosis (Elgazzar et al., 2010). The surgeon must aim to obtain satisfactory mouth opening while also restoring the vertical, protrusive and lateral movements of the mandible. The vertical dimension must also be maintained while simultaneously addressing the facial asymmetry during and after the growth phase (Passi et al., 2014). There is no published consensus about the best treatment. Several techniques have been described (Pogrel and Kaban, 1990; Kaban et al., 1990; Paterson and Shepherd, 1992; Chossegras et al., 1997; Gunaseelan, 1997; Dean and Alamillos, 1999; Saeed et al., 2002; Schliephake et al., 2003; K. et al., 2004; Li et al., 2006; Huang et al., 2007; Schwartz and Relle, 2008; Mercuri et al., 2008; Danda et al., 2009; Kaban et al., 2009), but there are three basic surgical techniques that have been developed. The first is gap arthroplasty, in which the osseous mass between the articular cavity and the mandibular ramus is resected without interpositional material being inserted. Secondly, interpositional arthroplasty in which a gap is created by resecting the osseous mass into which biological material is interposed, such as a temporal muscle flap, or a non-biological material such as acrylic, or silastic, can be performed (Kaban et al., 1990; Pogrel and Kaban, 1990; Paterson and Shepherd, 1992; Dean and Alamillos, 1999; Saeed et al., 2002; Schliephake et al., 2003; Li et al., 2006; Kaban et al., 2009; Tripathy et al., 2010). Lastly, the joint can be reconstructed. The osseous mass is resected and the joint reconstructed by autogenous bone grafts or a total joint prosthesis (Kaban et al., 1990; Pogrel and Kaban, 1990; Huang et al., 2007; Kaban et al., 2009). The most commonly followed protocol for the management of ankylosis is that given by Kaban et al. (Kaban et al., 1990; Kaban et al., 2009). This includes early surgical intervention, resection (1.5–2.0 cm), ipsilateral coronoidectomy (if mouth opening less than 35 mm), contralateral coronoidectomy (if mouth opening less than 35 mm after the ipsilateral coronoidectomy), lining of the TMJ with temporalis fascia or cartilage, reconstruction of the ramus with a costochondral graft or distraction osteogenesis, rigid fixation, early mobilisation and physiotherapy, regular long term follow up, and finally cosmetic surgery after growth has been completed. Various disadvantages have been noted after resection of the ankylotic mass, among which the most important is reconstruction of the created gap (Paterson and Shepherd, 1992; Schliephake et al., 2003). Most authorities also agree that ankylosis is less likely to recur when something is interposed between the cut ends of bone, irrespective of the size of the gap arthroplasty (interpositional arthroplasty) (Schliephake et al., 2003). However, the results are inconclusive.

Considering the high possibility of TMJ reankylosis in just a few weeks after surgical treatment of TMJa, the authors, starting from 2007, introduced a new two phase physiotherapy protocol for TMJa management. We therefore organized this retrospective study to evaluate the efficacy of our institutional protocol in the management of TMJa, involving a conservative gap interpositional arthroplasty with collagen membrane and physiotherapy, thereby preventing re-ankylosis.

2. Materials and methods

2.1. Patients

A 9-year retrospective study of a consecutive case series of patients with TMJa who underwent TMJ release at Department of

Craniofacial Surgery from 2007 to 2016 was conducted. The approval of the university ethical committee was obtained.

For enrolment into this study, patients had to fulfil inclusion criterion such as: diagnosis of true TMJa; complete patient records (both clinical and radiographic data) available for examination; post-operative follow-up of at least 24 months and patient's consent for participation in the study. Patients in whom pre/post-operative Three-Dimensional Computed Tomography (3DCT) data was not available and those who underwent surgical procedures to increase the ramus length (like distraction osteogenesis) after ankylosis release surgery were excluded from the study.

Sociodemographic details such as age, gender and etiology were recorded. Clinical data retrieved were the laterality of ankyloses (unilateral or bilateral), maximum interincisal distance (MIID) (before surgical release, after surgical release, at 12 months post-operatively and at the end of follow-up); and complications, if any.

143 patients were operated for TMJa release by a single craniofacial surgeon. 98 patients fulfilled the inclusion criteria. 56 males and 42 females; age range between 2 and 40 years, with a mean of 20 years were included in the study. Records for all the patients included in the study were assimilated and evaluated.

2.2. Surgical procedure

All patients were operated under general anaesthesia following standard anaesthetic protocol (Most often requiring a fiberoptic nasal endotracheal intubation). The standard analgesic and antibiotic regimen was followed from 1 h pre-operatively to Day 4. A conservative preauricular incision was made extending from the superior end of tragus to the junction of ear lobe with the face inferiorly (Fig. 1 and 2 (1)). Dissection was carried out to expose the ankylotic mass completely. A Dunn-Dautery retractor was placed on the medial side of the condyle to avoid damage to the maxillary artery when possible.

If there was flattening or deformity of the condyle, and the coronoid process was differentiable, two anterior and posterior points ascertained via 3DCT were marked on the cranial base end of the ankylotic mass. A horizontal osteotomy cut was placed using a #703 51 MM carbide bur with head diameter of 2.1 mm and working length of 4.8 mm (S.S. White Burs, Lakewood, NJ) with a friction grip straight hand piece, and a vertical reduction of

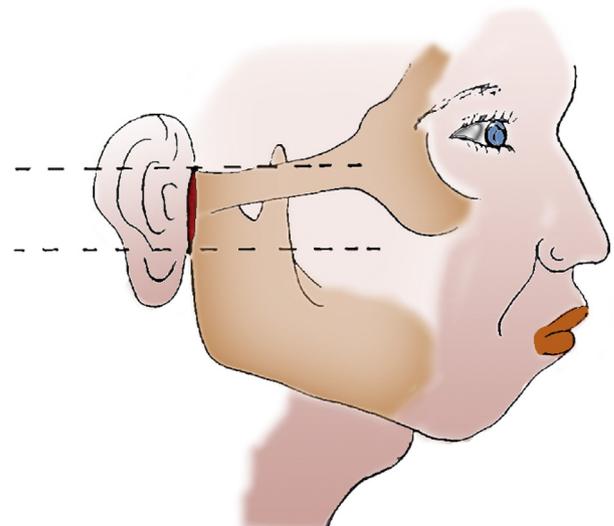


Fig. 1. Schematic representation of pre-auricular incision.



Fig. 2. Minimally invasive surgical technique. 1. Pre-auricular incision from the superior end of tragus to the junction of ear lobe with the face. 2. Exposure of ankylotic mass. 3. Horizontal osteotomy cut. 4. Reshaping of condylar stump and removal of wedge shaped ankylotic mass. 5, 6, 7. Preparation of collagen sheet by wrapping around gelatine sponge and interposing into the joint space. 8. Assessment of intra operative mouth opening. 9. Surgical closure done with sutures.

ankylotic mass of about 2 mm more than the head diameter of bur was performed. Smith spreader was inserted into the gap created and the beaks were opened to break the fibrous bands of tissue surrounding the TMJ. Stump of the remnant condyle was reshaped using an oblique cut running superolaterally to inferomedially, thereby removing a wedge shaped mass in sagittal and coronal views (Fig. 2 (2–4)). In case of unilateral TMJa, this was followed by ipsilateral coronoidectomy. If adequate mouth opening (>35 mm) was not achieved, contralateral coronoidectomy was performed using an intraoral approach. For all bilateral TMJa, a conservative vertical reduction of 5–6 mm of ankylotic mass from the cranial base end was performed bilaterally followed by bilateral coronoidectomy (Fig. 3 (1)).

If the entire joint was replaced by mass of bone, the same procedure was followed for the ankylotic mass reduction and reshaping. As the coronoid process cannot be differentiated in these cases, additional coronoidectomy was not desirable (Fig. 3 (2)).

Once the intraoperative mouth opening of greater than 35 mm was achieved, a bite block was used to maintain the opening. A sheet of collagen membrane [Kollagen®, Eucare Pharmaceuticals Pvt. Ltd., Chennai, India] was taken, washed in saline and evenly spread to remove any crease, wrapped tightly around an absorbable gelatine sponge [GelSpon®, Eucare Pharmaceuticals Pvt. Ltd., Chennai, India], and interpositioned in the gap. Joint mobility was ensured under direct visualization with the collagen membrane interposed. Haemostasis was achieved and closure was done in 3 layers (Fig. 2 (5–9)).

2.3. Physiotherapy protocol

The post-operative management involving physiotherapy with the use of bite block (Fig. 4) was divided into two phases, as shown in Table 1.

All patients were followed up at monthly intervals during the first year, quarterly intervals during the second year, and at

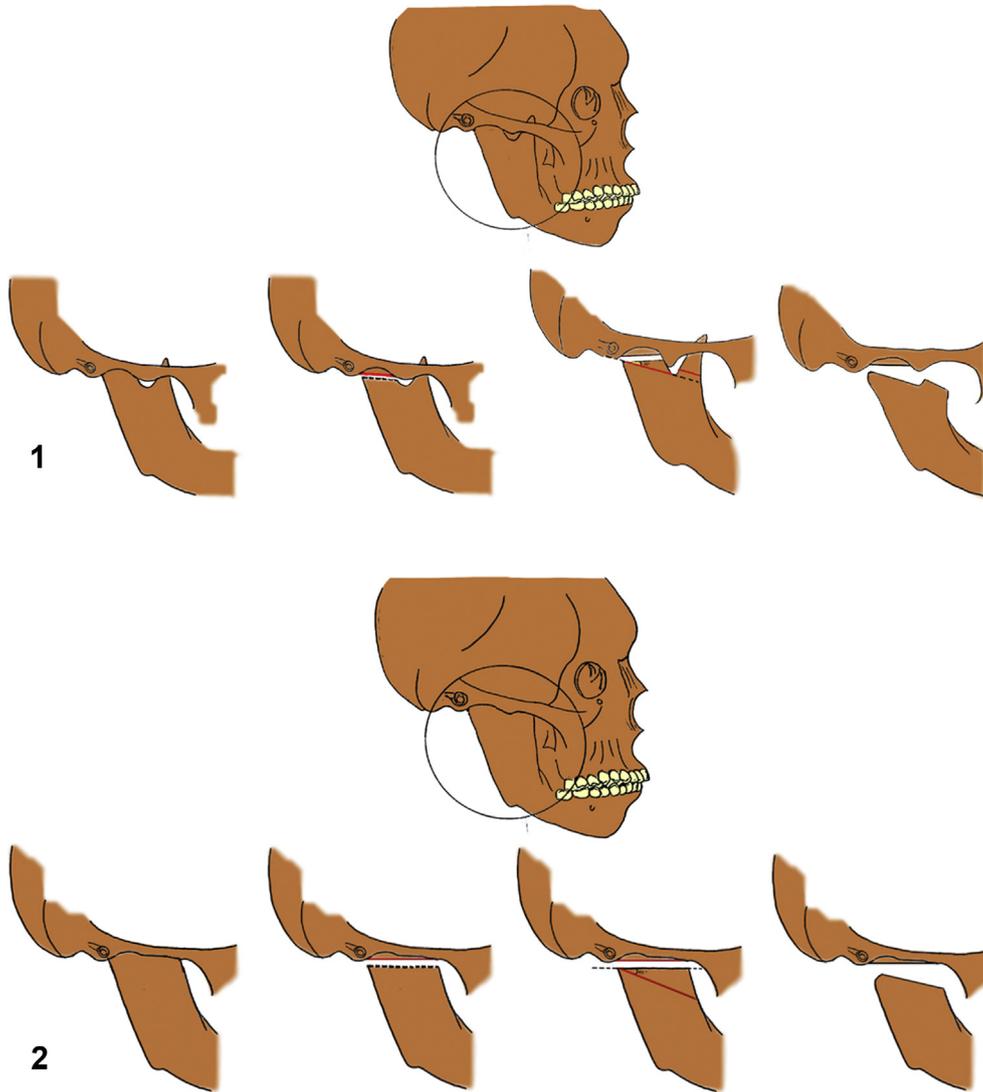


Fig. 3. Schematic representation of conservative excision of ankylotic mass. 1. In case of flattening of the condyle, and the coronoid process is differentiable. 2. When the entire joint is replaced with bone and coronoid process is not differentiable.

intervals of 6 months during subsequent follow-up years. Every visit involved a clinical examination of the joint, mobility and occlusion. Maximum mouth opening was measured at every follow-up visit. At any point in the follow-up period if the maximum mouth opening was found to reduce to less than 35 mm, brisement of jaws was performed using a guarded Fergusson-Ackland mouth gag under general anaesthesia. Physiotherapy was reinforced on every visit.

2.4. Primary outcome measures

1) Maximum Interincisal Distance (MIID)

Using a metal scale, mouth opening was measured from the mesio-incisal angle of the upper right central incisor to that of the lower right central incisor. In case of upper missing teeth, the most anterior tooth with a counterpart in the opposing arch was used. If the upper and lower anterior teeth were missing, the vertical dimension between the alveolus was measured and the approximate length of maxillary central incisor crown was added. The



Fig. 4. Bite block.

Table 1
TMJ ankylosis management physiotherapy protocol.

Phase I (Immediate post-operative to Day 30)		
Immediate Post-operative- Day 2	A mouth prop was maintained insitu for 24 h at interincisal opening of minimum 35 mm. If respiratory distress with or without bradycardia is noted due to the wide mouth opening, remove the bite block for 2 h, secure the airway and place a smaller bite block, depending on patient's comfort, for 2 days.	
Post-operative Day 3- Day 8	Night time	10 h of continuous bite block. ^a
Day 8	Day time	Two sessions of 5 h each of continuous bite block. ^a
Post-operative Day 9- Day 30	Suture removal and discharge	
	Night time	10 h of continuous bite block. ^a
	Day time	Two sessions of 4 h each of continuous bite block. ^a
Phase II (Post-operative to Day 31- Day 365)		
Post-operative Day31-Day365	Night time	No bite block. If patient has tendency to keep mouth open, engage light elastics to keep mouth closed. ^b
	Day time	Two sessions of 4 h each of continuous bite block. ^a
At any point in time, if maximum incisal opening reduces below 35 mm	Forceful brisement of jaws under general anaesthesia to open beyond 35 mm minimum, followed by Phase I for 3 months and Phase II for 1 year.	

^a With maximum incisal opening (35 mm minimum).

^b Elastics engaged via orthodontic braces or intermaxillary fixation screws.

distance between the described teeth was quantified in millimetres and recorded at the time of presentation (pre-operative MIID, intraoperatively MIID and at each subsequent visit). The measurement at the end of follow-up was considered the final MIID. Difference between the preoperative MIID and final MIID was suggested the improvement in mouth opening (Fig. 5).

2) Ramus length measured using 3DCT data

Pre-operative and post-operative 3DCT scans were measured for ramus length on Medixant RadiAnt DICOM Viewer Software (version 5.0.0) (Medixant, 2019). The shortest distance between the gonion and zygomatic root point was considered the ramus length,

and the difference of these were measured amongst the presurgical, postsurgical and follow up 3DCT (Fig. 6).

3) Complications

All intraoperative and post-operative complications were retrieved from the clinical records and classified as followed (Dindo, Demartines and Clavien et al., 2009).

Grade I- Surgical site infection which is treated with regular wound cleaning and dressing supplemented with antibiotic regimen.

Grade II- Reactionary bleeding during the postoperative phase which can be controlled with Tranexamic Acid injections. In case of



Fig. 5. Maximum interincisal distance assessment at T1, T2 and T3.

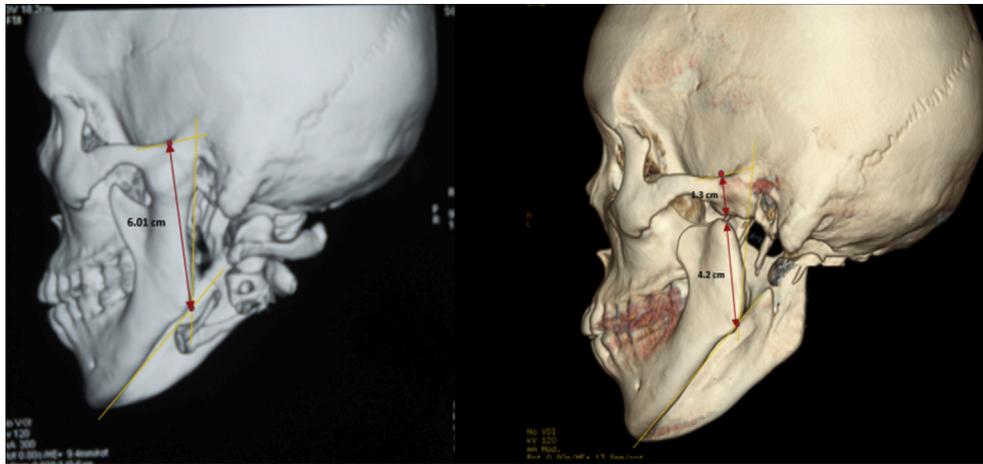


Fig. 6. Ramal length assessment on pre-treatment and post treatment 3DCT.

severe blood loss, the option of blood transfusion should also be considered.

Grade III- Recurrent Ankylosis. It can be fibro-osseous or bony ankyloses.

IIIa- The use of postoperative low dose radiation and medications such as indomethacin and didrinal or physiotherapy with early joint mobilisation to minimise the chances of reankylosis.

IIIb- If it still recurs, treatment requiring re-arthroplasty or joint removal under general anaesthesia.

Grade IV- Life threatening complications such as damage to the adjacent organs during surgery; for e.g.-middle ear damage, cranial base injury (very rare). Permanent nerve damage is also a very serious complication warranting nerve repair (Most commonly Cranial nerve VII).

IVa- Single organ dysfunction.

IVb- Multiorgan dysfunction.

Grade V- Death from TMJ Ankylosis surgery is very rare but is a possibility if the surgeon fails to control the bleeding from major vessels; most commonly from Maxillary Artery.

The aforementioned numerical data were entered into spreadsheets and statistically analysed using SPSS software version 22 (IBM, Armonk, New York, United States). Descriptive statistics mean, standard deviation, interquartile range were calculated for continuous variables. Frequency and percentages were calculated for categorical variables. ANOVA with repeated measures with Greenhouse-Geisser correction was used for statistical analysis.

3. Results

A total of 98 patients were selected for the study according to the inclusion criteria (56 males and 42 females with a mean age of 19.60 years and 17.46 years respectively), inclusive of patients who developed complications intraoperatively and postoperatively. Mean follow up period comparing the mouth opening and the ramal length differences was 6.38 ± 2.36 years (Table 2).

19 patients presented with Grade I complications. 12 patients (9 female, 3 male) experienced respiratory distress and/or bradycardia. The bite block was removed for 2 h then continued for 48 h with lesser mouth opening. 2 patients (2 female, 2 male) showed transient facial nerve weakness. They recovered within 6 months of their follow up period. 5 patients (3 female, 2 male) had infection of the surgical wounds and were managed with regular wound debridement and sterile dressing along with antibiotic coverage and within 5 days, the wound healed uneventfully. 8 patients (5

female, 3 male) presented Grade IIIa complication. They reported with reduced mouth opening 3–8 months post-surgery. Forceful brisement of jaws was done and physiotherapy protocol was reinforced. 3 non-compliant patients (2 female, 1 male) belonged to the Grade IIIb category. They reported with reankylosis after 4 years. TMJa surgery and physiotherapy protocol were re executed. 1 male patient showed grade IV complication. The patient showed signs of facial palsy and was kept under regular follow up (Fig. 7).

The mean scores for mouth opening at T1, T2 and T3 were statistically significantly different at all intervals ($F(1.589, 155.69) = 2112.2, p < 0.0005$) (Table 3). The mean scores for ramal length were also statistically significantly different ($F(1.422, 139.3) = 111.1, p < 0.0005$) (Table 4, Figs. 2 and 8 (1)).

The Intra Class Coefficient values of 0.996 and 0.998 indicate excellent inter and intra examiner agreement, respectively (Table 5).

4. Discussion

The ankylosis of the TMJ is a severely disfiguring disorder and the management requires cautious treatment planning and accurate execution. Most patients present with difficulty in mouth opening, usually accompanied by speech and mastication difficulties, in addition to the compromised aesthetics. The main aim of treating TMJa is to achieve adequate mouth opening with minimal chance of recurrence in long term follow up, thereby striving to achieve functional efficiency and structural stability.

Table 2

Descriptive statistics for the patient's age, gender, follow up period, mouth opening and ramal length.

	Mean	SD
Patient's age (n)		
Males (47)	19.60	9.97
Females (52)	17.46	12.75
Follow up (years)	6.38	2.36
Mouth opening (mm)		
Pre OP	5.99	4.66
Post OP	34.80	3.09
Follow up	36.90	4.40
Ramal length (cm)		
Pre OP	4.32	0.81
Post OP	3.72	0.77
Follow up	3.73	0.78

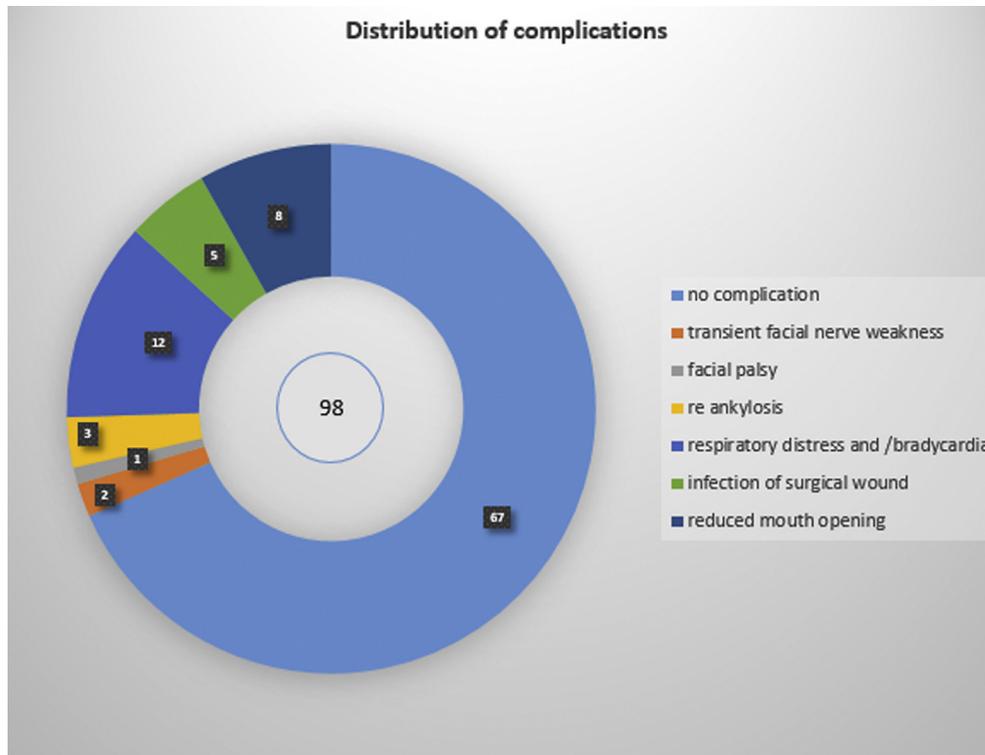


Fig. 7. Distribution of complications.

Table 3
Comparison between mouth opening at pre op, post op and follow up.

Time		Mean Difference	p value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Post	Pre	28.80	0.001	27.502	30.114
	Follow up	-2.10	0.001	-3.062	-1.140
Follow up	Pre	30.90	0.001	29.360	32.458
	Post	2.10	0.001	1.140	3.062

ANOVA, repeated measure, Post hoc tests using the Bonferroni correction.
p value < 0.05, statistically significant.

Table 4
Comparison between ramal length at pre op, post op and follow up.

Time		Mean Difference	p value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Pre	Post	0.600	0.001	0.475	0.726
	Follow up	0.660	0.001	0.514	0.806
Post	Pre	-0.600	0.001	-0.726	-0.475
	Follow up	0.060	0.172	-0.016	0.136

ANOVA, repeated measure, Post hoc tests using the Bonferroni correction.
p value < 0.05, statistically significant.

Kaban indicated that post-operative MIID greater than 35 mm is difficult to achieve and emphasized complete excision of ankylotic mass and coronoidectomy to enhance the motion of the joint. He insisted on an extensive hemicoronal incision to gain adequate surgical access to expose and resect the ankylotic mass (Kaban et al., 1990). However, a conservative surgical approach yielding the required results with minimal scar visibility is the call of the hour. The pre auricular incision described in the current report is minimal in extent, thereby reducing the post-operative healing time, reduced post-operative patient discomfort and minimal scar visibility. The mean MIID value post-operatively was more than

pre-operative MIID by 28.8 mm and the results were significant. The MIID improved further during the follow up period with a mean difference of 2.1 mm from post-operative MIID and a total mean difference of 30.9 mm from the pre-operative value.

An imperative facet of contemplation is the extent of ankylotic mass removal. Most of the authors recommend bone removal of 1.5 cm the least (Chossegras et al., 1997; Kaban et al., 2009; Elgazzar et al., 2010; Kumar et al., 2013). Chidzonga et al. suggest establishing a gap of 0.5 cm–1 cm (Chidzonga, 1999). However, the author emphasizes that vertical bone reduction of 5–6 mm is sufficient, followed by recontouring of condylar stump by removing

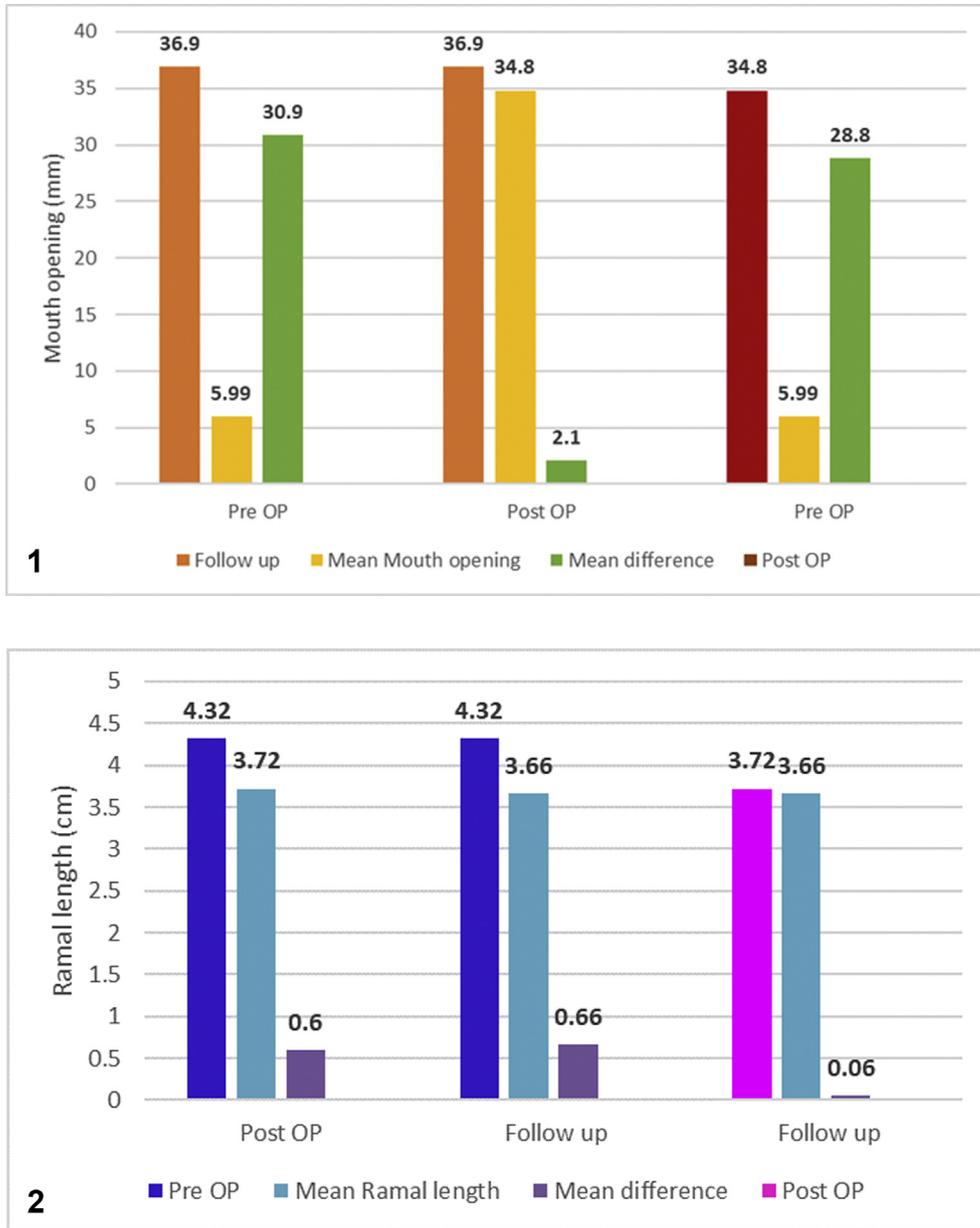


Fig. 8. Graphical representation of 1. Mean mouth opening difference. 2. Mean Ramal length difference.

Table 5
Inter examiner and intra examiner reliability.

Reliability	Intraclass Correlation	95% Confidence Interval		p value
		Lower Bound	Upper Bound	
Inter examiner	0.996	0.993	0.997	0.001
Intra examiner	0.998	0.997	0.999	0.001

p < 0.05- statistically significant.

a wedge shaped mass completely from the medial aspect, thereby allowing to maintain the vertical ramal length on the lateral aspect, further reducing the burden on surgeries for secondary asymmetry correction. The mean ramal length value post-operatively was lesser than pre-operative ramal length by 6 mm and the results were significant. The mean difference in ramal length from post-operative to follow up was statistically insignificant. The results obtained are concurrent to the results with techniques employed

by other authors (Chossegras et al., 1997; Kaban et al., 2009; Elgazzar et al., 2010; Kumar et al., 2013). Patients with severe facial asymmetries subsequently underwent successful distraction osteogenesis/orthognathic surgeries at the author's center.

It is suggested, to prevent re-ankylosis, a gap of 10–20 mm is required in arthroplasty without interposition, which leads to shortened mandibular ramus, deviation of the jaw on opening mouth and contralateral open bite, unstable anatomical relations between the mandible and the skull base and high risk of reankylosis. When an interpositional material is used, it is required to create a slight gap of not more than 10 mm to avoid reankylosis (Mitra et al., 2016). Most authors tend to agree that if a material is interposed between the divided bone ends, recurrent ankylosis is less likely and suggest the material to be soft but firm, able to be handled easily and sculptured at the time of surgery to fit any volume and shape of joint space, and which adapts and responds to the demands of joint function without fragmentation or

degeneration over time (Dimitroulis, 2011). However, debate arises over whether to place alloplastic material (silastic methyl acrylate, Teflon, etc.), autogenous tissues (fascia lata, temporalis muscle, full thickness skin, fat or cartilage) or xenograft (bovine collagen) (Tripathy et al., 2010).

Autogenous tissue has the disadvantage of morbidity at the donor site and erratic growth and resorption. On the other hand, when permanent alloplastic materials are used, there is a risk of foreign body reaction, disintegration and graft rejection (Herbosa and Rotskoff, 1990; do Egito Vasconcelos et al., 2006). None of these materials have shown prevention of re-ankylosis with long-term follow up studies in large patient series. Concomitantly, the possibility and effectiveness of collagen membrane as an interpositional material is also infrequently reported in literature.

Collagen is the major insoluble protein in the extra-cellular matrix and in connective tissues. Collagen membranes are used commonly in the management of burns, chronic wounds, diabetic foot ulcer etc. This versatile material also has its application in the field of oral and maxillofacial surgery, such as for coverage of minor intraoral soft tissue defects of the oral cavity, as an interpositional graft material, for orbital floor reconstruction, bone augmentation of atrophic mandibular ridge for placement of implants, for guided bone regeneration, etc. This collagen may be derived from bovine, porcine, avian or equine sources, following which it is purified to make it non-antigenic.

The physical properties of a collagen membrane can be studied under its biological and physiological properties. Biological properties include its non-inflammatory non-toxic nature, low antigenicity and minimal biodegradation. It also helps in the synthesis of neodermal collagen matrices by facilitating migration of fibroblasts and microvascular cells. The physiological properties of collagen include non-permeability to bacterial migration, elasticity, softness, flexibility, good tear strength and enough strength to be peeled off the wound.

The resorption of these membranes is due to collagenases that cleave the collagen in two molecules which are denatured at 37 °C and further decomposed into oligopeptides and amino acids by the gelatinase and proteinase (Van Swol et al., 1993) (Vastani et al., 2016). They are biocompatible, easy to manipulate, and only weakly immunogenic (Almazrooa et al., 2014).

The authors used a collagen membrane wrapped around gel foam as the interposition material (xenograft). The collagen membrane used [Kollagen®, Eucare Pharmaceuticals Pvt. Ltd., Chennai, India] was a bovine based extracellular matrix native collagen membrane which is supplied in gamma-sterilised sheets. Direct contact between the resected bony margins was prevented by collagen membrane in the initial healing phase.

The purpose of the absorbable gelatine sponge [GelSpon®, Eucare Pharmaceuticals Pvt. Ltd., Chennai, India] was to provide a framework for the collagen membrane until the time that it gets resorbed, by when the bony surfaces would undergo eburnation. The gelatine sponge expanded in size over time by absorption of tissue fluids and further prevented the collapse of the collagen membrane. Collagen membranes are known to resorb in up to 32 weeks. This provides enough time for functional articulation of the condyle to the skull base. Therefore, none of our patients presented with foreign body reaction or graft rejection, as it is a temporary interpositional material (Almazrooa et al., 2014).

However, the suggested physiotherapy protocol is the most domineering aspect of TMJa management. Usually, the primary therapeutic objective is the re-establishment of mandibular opening by a surgical stage to resect the ankylotic block. This stage is followed by rehabilitation in which mandibular mobility is restored with intensive physiotherapy. Physiotherapy in the post-ankylosis release phase not only helps to prevent re-ankylosis, but also has

an important task in building up muscle bulk, strength and improving range of motion following a protracted period of relative inactivity of the surrounding mandibular musculature (Cope et al., 1993).

Danda et al. compared gap arthroplasty and interpositional arthroplasty with a temporalis muscle flap for the treatment of TMJa in 16 patients. The patients were assessed for mouth opening, diet consistency, and weight postoperatively and concluded that there is no significant difference in maximal interincisal opening, diet scores, and weight of the patients in both groups. The overall outcome of the treatment depends on patient cooperation, active physiotherapy, and regular follow-up (Danda et al., 2009).

Between the surgical and physiotherapy stages, there is usually a period of about 2–3 weeks in which the patient is not amenable to active functional therapy because of adverse clinical conditions, especially pain and swelling. Most of the authors think that this period can be considered a genuine intermediate stage to wait for clinical symptoms to stabilize. However, during this time, the risk of losing the maximum oral opening obtained by surgery is very high.

Topazian affirmed the use of a spacer between the dental arches after the arthroplastic surgery to avoid contact and ankylosis of the articular surfaces and prevent relapse (Topazian, 1966). Nakajima et al. proposed using a bite block (BB) consisting of 2 resins with progressively extensible elements via a system of expandable screws (Nakajima et al., 1980). Ziccardi et al. reported the use of a rigid resin BB, positioned during surgery and left in place between the dental arches for 24 h, followed by rehabilitative physiotherapy (Ziccardi et al., 1995). Gianluigi et al. reported that in patients who underwent physiotherapy, the nocturnal mandibular inactivity rendered the surgical results unstable, hence suggested that while awaiting remission of the clinical symptoms, during the period from surgery to functional therapy, a bite block may be useful to favour surgical recovery and, at the same time, allow healing of the maximum oral opening (Longobardi et al., 2009). Dimitroulis et al. did not use mouth opening devices but insisted that such devices would certainly be useful in patients lacking access to physiotherapists and also prevent postoperative adhesions (Dimitroulis, 2004). Kaban recommends gum chewing, finger stretching and mouth opening exercises for up to 1 year (Kaban et al., 2009).

In light of these studies, the author proposes a two phase physiotherapy protocol with bite block exclusively, extending up to 1 year post-operatively, in contrast to 3 weeks as suggested by Gianluigi et al. (Longobardi et al., 2009). The patients were followed up half yearly during the subsequent years, and the mean follow up period was 6.38 ± 2.36 years. The irregular patients were reminded periodically of their appointments and if they still did not report, a care person was sent from the author's centre to bring them. The increased MIID and the consistent ramal length on follow up are indicative of an efficient TMJa management protocol. Reankylosis was observed in only 3 of our patients, due to loss of compliance. In these patients, TMJa release was done again and the physiotherapy protocol was reinforced. No subsequent reankylosis followed.

The advantages of this technique include:

- A lesser residual deformity (reduces apertognathia due to shortened mandibular ramus)
- Early recovery, as the procedure utilized a minimally invasive incision
- Preservation of vital structures
- Avoids donor site morbidity and
- Restoration of functional efficiency with the physiotherapy protocol.

Limitations: The success of the suggested physiotherapy protocol is largely dependent on patient compliance, which is one of the

major factors in the treatment outcome. Frequent follow up of the patients from far off places is a difficult task and therefore requires active effort from the clinician's centre to set up reminders.

5. Conclusions

The authors suggest a conservative surgical technique with minimal ankylotic mass resection and interpositional arthroplasty using an easily available xenograft to be followed by a new two phase physiotherapy protocol in the management of TMJa. The results obtained strengthen the claim that the success of the surgical technique is less dependent on the longevity and rigidity of the interpositional material but more indebted to the physiotherapy protocol, considering the patient compliance to be a primary obligation in the management of TMJa.

Conflict of interest

None.

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References

- Almazroo SA, Noonan V, Woo S-B: Resorbable collagen membranes: histopathologic features. *Oral Surg, Oral Med, Oral Pathol Oral Radiol* 118(2): 236–240, 2014 Elsevier
- Chidzonga MM: Temporomandibular joint ankylosis: review of thirty-two cases. *Br J Oral Maxillofac Surg* 37(2): 123–126. <https://doi.org/10.1054/bjom.1997.0089>, 1999
- Chossegras C, Guyot L, Cheynet F, Blanc JL, Gola R, Bourezak Z, et al: Comparison of different materials for interposition arthroplasty in treatment of temporomandibular joint ankylosis surgery: long-term follow-up in 25 cases. *Br J Oral Maxillofac Surg* 35(3): 157–160. [https://doi.org/10.1016/S0266-4356\(97\)90554-4](https://doi.org/10.1016/S0266-4356(97)90554-4), 1997
- Clavien PA, Barkun J, De Oliveira ML, Vauthey JN, Dindo D, Schulick RD, De Santibañes E, Pekolj J, Slankamenac K, Bassi C, Graf R: The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg* 250(2): 187–196, 2009
- Cope MR, Moos KF, Hammersley N: The compressible silicone rubber prosthesis in temporomandibular joint disease. *Br J Oral Maxillofac Surg* 31(6): 376–384, 1993 Elsevier
- Danda AK, Ramkumar S, Chinnaswami R: Comparison of gap arthroplasty with and without a temporalis muscle flap for the treatment of ankylosis. *Br J Oral Maxillofac Surg* 47(7): 1425–1431. <https://doi.org/10.1016/j.joms.2008.12.049>, 2009 American Association of Oral and Maxillofacial Surgeons
- Dean A, Alamillos F: Mandibular distraction in temporomandibular joint ankylosis. *Plast Reconstr Surg* 104(7): 2021–2031, 1999
- Dimitroulis G: The interpositional dermis-fat graft in the management of temporomandibular joint ankylosis. *Int J Oral Maxillofac Surg* 33(8): 755–760, 2004 Elsevier
- Dimitroulis G: A critical review of interpositional grafts following temporomandibular joint disectomy with an overview of the dermis-fat graft. *Int J Oral Maxillofac Surg* 40(6): 561–568, 2011 Elsevier
- do Egito Vasconcelos BC, Bessa-Nogueira RV, Cypriano RV: Treatment of temporomandibular joint ankylosis by gap arthroplasty. *Med Oral Patol Oral Cir Bucal* 11: E66–E69, 2006
- Elgazzar RF, Abdelhady AI, Saad KA, Elshaal MA, Hussain MM, Abdel SE, et al: Treatment modalities of TMJ ankylosis: experience in delta Nile, Egypt. *Int J Oral Maxillofac Surg Int Assoc Oral Maxillofac Surg* 39(4): 333–342. <https://doi.org/10.1016/j.jiom.2010.01.005>, 2010
- Gunaseelan R: Condylar reconstruction in extensive ankylosis of temporomandibular joint in adults using resected segment as autograft. *Int J Oral Maxillofac Surg* 26(6): 405–407. [https://doi.org/10.1016/S0901-5027\(97\)80002-1](https://doi.org/10.1016/S0901-5027(97)80002-1), 1997
- Herbosa EG, Rotskoff KS: Composite temporalis pedicle flap as an interpositional graft in temporomandibular joint arthroplasty: a preliminary report. *J Oral Maxillofac Surg* 48(10): 1049–1056, 1990 Elsevier
- Huang IY, Lai ST, Shen YH, Worthington P: Interpositional arthroplasty using autogenous costal cartilage graft for temporomandibular joint ankylosis in adults. *Int J Oral Maxillofac Surg* 36(10): 909–915. <https://doi.org/10.1016/j.jiom.2007.05.009>, 2007
- Kaban LB, Perrott DH, Fisher K: A protocol for management of temporomandibular joint ankylosis. *J Oral Maxillofac Surg* 48(11): 1145–1151. [https://doi.org/10.1016/0278-2391\(90\)90529-B](https://doi.org/10.1016/0278-2391(90)90529-B), 1990
- Kaban LB, Bouchard C, Troulis MJ: A protocol for management of temporomandibular joint ankylosis in children. *J Oral Maxillofac Surg* 67(9): 1966–1978. <https://doi.org/10.1016/j.joms.2009.03.071>, 2009 Elsevier Inc
- Kumar D, Rajan G, Raman U, Varghese J: Autogenous reconstructive modalities of TMJ ankylosis—A retrospective analysis of 45 cases. *J Oral Maxillofac Surg* 13(4): 359–365. <https://doi.org/10.1007/s12663-013-0504-9>, 2013
- Li ZB, Li Z, Shang ZJ, Zhao JH, Dong YJ: Potential role of disc repositioning in preventing posturgical recurrence of traumatic temporomandibular joint ankylosis: a retrospective review of 17 consecutive cases. *Int J Oral Maxillofac Surg* 35(3): 219–223. <https://doi.org/10.1016/j.jiom.2005.06.021>, 2006
- Longobardi G, Boniello R, Gasparini G, Pelo S: A new 3-phase therapy protocol in temporomandibular joint ankylosis: our experience. *J Craniofac Surg* 20(2): 483–487. <https://doi.org/10.1097/SCS.0b013e31819b9d47>, 2009
- Matsuura H, Miyamoto H, Ogi N, Kurita K, Goss AN: The effect of gap arthroplasty on temporomandibular joint ankylosis: an experimental study. *Int J Oral Maxillofac Surg* 30(5): 431–437. <https://doi.org/10.1054/jiom.2001.0115>, 2001
- Medixant: RadiAnt DICOM Viewer [Software]. Version 5.0.0. Apr 25; 2019, URL: <https://www.radiantviewer.com>
- Mercuri LG, Ali FA, Woolson R: Outcomes of total alloplastic replacement with periarticular autogenous fat grafting for management of reankylosis of the temporomandibular joint. *J Oral Maxillofac Surg* 66(9): 1794–1803. <https://doi.org/10.1016/j.joms.2008.04.004>, 2008
- Mitra S, Joshi S, Bhate K, Kumar SS, Kshirsagar K, Pawar V: Role of interpositional dermal graft in management of recurrent temporomandibular joint ankylosis: a case series of three patients. *Int J Med Pharmaceut Case Rep*; 2016: 1–5, 2016
- Nakajima T, Sasakura H, Kato N: Screw-type mouth gag for prevention and treatment of postoperative jaw limitation by fibrous tissue. *J oral surg (Am Dent Assoc)* 1965) 38(1): 46–50, 1980
- Passi D, Singh G, Singh S, Mehta G, Dutta S, Sharma S: Advances in temporomandibular joint reconstruction in TMJ ankylosis: our experiences and literature review. *Int J Dent Res* 2(2): 45–49. <https://doi.org/10.14419/ijdr.v2i2.2502>, 2014
- Paterson AW, Shepherd JP: Fascia lata interpositional arthroplasty in the treatment of temporomandibular joint ankylosis caused by psoriatic arthritis. *Int or Oral Maxillofac Surg* 21: 137–139, 1992 1–3
- Pogrel MA, Kaban LB: The role of a temporalis fascia and muscle flap in temporomandibular joint surgery. *J Oral Maxillofac Surg* 48(1): 14–19. [https://doi.org/10.1016/0278-2391\(90\)90173-Y](https://doi.org/10.1016/0278-2391(90)90173-Y), 1990
- Rao K, Kumar S, Kumar V, Singh AK, Bhatnagar SK, Paterson AW, et al: The role of simultaneous gap arthroplasty and distraction osteogenesis in the management of temporomandibular joint ankylosis with mandibular deformity in children. *J Cranio-Maxillofacial Surg* 32(1): 38–42. <https://doi.org/10.1016/j.jphotochem.2004.07.011>, 2004
- Saeed NR, Hensher R, McLeod NM, Kent JN: Reconstruction of the temporomandibular joint autogenous compared with alloplastic. *Br J Oral Maxillofac Surg* 40(4): 296–299. [https://doi.org/10.1016/S0266-4356\(02\)00139-0](https://doi.org/10.1016/S0266-4356(02)00139-0), 2002
- Schliephake H, Schmelzeisen R, Maschek H, Haese M: Long-term results of the use of silicone sheets after diskectomy in the temporomandibular joint: clinical, radiographic and histopathologic findings. *Int J Oral Maxillofac Surg* 28(5): 323–329. <https://doi.org/10.1034/j.1399-0020.1999.285280501.x>, 2003
- Schwartz HC, Relle RJ: Distraction osteogenesis for temporomandibular joint reconstruction. *J Oral Maxillofac Surg* 66(4): 718–723. <https://doi.org/10.1016/j.joms.2007.11.016>, 2008
- Topazian RG: Effect of soft tissue implantation on the healing of static bony defects. *J Den Res* 45(4): 1168–1173, 1966 SAGE Publications Sage CA: Los Angeles, CA
- Tripathy S, Yaseen M, Singh NN, Bariar LM: Interposition arthroplasty in post-traumatic temporomandibular joint ankylosis: a retrospective study. *Indian J Plast Surg* 42(2): 189. <https://doi.org/10.4103/0970-0358.59277>, 2010
- Valentini V, Vetrano S, Agrillo A, Torroni A, Fabiani F, Iannetti G: Surgical treatment of TMJ ankylosis: our experience (60 cases). *J Craniofac Surg* 13(1): 59–67. <https://doi.org/10.1097/00001665-200201000-00013>, 2002
- Van Swol RL, Ellinger R, Pfeifer J, Barton NE, Blumenthal N: Collagen membrane barrier therapy to guide regeneration in Class II furcations in humans. *J Periodontol* 64(7): 622–629, 1993 Wiley Online Library
- Vastani A, Chourasia N, Pahlajani V, Choubey S: Collagen membrane for reconstruction of soft tissue defects after surgery of oral cancer and precancer: a brief review. *Plast Aesthet Res* 3(3): 100. <https://doi.org/10.20517/2347-9264.2015.119>, 2016
- Zhi K, Ren W, Zhou H, Gao L, Zhao L, Hou C, et al: Management of temporomandibular joint ankylosis: 11 years' clinical experience. *Oral Surg, Oral Med, Oral Pathol, Oral Radiol Endodontology* 108(5): 687–692. <https://doi.org/10.1016/j.tripleo.2009.06.041>, 2009 Elsevier Inc.
- Ziccardi VB, Ochs MW, Braun TW: Intraoperatively fabricated bite block in the management of scar contracture hypomobility. *Oral Surg, Oral Med, Oral Pathol, Oral Radiol Endodontology* 80(1): 34–35, 1995