REVIEW ARTICLE

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Classification and surgical management of temporomandibular joint ankylosis: a review

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Abstract (J Korean Assoc Oral Maxillofac Surg 2021;47:239-248)

The paper reviews various classifications and surgical techniques for the treatment of temporomandibular joint ankylosis. PubMed, EBSCO, Web of Science, and Google Scholar were searched using a combination of keywords. Articles related to classification, resection-reconstruction of the temporomandibular joint, and management of airway obstruction were considered and categorized based on the objectives. Seventy-nine articles were selected, which included randomized clinical trials, non-randomized controlled cohort studies, and case series. Though several classifications exist, most classifications are centered on the radiographic extent of the ankylotic mass and do not include the clinical and functional parameters. Hence there is a need for a comprehensive staging system that takes into consideration the age of the patient, severity of the disease, clinical, functional, and radiographic findings. Staging the disease will help the clinician to adopt a holistic approach in treating these patients. Interpositional arthroplasty (IA) results in better maximal incisal opening compared with gap arthroplasty, with no significant difference in recurrent rates. Distraction osteogenesis (DO) is emerging as a popular technique for the restoration of symmetry and function as well as for relieving airway obstruction. IA, with a costochondral graft, is recommended in growing patients and may be combined with or preceded by DO in cases of severe airway obstruction. Alloplastic total joint replacement combined with fat grafts and simultaneous osteotomy procedures are gaining popularity. A custom-made total joint prosthesis using CAD/CAM can efficiently overcome the shortcomings of stock prostheses.

Key words: Temporomandibular joint, Ankylosis, Classification, Arthroplasty, Distraction osteogenesis

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I. Introduction

Temporomandibular joint ankylosis (TMJA), arising as a result of fibrous or bony fusion of the condylar head to the glenoid fossa, is a formidable problem for the patient and a challenge to the surgeon[1]. This disorder is characterized by the restriction of mandibular movements resulting in difficulties in chewing, speech impairment, facial deformity, airway compromise, and psychosocial problems, especially in younger individuals[2]. Trauma and infection are the leading causes; however, TMJA can also occur following TMJ surgery and systemic diseases, like rheumatoid arthritis[3]. The mainstay of treatment for TMJA across the world is surgery; however, the choice of technique and sequence of management vary among surgeons and institutions. The objectives of this review are:

1) To review the existing classification systems proposed for TMJA.

2) To compare the postoperative maximal incisal opening (MIO) distance between the upper and lower incisal edges during maximal opening and the recurrence rates of gap arthroplasty (GA) – the creation of a gap between the ramus and glenoid fossa following the resection of the ankylotic mass, interpositional arthroplasty (IA) – interpositioning an autogenous/alloplastic material in the gap created following GA to prevent contact between the bony surfaces, and joint reconstruction methods.

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3) To review various treatment options and sequences for the surgical management of TMJA.

4) To review the management of obstructive sleep apnea (OSA) in patients with TMJA.

II. Methods

PubMed, EBSCO, Web of Science, Science Direct, and Google Scholar were searched using a combination of search terms: temporomandibular joint ankylosis, TMJ ankylosis, ankylosis classification, ankylosis resection, gap arthroplasty, interpositional arthroplasty, temporalis myofascial flap, costochondral graft, total joint replacement, obstructive sleep apnea, distraction osteogenesis physiotherapy, and airway obstruction.

The search was not time-bound. Articles published in English and articles with English translations were considered. The screening of all relevant reports was performed using the title and abstract and the full texts of relevant studies were retrieved for evaluation.

The retrieved articles were segregated into 3 categories based on the objectives:

1) Articles proposing/describing the classification of TMJA

2) Articles describing the surgical management of TMJA

3) Articles on the management of airway obstruction in patients with TMJ ankylosis

1. Inclusion criteria

Articles pertaining to:

1) Patients with congenital/acquired TMJA

2) Randomized clinical trials, non-randomized controlled cohort studies, and case series

2. Exclusion criteria

1) Articles without English translations

2) Articles reporting conditions that may contribute to mouth opening restriction and airway obstruction for reasons other than TMJA

3) Animal studies

4) Case reports, technical notes, and reviews

III. Results

Seventy-seven articles pertaining to various aspects of TMJA were selected, which included randomized clinical trials, non-randomized controlled cohort studies, and case series.

1. Classification

TMJA has been broadly classified by Kazanjian[4] as true ankylosis when the joint is affected and false ankylosis when the fusion is extra-articular. TMJA is also classified as fibrous, bony, or mixed types according to the type of tissue growing within the joint[5]. Over the years several classification systems have been proposed for TMJA[4-11], which are widely based on the radiographic extent of the ankylotic mass and the histologic features. Most of the classifications are modifications of the classification proposed by Sawhney[6]. Most classifications are centered on the radiographic extent of the ankylotic mass and do not include the clinical and functional parameters. The overview of the classifications is listed in Table 1.

2. Management strategies

1) Gap arthroplasty vs interpositional arthroplasty

Four main surgical techniques are currently advocated in the treatment of TMJA: ① GA, ② IA, ③ reconstruction of the joint with autogenous grafts, alloplastic materials, or a combination of both, and ④ distraction osteogenesis (DO)/orthognathic surgery for secondary deformity correction[12].

GA is the oldest technique used in treating TMJA and evolved from the 19th-century practice of simply dividing the bone to separate the ramus from the skull base. Since this resulted in higher rates of recurrence, the gap between the segments was increased, giving rise to the GA technique[13].

GA is technically less challenging, with a shorter operation time and less expense compared to IA; however, the rates of reankylosis are higher[2]. GA is also believed to require a larger gap (10 mm) compared to IA (5 mm) to prevent reankylosis, which results in increased shortening of the ramus[2]. Babu et al.[14], found that minimal gap IA, with the total removal of the ankylotic mass from the mediolateral aspect, is an effective way of preventing recurrence.

Rajan et al.[15], described transoral access for GA for small- to moderate-size ankylotic masses. They reported that, though transoral access is technically challenging, it does not produce facial scars and facial nerve injury.

Ten studies[16-25] comparing GA and IA for the treatment of TMJA, were evaluated. Eight of the nine studies concluded that IA results in better MIO and decreased incidence of re-

Table 1. Classification of TMJ ankylosis

No.	Study	Sample size	Parameter	Description of each type
1	Topazian[5] (1966)	44		Stage I: ankylotic bone limited to the condylar process Stage II: ankylotic bone extending to the sigmoid notch Stage III: ankylotic bone extending to the coronoid process
2	Sawhney[6] (1986)	70	Extent of fusion visualized on tomograms	Type I: significantly deformed but visible condylar head. TMJ movement is not possible due to fibroadhesions. Type II: consolidation of the deformed condylar head and articular surface mainly at the edges and in the anterior and posterior parts of the structures. The medial part of the condylar head remains undamaged. Type III: involvement of the mandibular ramus and zygomatic arch. Medially, an atrophic and displaced fragment of the anterior part of the condylar head is present. Type IV: complete obliteration of the joint by a bony ankylotic mass between the cranial base and the mandibular ramus.
3	Durr et al.[7] (1993)	10 patients (15 joints)	Heterotopic bone formation within the ankylotic mass	No bone islands visible (Grade 0) Soft tissues around the joint show islands of bone (Grade 1) Periarticular bone formation (Grade 2) Apparent bony ankylosis (Grade 3) All 3 grades are further classified as symptomatic (S) and asymptomatic (A). Symptomatic: severe pain, reduced inter-incisal opening (15 mm or less), closed locking of the jaw, or decreased lateral or protrusive movement.
4	El-Hakim and Metwalli[8] (2002)	33 patients (42 joints)	Relation of the ankylosed mass to the surrounding vital structures, especially at the base of the skull as seen on post-contrast axial and coronal CT	Class I: unilateral and bilateral fibrous ankylosis. The condyle and glenoid fossa retain their original shape, and the maxillary artery is in normal anatomical relation to the ankylosed mass. Class II: unilateral or bilateral bony fusion between the condyle and the temporal bone. The maxillary artery lies in normal anatomical relation to the ankylosed mass. Class III: the distance between the maxillary artery and the medial pole of the mandibular condyle is less on the ankylosed than on the normal side or the maxillary artery runs within the ankylotic bony mass. Class IV: extensive bone formation and fusion to the skull base with a close relationship to vital structures such as the pterygoid plates, the carotid and jugular foramina and foramen spinosum.
5	He et al.[9] (2011)	84 patients (124 joints)	Bony/fibrous fusion as seen on coronal CT scan images	Type A1: fibrous ankylosis without bony fusion of the joint Type A2: bony fusion on the lateral aspect of the joint, while the residual condyle fragment is bigger than 0.5 of the condylar head in the medial side. Type A3: similar to A2 but the residual condylar fragment is smaller than 0.5 of the condylar head Type A4: ankylosis with complete bony fusion of the joint.
6	Braimah et al.[10] (2018)	36	Sawhney's classification-maxillary involvement on CT images	Class V (joint architecture completely replaced by bone with fusion of the condyle, sigmoid notch and coronoid process to the zygomatic arch, glenoid fossa and maxilla)
7	Xia et al.[11] (2019)	71 patients (102 ankylosed joints)	CT images Post trauma period Maximal mouth opening Complication rate Histopathological changes	Type I: non-bony ankylosis with near normal joint space; Type II: lateral bony ankylosis with a radiolucent line within a normal joint space; Type III: complete bony ankylosis with only a radiolucent line; and Type IV: extensive bony ankylosis with absence of radiolucent line

(TMJ: temporomandibular joint, CT: computed tomography)

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currence compared to GA indicating that the interpositional material acted as a barrier, preventing recurrence.(Table 2)

A variety of autogenous, alloplastic, and xenografts have been used as interpositional grafts[12]. Temporalis muscle flap[26], temporalis fascia[14], and temporalis muscle and fascia flap[12,27] are popularly used and preferred by most surgeons due to their proximity to the surgical site and bulk that they provide. Chossegros et al.[28] compared the different interpositional

Table 2. Comparison of gap arthroplasty and interpositional arthroplasty

Study	Sample size (GA/IA)	Mean age of patients (yr)	Follow-up period (mo)	Increase in MIO (mm), GA/IA	Incidence of reankylosis, % (GA/IA)
Tanrikulu et al.[16] (2005)	8/9	12	12-180	28.5/29.2	0 (0/8)/11.1 (1/9)
Ramezanian and Yavary[17] (2006)	22/26	19.5	59	24.33/23.6	45.4 (10/22)/23.1 (6/26)
Zhi et al.[18] (2009)	24/17	22.25	12-132	18.58/20.57	12.5 (3/24)/0 (0/17)
Danda et al.[19] (2009)	8/8	9.6	26.5	27.37/27.93	12.5 (1/8)/12.5 (1/8)
Elgazzar et al.[20] (2010)	11/14	19.43	14-96	29.1/30.7	18.2 (2/11)/7.1 (1/14)
Mansoor et al.[21] (2013)	30/30	13.3	6	24.33/23.77	0 (0/30)/3.3 (1/30)
Holmlund et al.[22] (2013)	14/22	49	12-108	30.9/36.7	0 (0/14)/0 (0/22)
Shaikh et al.[23] (2013)	10/10	15.15	12	29.4/32.9	0 (0/10)/0 (0/10)
Bhatt et al.[24] (2014)	207/55	12.95 (GA) 13.3 (IA)	43	29.76/30.51	14.6 (26/178)/4.8 (2/42)
Bansal et al.[25] (2014)	30/30	26.7	24	12.6/19	26.6 (8/30)/0 (0/30)

(GA: gap arthroplasty, IA: interpositional arthroplasty, MIO: maximal incisal opening)
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materials (skin, temporal muscle, homologous cartilage) used over a period of 22 years. Good results were obtained in over 92% of the cases with a full-thickness skin graft and 83% of cases with a temporal muscle flap. Homologous cartilage yielded poor results[28].

Following GA, Dimitroulis[13] filled the resultant gap with an autogenous dermis fat graft procured from the patient's groin. Though favorable results were obtained, the authors could not draw conclusions due to the small sample size. Full-thickness skin-subcutaneous fat grafts have been used successfully[29]. Malhotra et al.[30] described a simple and cost-effective procedure of lateral arthroplasty followed by interpositioning with a buccal fat pad for Sawhney type III ankylosis. Studies on the various interpositional materials used[12-14,26-29,31] are listed in Table 3.

In cases of reankylosis following GA, IA has been recommended as the treatment of choice. Following interpositioning with various materials, if the ramal height is not adequately restored, then reconstructing the joint with autogenous/alloplastic materials should be considered[2].

2) Reconstruction of the joint and total joint replacement

Reconstruction of the ramal-condylar unit with a costochondral graft (CCG) has been advocated, especially in young patients, as the graft is believed to possess growth potential[1]. Sharma et al.[32] observed that children with a CCG showed improved mandibular symmetry and growth with adequate mouth opening. However, studies have shown that, compared to CCG reconstruction, IA results in greater improvement in MIO with recurrence rates that are comparable[16,33-35]. The CCG appears to produce greater MIO when compared to alloplastic joint reconstruction (AJR); however, in terms of pain reduction, AJR seems to be superior to CCG[1,36,37].

Since DO obviates the need for a donor site, it is gaining popularity in the management of TMJA. DO is indicated as a primary mandibular lengthening procedure or a secondary procedure when other procedures have failed or produced inadequate results[20].

Chen et al.[38] divided 130 ankylosis patients into 3 groups based on age. They found that children showed a significantly greater rate of reankylosis compared with adults. In the adults, reconstruction was done using a coronoid process graft (CPG), DO, or prosthesis implantation for type III. The CPG resulted in the highest recurrence rate compared to the other two treatment modalities.

Sahoo et al.[39] compared the outcomes of 3 groups of TMJA patients: IA with temporalis myofascial flap (TMMF), IA+TMMF+CCG reconstruction, and IA+TMMF+DO. No statistical difference was seen between the groups in terms of the MIO. IA with TMMF is recommended in patients where growth is completed. In younger patients, the CCG allowed for growth and maintenance of ramal height. DO for joint reconstruction can be performed at any age.

The commonly used TMJR (TMJ reconstruction) systems are TMJ Concepts, Biomet, and Nexus. Wolford et al.[40], compared Concepts and Nexus prostheses in patients with TMJA and reported that 25 of 76 (33%) Nexus prostheses had to be removed due to elevated pain scores attributed to device failure. Biomet and TMJ Concepts have shown comparable results; however, TMJ Concepts has the advantage of being backed by a longer follow-up compared to Biomet[41].

Custom-made patient-fitted CAD/CAM prostheses, fabricated on stereolithographic models, are gaining popularity over stock prostheses as the custom TMJR components interface well with the host anatomy. The majority of the issues with the stock components, resulting from fit-miscalculation, are not present[42,43].

Table 3. Autogenous grafts and alloplastic materials used in interpositional arthroplasty

Study	Sample size	Age (yr)	Interpositional material	Mean follow-up period (mo)	Mean preoperative MIO (mm)	Mean postoperative MIO (mm)	Author's conclusion
Chossegros et al.[28] (1997)	13 6	19 46	Full thickness skin graft Temporalis muscle flap	36 36	15.6 16.8	37.1 31.1	Full-thickness skin graft and pedunculated temporalis muscle flap are the best interpositional materials in adults.
Kim[12] (2001)	7	31.1	Temporalis muscle and fascia flap	20.1	15	36.1	Temporalis muscle and fascia flap is effective in treating TMJ ankylosis.
Dimitroulis[13] (2004)	11	32.5	Dermis fat graft (groin)	41.5	15.6	35.7	Autogenous dermis-fat interpositional graft is effective in preventing re-ankylosis up to 6 years following surgical release.
Bayat et al.[26] (2009)	34	21.5	Temporalis muscle flap	21.3	4.9	32.8	Satisfactory mouth opening achieved with only 2 cases of recurrence
Guruprasad et al.[27] (2010)	9	24.7	Temporalis muscle and fascia flap	18.3	11.7	38.3	100% success rate with increased mandibular mobility and improved function
Thangavelu et al.[29] (2011)	7	27.2	Full thickness skin-subcutaneous fat grafts from abdomen	23.2	3.4	31.7	Donor site provides ample tissue to fill the dead space. The skin prevents fat fragmentation.
Babu et al.[14] (2013)	15	20	Temporalis fascia	36	3.8	29.4	Maximum MIO between 30-40mm was achieved with no recurrence at the end of 3 years.
Shakeel et al.[31] (2016)	38 12 25	12.4 13.6 14.3	Costochondral graft Acrylic spacer Temporalis myofascial flap	12	10.5 15.3 7.1	34.3 28.7 38.4	The spacer group showed the least improvement in MIO and maximum recurrence. The temporalis myofascial flap showed maximum improvement in MIO and no recurrence.

(MIO: maximal incisal opening, TMJ: temporomandibular joint)

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The placement of autologous fat grafts around the total joint replacement (TJR) to obliterate the dead space around the prosthesis has shown promising results and is gaining popularity. Significant work on fat grafts by Wolford et al.[40,44,45] demonstrate a significant advancement in preventing the recurrence of ankylosis. The fat grafts prevent the organization of a clot, extensive fibrosis, and heterotopic calcification. The outcomes of various studies[41,44-49] on the use of autologous fat grafts, along with a TMJ prosthesis, are shown in Table 4.

3) Role of postoperative physiotherapy

Relapse can be prevented by early and rigorous physiotherapy[15] for a minimum of 6 months[50]. Several techniques and appliances have been used for the maintenance of postoperative mouth opening and physiotherapy, such as stacked tongue depressors, interocclusal splints[51], TheraBite, custom-made devices (including screws or cones with enlarging diameters), wedge exercisers, elastic traction, and hydraulic passive motion devices[52]. Shirani et al.[53], found better results in the IA group that used postoperative activator appliances for physiotherapy compared with the group that underwent CCG reconstruction.

Table 4. Studies on autogenous fat grafting and alloplastic total joint replacement

Study	Sample size	Mean age of patients (yr)	Prosthesis used	Source of autologous fat	Follow-up period (mo)	Increase in MIO (mm)	Incidence of reankylosis
Wolford and Karras[44] (1997)	15 (22 joints)	40.1	Techmedica custom made total joint prosthesis	Abdominal fat	21.8	11.8	None
Wolford et al.[40] (2008)	115 (203 joints)	NA	Group 1: Christensen total joint prostheses Group 2: TMJ Concepts total joint prostheses	Abdominal fat	12	3.5 6.8	None
Mercuri et al.[46] (2008)	20 (33 joints)	44±11.3	TMJ Concepts Patient-Fitted Total TMJ Prosthesis System	Abdominal fat	50.4±28.8	21.15	None
ShanYong et al.[47] (2015)	15 (19 joints)	55.8	Biomet-Lorenz stock Prosthesis	Retro-mandibular subcutaneous fat	18-72	NA	2 cases of heterotopic bone formation in which fat grafts were not placed.
Wolford et al.[45] (2016)	32 (48 joints)	39	TMJ Concepts	Abdominal and other sites	59.5	20.5	2 cases of heterotopic bone
Selbong et al.[48] (2016)	3	55.3	TMJ Concepts	Abdominal fat	15.3	16	None
Roychoudhury et al.[49] (2017)	11 (17 joints)	18.82±2.7	Stock Total TMJ Replacement	Buccal pad fat	12-30	38±6	None

(MIO: maximal incisal opening, NA: information not available, TMJ: temporomandibular joint)
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4) Correction of secondary deformities

Simultaneous arthroplasty and DO in treatment of children with TMJA and secondary mandibular deformities was performed by Ma et al.[54]. Following ankylosis release, DO was used to lengthen the mandibular body, ramus, or both. They found that it was an effective technique; however, the long-term influence on mandibular growth needs to be further investigated.

Zhang et al.[55] performed DO, initially followed by arthroplasty or TMJ reconstruction (n=40). All patients showed improvement in MIO and appearance with the disappearance of snoring. Airway space significantly increased. The authors suggest that undertaking DO as the initial surgery and arthroplasty/joint reconstruction, in the second stage, may produce desirable results, especially for patients with obstructive sleep apnea-hypopnea syndrome (OSAHS). However, some patients may require orthognathic surgery during or after the second stage, to improve occlusion and face shape.

Simultaneous maxillo-mandibular DO followed by IA was performed by Mehrotra et al.[56] in patients with unilateral TMJA (n=10) with an aesthetic deformity and maxillary cant. Ankylosis release and IA with temporal fascia was performed as a second surgery, along with genioplasty when required. All cases showed marked improvement in facial symmetry occlusal cant and mandibular retrusion. The authors concluded that DO followed by IA improves facial esthetics, along with function.

Anchlia et al.[57] proposed a single-stage management plan for TMJA in adult patients with an apnea-hypopnea index (AHI) score of less than 20. Ankylosis is released and TMMF, abdominal dermis fat or buccal fat pad is interposed in the gap. The ramus-condyle unit (RCU) is reconstructed by vertical ramus osteotomy or L osteotomy and extended advancement centering genioplasty is performed.

Neocondyle distraction with internal distractors has been used by Sharma et al.[58] for the reconstruction of the RCU in five patients following GA. They advocate this approach for restoring physiological TMJ function, simultaneously correcting hard and soft tissue deficiency and preventing reankylosis.

Gabbay et al.[59] compared transport DO and Matthews device arthroplasty. Group I underwent mandibular advancement by DO, followed by condylar resection, the lining of the glenoid fossa and transport distraction. In Group II the

Matthews devices were anchored to the temporal bone and mandibular rami. Although both techniques were successful, long-term relapse was avoided with a Matthews device.

5) Airway management

The effectiveness of maxillo-mandibular advancement (MMA) by orthognathic surgery has been proven for patients who cannot adhere to continuous positive airway pressure (CPAP) therapy[60,61] and in children in whom traditional orthognathic surgery was deemed impossible. Mandibular DO has been shown to improve the laryngeal view, as assessed by the Cormack–Lehane score, and reduce AHI[62].

For children with congenital micrognathia or midface hypoplasia, DO can produce large advancements, eliminating the need for bone grafting, with less risk of relapse[63,64]. For later onset OSAHS, DO may be a good alternative when acute bone movement is difficult due to scarring from previous surgeries or when the risk for inferior alveolar nerve damage is high[61]. Primary mandibular DO for the relief of upper airway obstruction has been found to be successful in preventing tracheostomy in patients with a micrognathia/Pierre Robin sequence and should be considered an acceptable alternative to tracheostomy[65-67]. Mandibular DO for airway obstruction shows excellent results in patients below 6 years who are unresponsive to conservative measures and it allows for early decannulation in patients with a previous history of tracheotomy[68,69].

The simultaneous genial distraction of the non-occlusion bearing segment of the mandible along with IA has been performed in adults with stable occlusion. This not only corrects the secondary deformity and OSAHS but also does not interfere with the immediate postoperative outcome[70]. Li et al.[71] applied DO in adult patients for skeletal advancement and treatment of OSAHS. The application of pre-operative simulation surgery using a three-dimensional (3D) craniomaxillofacial model for precision in surgical planning[72] and the use of a new generation of a curvilinear distractor for vector control and the prevention of open bite development have been advocated[73].

Jia et al.[74] reported a one-stage technique for the treatment of TMJA, secondary micrognathia, and a prominent mandibular angle. Resection of the ankylotic mass is performed followed by reconstruction of the ramal unit with a coronoid graft. Through a retromandibular incision, the bone posterior to the antegonial notch is resected and used to fill the gap created following mandibular advancement by inverted L-osteotomy. Advancement genioplasty is performed if required.

Srivastava et al.[75] performed GA and simultaneous dual distraction as a single-stage approach for the correction of TMJA and facial asymmetry in 7 patients above the age of 12 years. The authors concluded that dual distraction is a promising technique and it overcomes the disadvantage of a single distractor where the proximal condylar segment remains unstable.

Despite the advantages of DO over conservative methods, tracheostomy, and conservative orthognathic surgery, drawbacks, such as the need for increased patient compliance, second surgery for distractor removal, and frequent hospital visits should be considered as it may produce unfavorable outcomes in non-compliant patients[76,77].

Gonçalves et al.[78] reported a significant immediate increase in 3D airway space following maxillomandibular counter-clockwise rotation and mandibular advancement with total joint prostheses (TMJ Concepts) and fat grafting. Similar results were also reported by Coleta et al.[79], who noted an immediate increase in the dimensions of the oropharyngeal airway following MMA with counter-clockwise rotation and reconstruction of the TMJ with total joint prostheses combined with fat grafting.

IV. Conclusion

TMJA is a debilitating disease associated with adverse aesthetic, functional, and psychological sequelae. Though several classifications exist, there is a need for a comprehensive staging system that takes into consideration the age of the patient, severity of the disease, clinical, functional, and radiographic findings. Staging the disease will help the clinician in adopting a holistic approach to treat these patients.

IA results in better MIO compared to GA with no significant difference in recurrent rates. DO is emerging as a popular technique for the restoration of symmetry and function, as well as for relieving airway obstruction. IA with CCG is recommended in growing patients and may be combined with, or may be preceded by, DO in cases of severe airway obstruction. Alloplastic TJR combined with fat grafts and simultaneous osteotomy procedures are gaining popularity. A custom-made total joint prosthesis using CAD/CAM can efficiently overcome the shortcomings of a stock prosthesis.

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Authors' Contributions

V.H.U. participated in data collection and wrote the manuscript. H.K.B., B.H.S.R., and S.G.R. participated in the study design. H.K.B. helped to draft the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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