Controversies in the Management of Temporomandibular Joint Ankylosis Using Distraction Osteogenesis - A Systematic Review

Dyna Albert, M. R. Muthusekhar
Department of Oral and Maxillofacial Surgery, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India

Abstract

Background: The three commonly employed sequences of distraction osteogenesis (DO) in the management of temporomandibular joint (TMJ) ankylosis with dentofacial deformities include post-arthroplastic distraction osteogenesis (PAD), simultaneous arthroplastic distraction osteogenesis (SAD), and pre-arthroplastic distraction osteogenesis (PrAD). Objective: The aim of this systematic review is to compare the effectiveness of various sequences of DO in the management of TMJ ankylosis with micrognathia and obstructive sleep apnea syndrome (OSAS). Data Sources: A comprehensive online and manual search of English language literature with no date restrictions was done on March 2020. Eligibility Criteria: Inclusion criteria were case series and prospective and retrospective studies involving adult/paediatric human subjects with unilateral/bilateral TMJ ankylosis and micrognathia/OSAS treated with DO. Study Appraisal and Synthesis Methods: Of 73 studies identified, only 10 were included in the qualitative synthesis. The outcomes assessed were as follows: maximum mouth opening (MMO), posterior airway space (PAS), polysomnography variables, reankylosis, mandibular length, and chin and mandible position. Results: All the included studies showed high risk of bias. MMO and mandibular length increased, chin and mandibular position improved by the end of treatment in all the three sequences, and polysomnography variables and PAS significantly improved in PrAD compared to PAD and improved in SAD compared to baseline. Reankylosis was significantly less in PrAD. Conclusion: More well-designed studies comparing the three sequences of DO should be carried out to arrive at a consensus.

Keywords: Ankylosis, arthroplasty, congenital abnormalities, distraction osteogenesis, temporomandibular joint

Introduction

Temporomandibular joint (TMJ) ankylosis is the bony or fibrotic union of mandibular condyle to the articular/glenoid fossa. It may occur as a unilaterally or bilaterally compromising form, function, and psychology of the patient. In all cases, it causes restricted mouth opening and in a paediatric population, it poses additional risks of debilitating the growth of the mandible, thereby leaving the jaw micrognathic and in a retruded position, producing an overall unaesthetic facial appearance. In addition, in severe cases, it displaces the tongue posteriorly and reduces the dimension of the oropharyngeal airway, eventually leading to upper airway obstruction and obstructive sleep apnoea syndrome (OSAS). Hence, growing children often present a triad of symptoms, as follows: TMJ ankylosis, micrognathia/dentofacial deformity, and OSAS. As proposed by Andrade et al., the primary goal of treating paediatric TMJ ankylosis is: To release ankylosis and increase mouth opening, Correct dentofacial deformities such as micrognathia and retrognathia, Treat any associated OSAS, Prevent reankylosis.

While the release of ankylosis necessitates removal of ankylosic mass followed by gap/interpositional arthroplasty or total joint replacement if feasible, the correction of dentofacial deformity can be achieved by the following ways: [3]

Address for correspondence: Dr. Dyna Albert, Department of Oral and Maxillofacial Surgery, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India. E-mail: dyn.albrt@gmail.com

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1. Orthognathic surgery
2. Costochondral graft (in the case of growing patient only)
3. Distraction osteogenesis (DO).

If a surgeon’s treatment plan includes DO for the correction of dentofacial deformity associated with TMJ ankylosis, one among the following sequence of treatments should be opted [Table 1]:[4]

1. Prearthroplastic distraction osteogenesis
2. Postarthroplastic distraction osteogenesis
3. Simultaneous arthroplasty and distraction osteogenesis.

The aim of this systematic review was to analyze the existing literature to compare the effectiveness of various sequences of DO in the management of TMJ ankylosis with micrognathia and OSAS. The following was the structured question for this review: is there any difference in the outcomes between various sequences of DO? The primary outcomes considered were maximum mouth opening (MMO), posterior airway space (PAS), and reankylosis. Secondary outcomes considered were anteroposterior position of mandible, chin position, mandibular length, and polysomnography variables.

**Methodology**

This study was registered in PROSPERO under the registration number CRD42021239524.

**Inclusion criteria**

Studies including patients of any age and gender with unilateral or bilateral TMJ ankylosis with micrognathia and OSAS were included in this systematic review. Criteria for considering studies for the quality assessment were as follows: randomized controlled trials, clinical trials, retrospective studies, prospective studies, and case series of at least five cases.

**Search strategy**

Databases of PubMed Advanced Search, Cochrane Database of Systematic Review, and Google Scholar were searched. Two independent reviewers searched for the following keywords: “temporomandibular joint ankylosis,” “distraction osteogenesis,” “prearthroplastic distraction osteogenesis,” “simultaneous arthroplastic distraction osteogenesis,” “postarthroplastic distraction osteogenesis,” “mouth opening,” “pain,” “reankylosis,” “chin position,” and “SNB angle.” Hand search was done in the British Journal of Oral and Maxillofacial Surgery, International Journal of Oral and Maxillofacial Surgery, Journal of Oral and Maxillofacial Surgery, Journal of Cranio Maxillofacial Surgery, and Quintessence International Journal. Reference list of the identified randomized trials was also checked for possible additional studies.

**Quality assessment**

Quality assessment was done using Higgins and Green's Cochrane Reviewer’s Handbook, 2009. The four main quality criteria examined were randomization, allocation concealment, blinding, and completeness to follow-up. Each criterion was assessed with YES, NO, or UNCLEAR. The study was assessed to have a “high risk” of bias if it did not record a “yes” in three or more of the four main categories, “moderate risk” if two out of four categories did not record a “yes,” and “low risk” if all the four categories recorded a “yes”. In the case of nonrandomized and clinical trials without a control group, it is recorded as not applicable.

**Results**

The study selection process was done according to the PRISMA GUIDELINE. From a total of 72 identified research articles, only 10 articles were included for quality assessment after screening and exclusion. The details of the selection process is elaborated in Flow Chart 1. The characteristics of the studies included are given in Table 2. Of the ten included studies, one was a case series, seven were prospective studies, one was a retrospective study, and one was a randomized clinical trial. The follow-up periods in these studies varied from 6 months to 12 years. The quality assessment of all the included studies showed high risk of bias in all the studies [Table 3]. The total sample size in all the studies was 150. Four studies included paediatric population and six studies included both paediatric and adult population. Prearthroplastic DO alone or in combination was evaluated in three studies, postarthroplastic DO alone or in combination was evaluated in three studies, and simultaneous arthroplastic DO alone or in combination was evaluated in five studies. Of the primary outcome, MIO was measured in all studies, polysomnography variables were assessed in five studies, PAS was measured in three studies, and reankylosis was assessed in eight studies.

**Maximum mouth opening**

All the included studies measured maximum intercinsal opening (MIO). The studies showed a significant increase in MIO after ankylosis release. Hence, in PrAD, though mouth opening increases after Stage I, MIO shows a drastic increase only after Stage II ankylosis release. This, however, does not significantly impact the function [Table 4].

**Posterior airway space**

PAS was measured only in three studies, of which two involved PrAD and one involved SAD. All the three studies showed a significant increase in PAS after DO [Table 4].

**Reankylosis**

Reankylosis was reported in eight studies, of which two involved PAD, one involved PrAD, three involved SAD, one

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**Table 1: Sequences of distraction osteogenesis in temporomandibular joint ankylosis**

|          | Stage 1 surgery                              | Stage 2 surgery                              |
|----------|----------------------------------------------|----------------------------------------------|
| PAD      | Ankylosis correction                         | Dentofacial deformity correction             |
| SAD      | Ankylosis + dentofacial deformity correction | Ankylosis correction                         |
| PrAD     | Dentoalveolar deformity correction           | Reankylosis correction                       |

DO: Distraction osteogenesis, PAD: Postarthroplastic DO, SAD: Simultaneous arthroplastic DO, PrAD: Prearthroplastic DO
involved PrAD versus PAD, and one involved PrAD versus SAD. Reankylosis was reported more in PAD followed by SAD with none in PrAD. PAD showed significantly more incidence of reankylosis than PrAD [Table 4].

Polysonmography variables
Polysonmography variables were assessed in five studies, of which two involved PrAD, two involved SAD, and one involved PAD versus SAD. PAD showed worsening of polysonmography variables as noted by an increased incidence of bradycardia and respiratory distress in patients with concurrent severe micrognathia and OSAS. PrAD showed significant improvement in polysonmography variables with resolution of OSAS symptoms. SAD showed similar results with baseline comparisons [Table 4].

Discussion
Postarthroplastic distraction osteogenesis
Snyder et al. in 1973 reported mandibular lengthening in canine species using extraoral distractors following which many similar animal experiments were conducted by eminent researchers that proved DO is not restricted to long bones.[4-6] McCarthy et al. in 1992 performed mandibular lengthening of four syndromic patients (hemifacial microsomia, Nager

Table 2: Characteristic of the included studies

| Author             | Study design                                   | Duration of follow up | Sample size | Age                              | Technique used                          |
|--------------------|------------------------------------------------|-----------------------|-------------|----------------------------------|-----------------------------------------|
| Andrade et al., 2009 | Case series                                    | 1 year                | n=5         | 6-25 years with TMJ ankylosis and OSAS | PrAD                                    |
| Andrade et al., 2012 | Prospective study                             | 5 years               | n=15        | 6-18 years patients with TMJ ankylosis and OSAS | PrAD versus PAD                         |
| Andrade et al., 2018 | Prospective study                             | 1 year                | n=25; Adult group-11, Paediatric group-14 | 6-27 year old patients with TMJ ankylosis and OSAS divided into two groups: paediatric (<18 years) and adult (>18 years) groups | PrAD                                    |
| Chellappa et al., 2015 | Prospective randomized experimental study                 | 6 months              | n=20 with 10 in each group | 5-25 years                             | PrAD and SAD                            |
| Feiyun et al., 2010   | Prospective study                             | 29 months             | n=16        | 18-43 year old patients with bilateral TMJ ankylosis and mandibular retrognathia | SAD                                     |
| Hassan et al., 2019   | Retrospective study                            | 7-12-year follow-up   | n=20        | Mean age - 20.5 years             | PAD                                     |
| Ma et al., 2018       | Prospective study                             | 16-45 months          | n=17        | 7-12 years                         | PAD                                     |
| Qiao et al., 2018     | Prospective study                             | 3-4-year follow-up    | n=6         | 21-31 year old patients with unilateral TMJ ankylosis and mandibular dysplasia | PAD with interpositional arthroplasty and DO |
| Rao et al., 2004      | Prospective study                             | 6 months              | n=6         | 7-10 year old patients with TMJ ankylosis and mandibular deformity | PAD with gap arthroplasty and DO |
| Zanaty et al., 2016   | Prospective observational study               | 6 months              | n=30        | 8-17 year old TMJ ankylosis patients with micrognathia and OSAS | SAD with interpositional arthroplasty and DO |

DO: Distraction osteogenesis, PAD: Postarthroplastic DO, SAD: Simultaneous arthroplastic DO, PrAD: Preamphplastic DO, TMJ: Temporo-mandibular joint, OSAS: Obstructive sleep apnoea syndrome

Table 3: Risk of bias

| Study              | Randomization | Allocation concealment | Assessor Blinded | Dropouts described | Risk of bias |
|--------------------|---------------|------------------------|------------------|--------------------|--------------|
| Andrade et al., 2009 | No            | No                     | No               | None               | High         |
| Andrade et al., 2012 | No            | No                     | No               | Yes                | High         |
| Andrade et al., 2018 | No            | No                     | No               | None               | High         |
| Chellappa et al., 2015 | Yes          | No                     | No               | None               | High         |
| Feiyun et al., 2010 | No            | No                     | No               | None               | High         |
| Hassan et al., 2019 | No            | No                     | No               | Yes                | High         |
| Ma et al., 2018     | No            | No                     | No               | None               | High         |
| Qiao et al., 2018   | No            | No                     | No               | None               | High         |
| Rao et al., 2004    | No            | No                     | No               | None               | High         |
| Zanaty et al., 2016 | No            | No                     | No               | None               | High         |
In the 10th International Confederation for Plastic and Reconstructive Surgery (1992), Aytemiz and Sengezer presented their case series of 11 TMJ ankylosis patients treated by postarthroplastic DO. At the time DO was introduced for correcting dentofacial deformity in TMJ ankylosis, it was popularly believed that addressing the ankylosis should be of primary concern and correction of deformity is to be delayed. This poses greater importance on the restoration of function as the primary goal. Lopez and Dogliotti insist on postarthroplastic DO as they believe the need to first assess the growth potential of mandible which has been released from ankylosis before proceeding with DO. A straightforward drawback of postarthroplastic DO is the instability of proximal segment while placing the osteotomy cut as well as distracting, with the latter contributing to the risk of reankylosis. Hassan and Mohamed noted reankylosis in two out of twenty patients in whom postarthroplastic DO was performed. Qiao et al. performed postarthroplastic DO in six patients with unilateral TMJ ankylosis, maintaining a gap of 6 months between the two surgeries. During distraction, the authors insisted on avoiding active assist forces from any other device or apparatus in order to avoid the instability of the proximal segment and the risk of reankylosis. No complications were noted in a 3–4-year follow-up. Andrade et al. elaborated the drawback of using postarthroplastic DO in patients suffering from OSAS secondary to TMJ ankylosis and stated the following two problems: noncompliance to physiotherapy due to compromised airway and activation of trigemino cardiac reflex pathway while opening the mouth.

Simultaneous arthroplastic distraction osteogenesis
Driven by the proposition of Munro et al. that TMJ ankylosis and dentofacial deformity correction should be performed together as a single-stage procedure, Dean and Allamilos in 1999 became the first to document simultaneous arthroplastic DO technique in three unilateral TMJ ankylosis patients. Active physiotherapy was started from the 1st postoperative day and continued for a year while active distraction began from the 5th postoperative day. Though they reported no complications and achieved adequate mouth opening and deformity correction, no particular rationale was stated as to the advantages of this technique over the then popularly

Flow Chart 1: Prisma flow diagram
Table 4: Results of the included studies

| Author and technique used | Variables/method of evaluation | Mean values | Results |
|---------------------------|--------------------------------|-------------|---------|
| Andrade et al., 2009 PrAD | 1. MIO                          | -           | MIO increased drastically only after Stage 2 |
|                           | 2. Polysomnography variables - O₂ saturation, AH, Apnoea-Hypopnoea episodes |             | Improvement of all the polysomnographic variables and drastic increase PAS after Stage 1 and complete resolution of all symptoms of OSAS |
|                           | 3. PAS                          |             | Increase in mandibular length and increased chin prominence indicated by favorable SNB angle after Stage 1 |
|                           | 4. Mandibular lengthening       |             |         |
|                           | 5. Position of the mandible (SNB angle) |             |         |
| Andrade et al., 2012 PrAD versus PAD | 1. MIO                          |             | Of the 7 patients with severe OSAS treated by PAD, 6 patients had recurrence and 1 patient was lost to follow-up |
|                           | 2. O₂ saturation                |             | PAD caused bradycardia and respiratory distress during active physiotherapy |
|                           | 3. AHI                          |             | PrAD is superior to PAD in patients with severe OSAS |
|                           | 4. Pulse rate                   |             |         |
|                           | 5. Hyoid-menton distance        |             |         |
|                           | 6. Position of the mandible (SNB angle) |             |         |
|                           | 7. Reankylosis                  |             |         |
| Andrade et al., 2018 PrAD | 1. PAS width                    |             | MIO increased drastically only after Stage 2 |
|                           | 2. AHI                          |             | Improvement of all the polysomnographic variables and drastic increase PAS after Stage 1 and complete resolution of all symptoms of OSAS |
|                           | 3. O₂ saturation                |             | Increase in mandibular length and increased chin prominence indicated by favorable SNB angle after Stage 1 |
|                           | 4. Mandibular advancement       |             |         |
|                           | 5. MIO                          |             |         |
|                           | 6. Reankylosis                  |             |         |
| Chellappa et al., 2015 PrAD and SAD | 1. MIO                          |             | No significant difference in MIO observed between both groups |
|                           | 2. Duration to achieve active functional MO | 5           | Duration to achieve active functional MO is significantly reduced in SAD |
|                           | 3. Reankylosis                  |             | Risk of reankylosis and poor segment stability may be the drawbacks of SAD |

Contd...
practiced postarthroplastic DO except for the avoidance of a second surgery.\textsuperscript{[20]} Subsequently, Papageorge and Apostolidis in 1999 reported a case of unilateral TMJ ankylosis in which they had used the simultaneous technique. Although they noted unstable occlusion postdistraction, it was corrected with orthodontics. They achieved adequate mouth opening with no complications after 15-month follow-up.\textsuperscript{[20]} Yonehara \textit{et al.}, Douglas \textit{et al.}, Yoon and Kim, and Rao \textit{et al.} reported similar cases treated with simultaneous arthroplastic DO with no specific mention to the pros, cons, or rationale of the technique \textit{per se}.\textsuperscript{[21-24]}

Kwon \textit{et al.} in 2006 were the first to pose the following questions with regard to simultaneous arthroplastic DO: (1) can active physiotherapy be performed during a distraction period? (2) can occlusal stability be maintained after two concurrent surgeries? They noted the void in addressing these issues in the previous literature. The authors went on to conclude that these
unaddressed questions are a major setback to the simultaneous technique. The potential disadvantages of postarthroplastic DO such as instability of proximal segment and noncompliance to active physiotherapy still persisted in simultaneous technique. Ideally, during distraction, it is desirable to reduce the unwarranted mobility of the jaw to prevent pseudoarthrosis between the segments. Paradoxically, the need for active physiotherapy after ankylosis release, is a compulsive one and cannot be overlooked. This poses a variety of problems starting from interference of the distractor to physiotherapy, instability of proximal segment, difficulty in controlling occlusion, and risk of pseudo-arthritis. In addition, continuous pressure exerted by the proximal segment over glenoid fossa most often results in reankylosis. With respect to the management of concurrent OSAS associated with TMJ ankylosis, Andrade et al. reported that simultaneous technique is not efficient in improving the upper airway space as most often episodes of dyspnea and bradycardia occur whenever patient attempts active physiotherapy, which, in turn, results in noncompliance to physiotherapy and potential risk of reankylosis.

Chellappa et al. in a prospective randomized controlled trial in twenty patients, compared prearthroplastic and simultaneous arthroplastic DO and noted the following advantages of simultaneous technique in comparison to prearthroplastic technique: (1) adequate mouth opening is achieved early during the treatment, (2) final position of mandible that achieved is as predicted, and (3) single-stage surgery (more desirable in population who do not voluntarily seek treatment for TMJ ankylosis as is the case in developing/underdeveloped countries).

Prearthroplastic distraction osteogenesis

Introduced by Sadakah et al. as a modified technique in 2006, it has since gained wide acceptance because of its obvious advantages. In their research article, they stated that the technique was proposed to overcome the proximal segment instability which is most often encountered in postarthroplastic and simultaneous arthroplastic DO techniques. The unstable proximal condylar segment which displaces antero-superiorly toward the glenoid fossa during distraction is also a major cause for reankylosis. With this modified approach (prearthroplastic DO), Sadakah et al. were able to overcome the potential risks which allowed for a more predictable outcome. Stability with respect to intraoperative placement of osteotomy cuts was also improved as the TMJ remained fused during Stage I surgery, thereby improving surgical ease. Mehrotra et al. in 2016 performed simultaneous maxillomandibular distraction in ten patients who presented with TMJ ankylosis and resulting maxillary cant. They performed prearthroplastic DO in these patients and reported favorable results.

Distraction osteogenesis and obstructive sleep apnoea syndrome

OSAS is often an uninvited accomplice of TMJ ankylosis and needs to be addressed effectively. Zanaty et al. evaluated the upper airway changes in thirty TMJ ankylosis patients before and after DO. They demonstrated a significant improvement in Cormack and Lehane score and Apnoea-Hypopnoea index after DO, indicative of improved oropharyngeal airway space. They noted that as the mandible was lengthened, the tongue base moved forward due to its anterior muscular attachments to the mandible, increasing the airway space, and relieving airway obstruction. Similar results were noted in several other studies which have agreed the positive role of DO in treating OSAS secondary to TMJ ankylosis.

The results from our systematic review suggest that there is no significant difference between the three sequences of DO with respect to the MMO that can be achieved at the end of the treatment phase. Though postarthroplastic and simultaneous arthroplastic DO give quicker functional movement of the mandible when compared to prearthroplastic DO, there exists the risk of reankylosis. PAS and polysomnography variables improved drastically with prearthroplastic and simultaneous arthroplastic DO with resolution of OSAS symptoms. The chin position, mandibular length, and mandibular position improved in all the three sequences by the end of the treatment phase, provided there was no reankylosis. The quality of studies included in this review has a high risk of bias and hence, we interpret the results with caution. However, we believe that the evidence supporting the incidence of reankylosis to be lower in prearthroplastic DO is strong, with prearthroplastic DO showing no incidence of reankylosis in this systematic review.

Conclusion

Reankylosis remains a major determining factor in the maintenance of the results obtained from the various sequences of DO. Preearthroplastic DO has nil incidence of reankylosis in all the included studies. Hence, with the available evidence, we conclude that prearthroplastic DO shows more stable results. Well-designed clinical trials comparing various sequences of DO should be done to facilitate high-quality research data for systematic analyses to arrive at a more quantitative consensus.

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Conflicts of interest
There are no conflicts of interest.

References

1. Andrade NN, Kalra R, Shetye SP. New protocol to prevent TMJ reankylosis and potentially life threatening complications in triad patients. Int J Oral Maxillofac Surg 2012;41:1495-500.
2. Shivakotee S, Menon CS, Sham ME, Kumar V, Archana S. TMJ ankylosis management: Our experience. J Maxillofac Oral Surg 2020;19:579-84.
3. Anchlia S, Vyas SM, Dayatar RG, Domadia HL, Nagavadiya V. Guidelines for single-stage correction of TMJ ankylosis, facial asymmetry and OSA in adults. J Maxillofac Oral Surg 2019;18:419-27.
4. Barber S, Carter L, Mannion C, Bates C. Distraction osteogenesis part 1: History and uses in the craniofacial region. Orthod Update 2018;11:14-20.
5. Snyder CC, Levine GA, Swanson HM, Browne EZ Jr. Mandibular lengthening by gradual distraction. Preliminary report. Plast Reconstr Surg 1973;51:506-8.
6. Daokar S, Agrawal G, Junaid S, Rajput R. Distraction Osteogenesis. Ann Int Med Dent Res 2016;2:DE14-18. [Doi:10.21276/aimdr.2016.2.6.de3].

7. McCarthy JG, Schrieber J, Karp N, Thome CH, Grayson BH, Michael Sadove A. Lengthening the human mandible by gradual distraction. J Craniol Surg 1992;3:122.

8. Hopper RA, Ettinger RE, Purnell CA, Dover MS, Pereira AR, Tuchnilek G. Thirty years later: What has craniofacial distraction osteogenesis surgery replaced? Plast Reconstr Surg 2020;145:1073e-88e.

9. Wang JC, Nagy I, Demke JC. Syndromic craniosynostosis. Facial Plast Surg Clin North Am 2016;24:531-43.

10. Sengezer M. Mandibular lengthening by gradual distraction. Plast Reconstr Surg 1993;92:372-3.

11. Aytemiz C, Sengezer M. Gradual Distraction Technique in Correction of Mandibular Deformities. Proceeding of the Xth Congress of the International Confederation for Plastic Surgery, Madrid, Spain, 28 June-03 July, 1992, Amsterdam Excerpta Medica; 1992. p. 297-8.

12. López EN, Dogliotti PL. Treatment of temporomandibular joint ankylosis in children: Is it necessary to perform mandibular distraction simultaneously? J Craniofac Surg 2004;15:879-84.

13. Andrade NN, Raikwar KR. Management of patients with obstructive sleep apnoea induced by temporomandibular joint ankylosis: A novel 2-stage surgical protocol and report of 5 cases. Asian J Oral Maxillofac Surg 2009;21:27-32.

14. Schlundt M, Touzet-Roumazeille S, Nicot R, Ferri J. Temporomandibular joint ankylosis following mandibular distraction osteogenesis: A dreadful complication. J Craniofac Surg 2020;31:222-5.

15. Galié M, Candotto V, Elia G, Clauser LC. Temporomandibular joint ankylosis after early mandibular distraction osteosynthesis: A new syndrome? J Craniofac Surg 2017;28:1185-90.

16. Hassan SA, Mohamed FI. Distraction osteogenesis in the management of mandibular hypoplasia secondary to temporomandibular joint ankylosis. Long term follow up. J Craniofac Surg 2019;47:1510-20.

17. Qiao J, Yu B, Gui L, Fu X, Sengezer M, et al. Interpositional arthroplasty by temporalsis fascia flap and galea aponeurotica combined with distraction osteogenesis: A modified method in treatment of adult patients with temporomandibular joint ankylosis and mandibular dysplasia. J Craniofac Surg 2018;29:e184-90.

18. Munro IR, Chen YR, Park BY. Simultaneous total correction of temporomandibular ankylosis and facial asymmetry. Plast Reconstr Surg 1986;77:517-29.

19. Dean A, Alamillos F. Mandibular distraction in temporomandibular joint ankylosis. Plast Reconstr Surg 1999;104:201-31.

20. Papageorge MB, Apostolidis C. Simultaneous mandibular distraction and arthroplasty in a patient with temporomandibular joint ankylosis and mandibular hypoplasia. J Oral Maxillofac Surg 1999;57:328-33.

21. Yonehara Y, Takato T, Susami T, Mori Y. Correction of micrognathia attributable to ankylosis of the temporomandibular joint using a gradual distraction technique: Case report. J Oral Maxillofac Surg 2000;58:1415-8.

22. Rao K, Kumar S, Kumar V, Singh AK, Bhatnagar SK. The role of simultaneous gap arthroplasty and distraction osteogenesis in the management of temporomandibular joint ankylosis with mandibular deformity in children. J Craniomaxillofac Surg 2004;32:38-42.

23. Yoon HJ, Kim HG. Intraoral mandibular distraction osteogenesis in facial asymmetry patients with unilateral temporomandibular joint bony ankylosis. Int J Oral Maxillofac Surg 2002;31:544-8.

24. Douglas LR, Burton Douglass J, Smith PJ. Intraoral mandibular distraction osteogenesis in a patient with severe micrognathia secondary to TMJ ankylosis using a tooth and bone-anchored device (PII device): A case report. J Oral Maxillofac Surg 2000;58:1429-33.

25. Kwon TG, Park HS, Kim JB, Shin HJ. Staged surgical treatment for temporomandibular joint ankylosis: Intraoral distraction after temporals muscle flap reconstruction. J Oral Maxillofac Surg 2006;64:1680-3.

26. Andrade NN, Mathai PC, Ganapathy S, Aggarwal N, Rajpuri K, Nikalje T. Pre-arthroplastic mandibular distraction osteogenesis for the correction of OSA in TMJ ankylosis: A prospective observational study of 25 cases. Oral Maxillofac Surg 2018;22:409-18.

27. Chellappa AL, Mehrrota D, Vishwakarma K, Mahajan N, Bhutia DP. Pre-arthroplastic and simultaneous mandibular distraction for correction of facial deformity in temporomandibular joint ankylosis. J Oral Biol Craniofac Res 2015;5:153-60.

28. Sadakah AA, Elgazzar RF, Abdelhady IA. Intraoral distraction osteogenesis for the correction of facial deformities following temporomandibular joint ankylosis: A modified technique. Int J Oral Maxillofac Surg 2006;35:399-406.

29. Mehrrota D, Vishwakarma K, Chellappa AL, Mahajan N. Pre-arthroplasty simultaneous maxillomandibular distraction osteogenesis for the correction of post-ankyloitic dentofacial deformities. Int J Oral Maxillofac Surg 2016;45:820-7.

30. Zanaty O, El Metaimy S, Abo Alia D, Medra A. Improvement in the airway after mandibular distraction osteogenesis surgery in children with temporomandibular joint ankylosis and mandibular hypoplasia. Paediatr Anaesth 2016;26:399-404.

31. Chuha A, Mehrota D, Yadav PK. A systematic review on the outcome of distraction osteogenesis in TMJ ankylosis. J Oral Biol Craniofac Res 2021;11:581-95.

32. Fariha R, Canto L, Gunekel R, Alister JP, Uribe F. Temporomandibular joint ankylosis: Algorithm of treatment. J Craniofac Surg 2018;29:427-31.

33. Zhang W, Yang X, Zhang Y, Zhao T, Jia J, Chang S, et al. The sequential treatment of temporomandibular joint ankylosis with secondary deformities by distraction osteogenesis and arthroplasty or TMJ reconstruction. Int J Oral Maxillofac Surg 2018;47:1052-9.

34. Yu X, Wang J, Hou S, Zeng R. Mandibular distraction osteogenesis in the treatment of pediatric temporomandibular joint ankylosis with micrognathia and obstructive sleep apnea syndrome: A case report with 4-year follow-up. Exp Ther Med 2019;18:4888-92.

35. Vignesh U, Mehrrota D, Bhave SM, Singh PK. Quality of life after distraction osteogenesis in TMJ ankylosis patients. Oral Surg Oral Med Oral Pathol Oral Radiol 2021;131:295-303.