Original Article

Evaluation of effect of single vector mandibular distraction for correction of postankylotic mandibular hypoplasia requiring multiplanar correction: A prospective case series

ABSTRACT

Introduction: Uniplanar devices have been criticized for being insufficient to correct complex mandibular deformities and associated problems of open bite and cross bite. The use of oblique vector to correct complex multiplanar deformities using uniplanar mandibular distraction devices is the uniqueness of the present case series.

Aim and Objective: The aim of the present case series is to describe the successful use of uniplanar mandibular distraction devices for the correction of complex multiplanar deformities.

Material and Method: The technique of callous molding was employed to overcome any open bite. A total of 40 mandibular distractors in 20 patients (mean age 13 ± 2.67 years) were placed on the mandible for correction of the facial deformity associated with the lower jaw(mandible) in vertical, horizontal and/or sagittal plane, secondary to temporomandibular joint ankylosis. The distraction was done before and after the gap arthroplasty in 15 and 5 patients, respectively. A latency period of 3–5 days was applied, and distraction was performed at a rate of 1 mm/day with the rhythm of 0.5 mm twice daily.

Results: The significant lengthening was observed in both mandibular height (Ar Go) (50.40 ± 1.52 mm from 38.80 ± 4.38mm, P = 0.006) as well as in mandibular corpus length (Go Pg) (79.40 ± 2.28 from 58.80 ± 4.09, P = 0.001). Statistically significant changes in mandibular dimensions, facial proportions, and soft tissue profile were seen, which was assessed with the help of COGS analysis done on lateral cephalogram taken preoperatively and postoperatively.

Conclusion: With intelligent vector planning and callus molding multiplanar complex deformities can be corrected by using semiburieduniplanar devices.

Keywords: Callus molding, floating bone technique, mandibular distraction osteogenesis, oblique vector, uniplanar mandibular distraction device

INTRODUCTION

Addressing mandibular hypoplasia, whether it is acquired, congenital, or secondary to TMJ ankylosis has ever since been a challenging task to the maxillofacial surgeon, owing to the complexity of its presentation and associated functional and esthetic sequel. Out of the various causes for mandibular hypoplasia, temporomandibular joint (TMJ) ankylosis is one of the common reasons causing growth disturbances in mandible which leads to severe facial asymmetry and mandibular deficiency.[1,2] Mandibular hypoplasia, severe facial deformities (deviated chin, canting of the occlusion),

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and sleep apnea are the main sequel of TMJ ankylosis.[1,2] Establishment of normal mandibular movement and function and preventing reankylosis, have been the main surgical objective in the management, whereas accompanying esthetics have always been overlooked.

To address the esthetic aspect, bilateral sagittal split osteotomies (BSSO) have been the workhorse for the treatment of mandibular hypoplasia. BSSO has shown good stability for advancements of <6 mm, whereas advancements of more than 6 mm have been associated with a higher incidence of relapse.[3-5]

Among the plethora of therapeutic alternatives for correcting bony deformities/deficiencies, distraction osteogenesis (DO) is a surgical technique and is gaining popularity owing to its ability to reconstruct combined deficiencies in bone and soft tissues make this process unique and valuable.[5,6]

For a multiplanar three-dimensional defect like mandibular hypoplasia in TMJ ankylosis, multiplanar devices are used for greater vector control; however, these are complex in management, cause greater facial scarring and associated complications.[7,8] Uniplanar devices, on the other hand are simpler in placement and management, but they have been considered inadequate for correction of multiplanar defects and often result in malocclusion.[7] Oblique vector using uniplanar devices can be a solution for multiplanar defects, but there is the paucity of literature on this technique.[9] This article aims to report the efficacy of a single vector mandibular distraction technique using oblique vector for correction of a multiplanar defect, i.e., post ankylotic mandibular hypoplasia. The objectives of the present case series are to report the radiographic changes and the changes in soft tissue profile following oblique vector uniplanar mandibular DO.

MATERIALS AND METHODS

The present study was approved by the institutional ethical committee and review board. Ethical clearance obtained from, IEC (Institutional Ethical Committee), Reference number and date: SU/R/2021/1846 and 19/7/21.

Study design

Prospective single-arm interventional study.

Settings

The present study was conducted at the outpatient department of oral and maxillofacial surgery, Santosh Dental College and Hospital, Ghaziabad, Uttar Pradesh, India.

Sample

A total of twenty patients indicated for surgical correction of bilateral mandibular hypoplasiain vertical, horizontal and/ or sagittal plane, secondary to temporomandibular joint ankylosis were included based on the following inclusion and exclusion criteria. The patients were divided into two groups, In Group A, the distraction was done before the ankylosis release and in Group B, the distraction was done after the ankylosis release.

Inclusion criteria were the willingness (informed consent) of subjects to comply for the operative procedure as well as the entire duration of distraction schedule and availability for postoperative follow-up.

Exclusion criteria were inadequate bone stock to plan distraction, uncontrolled diabetes, blood dyscrasias, immuno-compromise, psychiatric disorders, severe osteoporosis, and uncontrolled seizures.

Preoperative evaluation and planning

Lateral cephalograms and PA cephalograms were taken and traced for all the patients pre- and postoperatively. All the tracings on lateral cephalogram were subjected to COGS (cephalometrics for orthognathic surgery) analysis, both for hard and soft tissue as described by Burstone *et al*.[10] and Grummons analysis[11] was done on PA cephalograms.

The amount of distraction needed was determined by drawing a triangle, two sides of which represent the amount of mandibular corpus and ramus shortening, respectively. The angle between these two sides is the gonial angle and the third side indicated the amount of distraction.

The angulations of distractors were decided according to the formula given by Losken *et al*.[12] as described in the text below.

$$\text{Pin placement angle} = \frac{\text{Sin a}}{\text{Dc / Dr} - \text{Cos a}}$$

where a = Gonialangle, Dc = Corpus deficiency, Dr = Ramus deficiency.

Pin placement angle = Angle between distraction vector and mandibular plane.

Distraction protocol

After a latency period of 3–5 days, distraction was done at a rate of 1 mm/day (0.5 mm twice daily). After distraction, a time period of 8 weeks was kept as consolidation period.

Intervention and surgical technique

Single vector mandibular distraction device placed subperiostally with titanium osteosynthesis screws in oblique direction was used to reconstitute bony structures for correction of facial deformity secondary to temporomandibular joint ankylosis. Surgery was performed under general anesthesia through nasotracheal intubation. The extraoral approach was used and the incision was made in the submandibular region 2 cm below the lower border of the mandible near the angle of the mandible, to expose the planned site for distractor placement. The osteotomy cuts were performed based on the intended position and angulation of distractors. After ensuring the correct alignment of the distractor, it was fixed with the help of at least two screws on each side of osteotomy. The activation port was then taken out percutaneously by making a small stab incision. The patency of the distractor was checked by activation. The surgical site was closed in layers, and pressure dressing was applied.

Evaluation parameters

Frontal and profile views of the patient were taken preoperatively and postoperatively to record changes in ramus length, anteroposterior dimension of the mandible, and facial asymmetry. Radiographic evaluation was done using 3D CT scan, Orthopantomogram (OPG), lateral cephalometric radiograph and COGS analysis.

Representative case

Figures 1-6 depict a representative case showing surgical technique and callous molding.

RESULTS

Data analysis revealed that the mean age of the sample group was 13 ± 2.67 years; there were 15 males and 5 females. The etiology of the defect in all of the subjects was trauma (100%). The clinical findings were mandibular hypoplasia (n = 10), no mouth opening (n = 6), bilateral TMJ ankylosis (n = 10) and obstructive sleep apnea (n = 2).

Mandibular corpus deficiency was calculated considering the normal mandibular corpus length in males and females, it was found that in 6 patients, there was 10–20 mm of corpus deficiency, 21–25 mm of corpus deficiency in 10 patients, 26–30 mm of corpus deficiency in 4 patients.

The data analysis revealed that significant lengthening was observed in both of the groups, such as pre-ankylosis release distraction group and post-ankylosis release distraction group. The mandibular height (Ar-Go) increased to "51.43 ± 1.32 mm from 39.95 ± 5.38 mm" and "54.40 ± 1.54 mm from 23.60 ± 4.18 mm" in preankylosis release distraction group and post-ankylosis release distraction group, respectively ($P < 0.05$). Similarly, mandibular corpus length (Go-Pg) increased

Figure 1: Preoperative facial profile

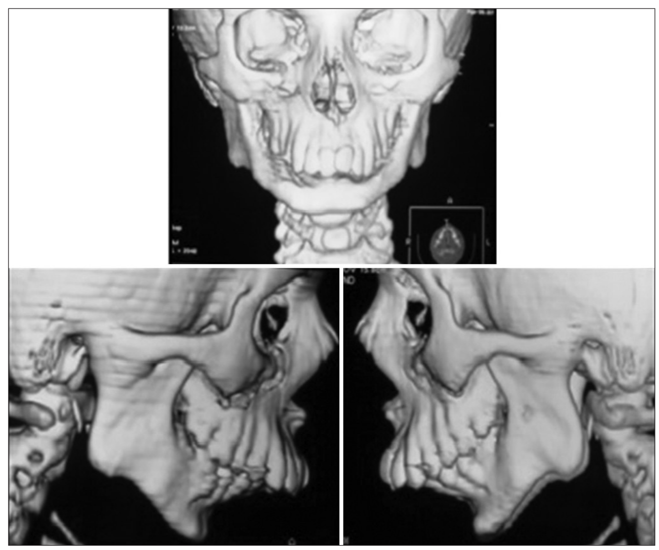

Figure 2: Preoperative cone beam computed tomography view

Figure 3: On the 7th day postoperatively

to "82.40 ± 3.08 mm from 59.76 ± 5.63 mm" and "76.23 ± 3.12 mm from 56.63 ± 3.19 mm" in preankylosis release distraction group and postankylosis release distraction group, respectively ($P < 0.05$).

Statistically significant changes in mandibular dimensions, facial proportions, and soft tissue profile were seen, which was assessed with the help of COGS analysis done on lateral cephalogram taken preoperatively and postoperatively [Tables 1 and 2]. The Grummon's analysis depicted asymmetry in the right and left sides preoperatively while the measured parameters showed statistically insignificant differences postoperatively [Table 3].

DISCUSSION

DO has become increasingly popular after McCarthy showed the clinical feasibility of lengthening hypoplastic mandibles.[7,13] First type of distraction device was external and uniplanar, which was, however, deemed insufficient to correct multiplanar deficiencies.[13] Multiplanardevices were developed to address this and incorporated multiple screws and joints to achieve movement in multiple planes but were bulky and inconvenient for patients.[7,8,14,15] Furthermore, these result in external scars [Figure 7]. Smaller intraoral and percutaneous devices have been introduced to overcome this problem. However, in contrast to some multidirectional extraoral distraction devices, intraoral and percutaneous uniplanar devices can be used for lengthening along single vector only.[16] Use of uniplanar devices to correct multiplanar problems have been criticized owing to the misapplication of vector and thus resulting in occlusal discrepancies, i.e., anterior open bite and crossbite, and facial asymmetry.[9,17]

The various limitations of semiburieduniplanar devices can be addressed by using appropriate vector planning and callous molding.[9,17] Semiburied uniplanar devices have been successfully used by Singh *et al*.[9] for correction of multiplanar deformities. The use of oblique vector of distraction for correction of mandibular body and ramus deformities at the same time using single vector device is the uniqueness of the present case series. Kunz *et al*.[17] published a case series in which they mentioned about the anterior open-bite. However, the detailed analysis of their cases revealed that the vector planning in relation to the occlusal plane was not appropriate. If the vector planning is adequately done concerning the occlusal plane, one can expect a class I occlusion with an improved gonial angle, contour and position as well as elongation of mandibular ramus and body. Planning the vector as more obtuse device-occlusal-plane angle drives the distal segment inferiorly and posteriorly to improve the gonial angle.

Figure 4: Open-bite deformity (on top) intraoral photographs showing inter-maxillary fixation screws in place and elastics given for callous moulding and corrected open-bite (last photo on lower right corner

Figure 5: Cone-beam computed tomography during consolidation showing new bone formation

Table 1: Preoperative and postoperative evaluation parameters for preankylosis release distraction cases

Evaluation parameter	Mean±SD					P¶
	Preoperative	Postoperative	6 months postoperative	12 months postoperative	18 months postoperative	
ANS-Gn	56.40±5.16	65.10±4.23	64.630±5.44	64.63±5.21	63.20±5.04	0.018*
Ar-Go	39.95±5.38	51.43±1.32	51.40±1.44	51.20±1.44	50.22±1.26	0.006*
Ar-Go-Gn angle	120.60±14.03	123.70±4.41	124.26±4.39	124.26±4.39	124.04±4.08	0.937
B-Pg	−3.14±6.92	5.83±0.54	5.83±0.54	5.45±0.49	5.44±0.49	0.046
Go-Pg	59.76±5.63	82.40±3.08	82.40±3.08	80.70±4.26	80.56±3.19	0.001*
MP-HP angle	45.20±8.87	9.55±2.27	9.55±2.27	10.13±2.39	10.98±3.98	0.001*
N-A	3.86±1.63	4.16±1.08	4.16±1.08	4.07±1.88	4.07±1.90	No *P* value can be computed
N-A-Pg angle	19.76±17.66	6.08±3.52	6.08±3.52	5.93±3.64	5.93±3.64	0.116
N-B	24.12±6.21	10.26±4.45	10.26±4.45	10.28±5.43	10.28±5.45	0.001*
N-Pg	27.56±13.22	7.48±5.17	7.48±5.17	7.92±4.37	7.93±4.86	0.012*
N-ANS	51.32±3.18	52.86±2.13	52.82±2.11	52.81±2.10	52.81±2.10	0.041*
PNS-N	49.86±2.12	50.63±3.11	50.62±3.10	50.62±3.12	50.62±3.13	0.067*
PNS-ANS	51.60±3.15	52.96±3.88	52.90±3.80	52.89±3.75	52.89±3.76	0.051*
Soft tissue analysis						
Li to Sn-Pg	10.16±3.15	6.39±1.29	6.39±1.29	6.96±0.82	6.94±0.45	0.003*
Si to Li-Pg	7.21±1.37	4.93±0.76	4.93±0.76	4.88±1.64	4.88±1.64	0.032*
Sn-Gn/C-Gn	1.87±0.77	1.43±0.82	1.49±0.87	1.52±0.14	1.52±0.14	0.373
Sn-Gn-C	156.34±4.16	124.56±7.13	124.60±7.23	123.60±7.62	123.60±7.62	0.001*
Sn-stm/stm-Me	0.53±0.08	0.57±0.12	0.57±0.12	0.57±0.22	0.57±0.22	0.814

*Significant *P* value, Calculated on the basis of repeated measures of ANOVA. SD: Standard deviation, ANS: Anterior nasal spine, MP: Mandibular plane, HP: Horizontal plane, PNS: Posterior nasal spine

Table 2: Preoperative and postoperative evaluation parameters for postankylosis release distraction cases

Evaluation parameter	Mean±SD					P¶
	Preoperative	Postoperative	6 months postoperative	12 months postoperative	18 months postoperative	
ANS-Gn	54.38±4.12	66.00±4.14	65.90±5.11	64.22±4.82	64.22±4.82	0.019*
Ar-Go	23.60±4.18	54.40±1.54	54.40±1.54	53.20±1.46	52.16±1.56	0.009*
Ar-Go-Gn angle	122.83±19.03	125.59±4.85	125.59±4.85	124.96±4.11	124.96±4.76	0.926
B-Pg	-4.13±6.22	5.13±0.49	5.13±0.49	5.02±0.29	5.02±0.29	0.066
Go-Pg	56.63±3.19	76.23±3.12	76.23±3.12	74.03±2.98	74.03±2.98	0.001*
MP-HP angle	49.20±8.87	12.16±3.17	12.67±3.45	12.67±3.45	12.42±3.31	0.001*
N-A	3.32±1.68	3.32±1.68	3.21±1.55	3.20±1.52	3.19±1.45	No *P* value can be computed
N-A-Pg angle	22.44±18.78	7.00±3.74	7.86±3.94	7.86±3.94	7.86±3.94	0.132
N-B	26.50±7.40	8.14±5.03	8.140±5.03	8.09±4.46	8.09±4.46	0.001*
N-Pg	26.44±14.32	7.78±4.17	7.92±4.67	7.92±4.67	7.93±4.81	0.016*
N-ANS	52.18±3.92	53.62±2.76	53.61±2.63	53.61±2.63	53.61±2.59	0.029*
PNS-N	50.36±3.54	51.86±3.21	51.85±3.22	51.76±3.56	51.76±3.56	0.043*
PNS-ANS	49.10±2.11	50.83±3.11	50.83±3.16	50.79±3.13	50.79±3.13	0.076*
Soft tissue analysis						
Li to Sn-Pg	8.48±2.43	5.48±0.24	5.43±0.85	5.43±0.85	5.05±0.67	0.004*
Si to Li-Pg	8.60±1.67	5.44±1.21	5.87±1.51	5.87±1.51	5.89±1.52	0.032*
Sn-Gn/C-Gn	1.93±0.77	1.59±0.31	1.60±0.34	1.60±0.34	1.60±0.34	0.373
Sn-Gn-C	149.40±5.27	120.60±8.82	121.60±8.92	121.60±8.92	121.60±8.92	0.001*
Sn-stm/stm-Me	0.51±0.19	0.55±0.27	0.55±0.27	0.55±0.27	0.54±0.22	0.824

*Significant *P* value, Calculated on the basis of repeated measures of ANOVA. SD: Standard deviation, ANS: Anterior nasal spine, MP: Mandibular plane, HP: Horizontal plane, PNS: Posterior nasal spine

While planning the vector assignment for the distractor devices, TMJ anatomy must also be taken into consideration[18-20] as it has been observed in the literature that more hypoplastic and rotated the condyle is within the glenoid fossa, the less is the gonial angle. In the present study, all the cases had TMJ ankylosis and the vector that was planned was more obtuse between the device and the occlusal plane.

Oblique vectors are preferred in those cases in whom both ramus and mandibular body deficiency are critical and the same scenario was present in the current study. Rubio-Bueno *et al*.[21] used internal distraction devices in their series of 9 patients and achieved up to 25 mm lengthening of the ramus as well as mandibular corpus with oblique vectors.

In the present study, with the oblique vector of distraction, significant corrections were observed in both mandibular height (Ar-Go) as well as in Mandibular corpus length (Go-Pg). The average correction achieved in ramus height was 11.60 ± 1.91 mm and in mandibular corpus length was 20.60 ± 1.84 mm. These results were similar to the finding of Douglas *et al*.[22] who used a pin and tube device for intraoral distraction in an adult patient with micrognathia due to temporomandibular joint ankylosis. The authors achieved a lengthening of 10 mm in their patient, which remained stationary after surgery. Similarly, Yonehara *et al.*[23] used bilateral DO of the mandible in patients with temporomandibular joint ankylosis and mandibular deformity. The authors achieved a mean lengthening of 13.5 mm in the ipsilateral mandibular body and 16 mm on the contralateral side. Rao *et al*.[16] achieved the mean lengthening in the mandibular body of 12.5 mm in their six patients with mandibular hypoplasia. The alteration in the vector of distraction for correction of mandibular ramus and body length may result in anterior open bite, which can be further corrected by the floating bone technique, which has been successfully used for counteracting the undesired effects of vector manipulation.[24,25]

In the present study, this limitation of uniplanar devices was overcome by correcting the open bite deformity and facial asymmetry by callous molding in the early consolidation period as per Pensler *et al*.[25] and Kunz *et al*.[17] In the

Figure 6: Postoperative profile view of patient

Figure 8: Distractor device hardware failure and callous slippage on the left side

Table 3: Preoperative versus 6 months postoperative paired sample statistics based on Grummons analysis

Pair	Mean	Co-AG	AG-Me	Co-Me	SD	*P*¶
Preoperative	Left	46	43	82	0.76	0.6455
	Right	44	85	85	0.67	
Paired difference					0.016000	
Postoperative	Left	58	56	102	2.73	0.0092*
	Right	54	100	100	1.85	
Paired difference					0.004300	

*Highly significant *P* value, ¶Calculated on the basis of paired *t*-test. SD: Standard deviation

Figure 7: Scars after distractors removal

Figure 9: Facial asymmetry caused by the distractor device failure which was corrected by genioplasty

present study also molding of fresh regenerate was done to reduce the mandibular plane angle and manage open bite [Figure 4]. Intermaxillary elastic traction was employed to achieve desired skeletal and occlusal outcomes. The skeletal anchorage using IMF screws was harnessed for elastic traction as dental anchorage may lead to undue dentoalveolar changes.[26] Remarkable improvements in facial profiles were reported in the present study.

Some relapse have been seen in patient in which the distraction was done after the ankylosis release, the reason for the relapse was thought to be due to the movement of both proximal as well as distal segment during the distraction. Azumi *et al*.[27] studied the positional and morphologic changes of the proximal segmen after mandibular DO in skeletal class I patients and concluded that most of the proximal segments were displaced in an upward and backward direction, and the amount of displacement was correlated with the amount of mandibular lengthening. They also reported a variable posterior and lateral open bite following the change in ramus length. In our study, we did slight overcorrections in the posterior facial height, which can overcome the relapse which occurred after the removal of ankylotic mass. Some relapse was seen in the mandibular ramus length in our study, the mean relapse was 4 mm, which is similar to the relapse found in the other studies by various authors.[19,28] These authors found the mean relapse of 3 mm in mandibular length in their study. The reason for this relapse was found to be due to amount of bone removed during gap arthroplasty exceeded the amount of over correction done in the ramus length. This relapse, however, was not found to be clinically significant. Furthermore, in one subject, hardware failure was observed, which resulted in callous slippage and gross mandibular asymmetry, which was further corrected by advancement genioplasty [Figures 8 and 9].

Mandibular skeletal deformities offer a complex set of treatment challenges to concerned surgeons. Every case presents a unique set of clinical challenges while there are no standard guidelines or operating principles for performing DO or handling associated complications or deviations from planned outcomes. There is always the role of orthodontic support in terms of predistraction assessment of the craniofacial skeleton and occlusal function while planning both the predistraction and postdistraction orthodontic care for the patients undergoing DO. The limitations of DO further, DO alone cannot render complete treatment, and the treatment is to be supplemented by a long duration of orthodontic correction of malocclusion. The treatment outcomes in each of the individual cases are dependent on tailor-made customized treatment planning and expertise and experience of surgeon.

CONCLUSION

The present case series successfully demonstrates the correction of multiplanar mandibular deformities with uniplanar semiburied devices by using oblique vector and callus molding. Thus with intelligent vector planning and callus molding multiplanar complex deformities can be corrected by using semiburied uniplanar devices.

Declaration of patient consent

The authors declare that they have obtained consent from patients. Patients have given their consent for their images and other clinical information to be reported in the journal. Patients understand that their names will not be published and due efforts will be made to conceal their identity but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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