A review of the consequences of mandibular osteodistraction on temporomandibular joint

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The purpose of this review was to address the question whether mandibular distractionostegenesis (DO) has any effect on temporomandibular joint (TMJ). A literature survey from the pub Med database used the medical subject heading terms osteodistraction, T.M.J and 13 articles written in English were obtained. mandibular DO may accompany with some resorption & remodeling of TMJ but apparently if correctly used produces less TMJ problems compared with conventional mandibular osteotomies and even according to some studies, It is beneficial to structure and position of TMJ. This technique has been proposed for advancement of mandible in patients with TMJ problem and for ramus lengthening for prevention of relaps and TMJ problems. Mandibular Do can be a valuable technique for reconstruction of ramus and condyle in severe mandibular deformities such as TMJ ankylosis and hemifacial microsomia. Transverse distraction of mandible may accompany with TMJ problems and should be used coutiously.
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Distraction osteogenesis (DO) is the surgical technique in which new bone formation is induced by gradual separation of bony segments after an osteotomy.

Principles of gradual tissue distraction (distraction histogenesis) and the mechanism of controlled tension stress were originally described by GA Ilizarov during the 1950 mainly for limb lengthening deformity correction and bone transport.[1,2]

McCarthy report in 1992 of the use of DO to lengthen a congenitally hypoplastic mandible was the first description of this technique in a human maxillofacial application in the English literature.[1]

For patients with dentofacial deformity, the obvious indication for DO, is a condition in which it would be more efficient than the other available treatment modalities- growth modification, camouflage, and orthognathic surgery.

The indications for distraction of the jaws, therefore, are largely the conditions in which it is uniquely able to produce significant improvements. These are as follows:

- severe deficiency of either jaw that needs to be ameliorated at an early age.
- Severe mandibular deficiency that requires lengthening of the mandible more than 10 to 15 mm.
- A short mandibular ramus that must be lengthened.
- A narrow maxilla in an adult that must be widened anteriorly.
- A narrow , V- shaped mandible that must be widened.[1]

There are several potential advantages to the use of DO for the correction of severe mandibular and midfacial abnormalities.

Most important, it appears that distraction offers the pos-

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sibility of obtaining results that simply cannot be achieved with more traditional osteotomy procedures or techniques such as costochondral grafting. The elimination of the need for bone grafting also significantly reduces the morbidity associated with this procedure. Increased long term stability after surgical correction with DO has also been described through case presentation and anecdotal evidence.[3]

Attention to temporomandibular joint (TMJ) and any probable effect of orthodontic, orthopedic or orthosurgery treatment on TMJ is very important and must be considerd in selection between alternative treatments.

The purpose of this paper was to review the articles about mandibular distraction osteogenesis and address the question whether mandibular osteodistraction has any positive or negative effect on TMJ.

Results

Harper et al[1] in an animal study evaluated the histologic changes within the condyle in response to mandibular widening using osteodistraction in monkeys. Although some animals showed no unusual morphology, others exhibited histologic changes within the fibrous layer, cartilage layer or bone/cartilage interface. All three layers of the condyle were more likely to be involved on the postero-lateral, the antero-middle and antero-medial surfaces of the condyles.

The severity of these changes were correlated with the likely rotational forces directed at the condyle on the postero-lateral and antero-medial surfaces.

Samchukov et al.[5] in a computer model study evaluated the biomechanical effects of linear distractors parallel to the body of the mandible or parallel to the axis of distraction. In addition, two types of DO for mandibular reconstruction were analyzed:

1) bilateral mandibular lengthening , and

2) bilateral mandibular lengthening in combination with midline mandibular widening. Distractors oriented parallel to the body of the mandible caused a lateral displacement of the posterior components of the distraction devices and a reduction of the midline distraction gap duriug mandibular lengthening. These effects were eliminated when the device was oriented parallel to the axis of distraction. Midline symphyseal widening created axial rotation of the mandibular condyles regardless of the orientation of the distractors.

Hikiji et al.[6] in an animal study investigated the applicability of transport distraction osteogenesis with an internal appliance for reconstruction of the temporomandibular joint. At 8 weeks after the completion of lengthening, the mature cortical bone was reconstructed. A collagenous- like structure formed a cap over the leading edge of the transport segment. This cap may substitute for an articular disc. The new bone remodeled and resembled the condyle.

Stelnicki et al.[7] in an animal study assessed the TMJ changes following various degrees of transverse distraction significant remodeling changes were observed in the TMJ of all animals involved in the study. The mandibular condyles demonstrated varying degrees of flattening and erosion at all contact points with the craniofacial skeleton. In some cases, the condyle became part of the distraction regenerate process and was hypertrophied in all dimensions. The condyles were frequently displaced out of the glenoid fossa, particularly on the side in the direction of various distraction. When the latter occurred, a new fossa was created on the undersurface of the zygomatic arch. Varying degrees of mandibular rotation in the sagittal plane were also observed , which led to abnormal torquing of the condyles in the coronal plane, depending on whether the axis of rotation occurred primarily around the condyle or around the distraction regenerate zone.

McCarthy et al.[8] in an article reviewed their 11-year clinical and research experience with mandibular distraction osteogenesis. They demonstrated that distraction does induce a minimal amount of condylar flattening, but the morphologic change was transient and completely reversible. Their study on humans demonstrated that unilateral distraction caused the condyles to assume a larger size and a more vertical orientation, normalizing their appearance overall. The contralateral condyle was unaffected. A similar finding was observed in bilateral distraction.

In these patients the condyles showed increased size, improved geometry and augmented vertical height. The conclusion of these studies was that the process of distraction was beneficial to the structure and position of the temporomandibular joint. They also mentioned that a technique termed transport distraction, generates a neo-condyle and temporomandibular joint in patients with severe joint ankylosis. This method produces a vertically elongated mandible with a functioning, nonankylosing temporomandibular joint in the short term that needs long-term follow-up studies to determine the efficacy of this process.

Rubio-bueno et al.[9] used internal devices for unidirectional distraction osteogenesis to treat different mandibular hypoplasias.

They reported that all adult patients experienced TMJ pain during activation.

They proposed distraction for those mandibular hypoplasias in which conventional surgical techniques are associated with a high degree of relapse. One of these factors that they found in the literature (Arnett, 1993) related to advancement relapse is pre-existing TMJ pathology. Condylar compression may be more likely to progress to condylar resorption when anterior disc displacement is pres-

ent prior to surgery.

Also they mentioned that lengthening of the ascending ramus is difficult to perform technically, due to the poor extensibility of the pterygomasseteric sling, that may be also followed by condylar sag, postoperative TMJ symptoms and relapse. According to this paper, distraction is currently considered as the best option in all cases in which lengthening of the ascending ramus of the mandible is necessary, even with deficiencies lower than 10 mm.

Braun etal.[10] performed a human study to determine the true nature of condylar displacements associated with mandibular symphyseal distraction osteogenesis. It was found that each condyle was laterally displaced in direct relationship to the amount of symphyseal distraction. Temporomandibular joints appeared to be able to accommodate the lateral displacements because symptoms were not introduced , or , if present before therapy, distraction did not exacerbate them.

Piero etal.[11] treated four patients with monolateral ankylosis of the TMJ and serious deformities of the maxillomandibular complex secondary to functional limitations. Patients treated with a combination of TMJ arthroplasty and intraoral osteodistraction and all of them showed recovery of the eurhythmy of the face and good re-establishment of the symmetry.

Cavaliere et al.[12] treated two patients with grade III hemifacial microsomia (HFM) with distraction osteogenesis (DO). Although DO has become a part of the treatment algorithm for many patients with HFM , surgeons have been reluctant to apply the technique in patients with complete agenesis of the ascending mandibular ramus and condyle (grade III HFM). Both patients treated with this method showed new bone formation within the distraction gap and development of a pseudoarthrosis between the proximal segment of the mandible and the skull base. Facial symmetry improved dramatically, and speech and mandibular excursion were attained.

According to authors this valuable surgical technique provides not only a means of augmenting the hypoplastic mandible but a means of creating an ascending mandibular ramus and neocondyle in cases of congenital absence.

Thurmuller et al.[13] conducted an animal study to evaluate the effect of Do, at varying rates 1,2, or 4 mm/d, on mandibular condyle and articular disc.

Ipsilateral condyles showed increasing changes in morphology and

A.P- dimention and surface contour irregularities as the Do rate increased.

These changes were present, but to a lesser degree, in the contralateral condyles. Articular discs of both ipsilateral and contralateral sides showed variable thinning at the medial aspect at the end of DO.

Gross changes occur in condyles and discs after unilateral mandibular Do. These changes are more severe at faster distraction rates and tend to resolve during neutral fixation when a rate of 1 mm/d is used.

Tucker and Walker[3] in a two part article compared traditional orthognathic surgery with DO for correction of mandibular deficiency. It has mentioned in the article that DO for mandibular lengthening is indicated for adult patients with internal derangements , presurgical or post surgical condylar resorption, and degenerative joint disease. Distraction osteogenesis should be considered in these patients even if only moderate lengthening of the mandible is anticipated. The unusual condylar resorption, short ramus height and severe micrognathia present difficult problems for performing typical mandibular advancement surgery. Do can be used to creat increased ramus height and mandibular body length without the need for bone grafting. Greater distances can be achived in lengthening of the mandible, with secondary favorable soft tissue adaptation.

There is minimal evidence of significant remodeling of the temporomandibular joint secondary to mandibular lengthening with Do documented in animal studies. Use of bidirectional and tridirectional distraction devices offers improved vector control during mandibular distraction, and appears to cause less remodeling of the temporomandibular joint than unidirectional devices.

Discussion

The healthy TMJ is responsive to changes in its biomechanical and biophysical environment. Exposed to such changes, the TMJ may undergo substantial remodeling, an adaptive capacity not shared by many other joints.[13]

The effect of DO on the temporomandibular joint remains in question. Because DO results in gradual stretching of the bone and the adjacent soft tissue, the hypothesis is that this may result in decreased abnormal loading on the joint. Rapid or large movement might promote condylar resorption in both DO and osteotomy patients[3]. Currently, little is known about the adaptability of the TMJ in response to mandibular lengthening by Do. Increase in articular contact pressure with injury and degeneration of cartilage have been reported in experimental DO research on long bones. How ever, the nature of pressure related alterations in the cartilaginous tissues of the TMJ , in response to DO, is still a matter of controversy. Although there is agreement that DO influences condylar morphology , opinions differ with regard to the extent and the nature of these changes, and to what extent normalization of the TMJ occurs with time.

This lack of consistency in the literature is a result of differences in study design, different DO protocols , and varying animal models. All of these factors make comparison of data difficult.[13]

Forces that successfully distract the mandible could conceivably generate compressive forces at distant sites such as the TMJ. Thurmuller et al.[13] in their study observed resorption and remodeling of bone not only at the posterior aspect of the condylar head but also at the most anterior surface of the condyle. Compressive forces directed in an AP vector could induce a posterior movement of the condyle.

This movement might be expected to subject the anterior intracapsular aspect of the pig condyle to compressive loading that, under normal conditions, does not occur. Such loading may lead to the contour irregularities and resorption of bone observed in their animal model. When a rate of 1 mm/d was used a reversal of these changes with time was observed.[13]

Anyway it is documented that acute loading of the temporomandibular joint from conventional mandibular osteotomies and lengthening can exacerbate TMJ problems. The amount of stripping of periosteum and musculature off the proximal segment may decrease its vascularity and result in further condylar remodeling and/or resorption.[4] Unfavorable forces on the condyle after orthognatic surgary may result in condylar resorption and dentofacial relapse. The application of slow force over a longer period of time will facilitate a more physiological adaptive response at the cellular level and allow the system to achieve a state of structural and functional equilibrium.[2]

According to McCarthy et al.[8] Unilateral or bilateral mandibular DO causes the condyles to assume a larger size and is beneficial to the structure and position of the temporomandibular joint complex.[8]

Stelnicki et al.[7] concluded from their animal study that unlike linear or angular mandibular distraction , transverse distraction has a multitude of nontransient effects on the TMJ and these effects can be negative. Therefore they emphasized that in clinical practice, transverse distraction should be used cautiously.[7] However , the result of Braun et al. human study was that TMJ appears to be able to accommodate the lateral displacements.[9]

Computer model study performed by Samchukov et al[3]. showed that distraction appliances must be oriented parallel to the axis of distraction to prevent adverse biomechanical effects during bilateral mandibular lengthening.

Additional ramus osteotomies, using hinged devices for angular correction, may be necessary to compensate for rotational movements of the mandibular condyles secondary to midline osteodistraction. Walker[4] mentioned that use of bidirectional and tridirectional distraction devices offers improved vector control during mandibular distraction, and appears to cause less remodeling of the TMJ than unidirectional device.

Rubio- Bueno et al.[9] proposed distraction for those mandibular hypoplasia in which TMJ symptoms or degenerative condylar changes exist because these conditions can be related to advancement relapse. They also cited that currently DO is considered as the best option in all cases in which lengthening of the ascending ramus of the mandible is necessary, because lengthening of the ramus is difficult to perform technically due to the poor extensibility of the pterygomasseteric sling and may be followed by condylar sag, postoperative TMJ symptoms and relapse.[9]

Piero et al.[11] in their case report about TMJ ankylotic patients mentioned that DO spur in craniofacial patients operates on the affected condyles , causing an increase in volume and optimization of the space orientation. Therefore , distraction seems to have a beneficial effect not only on the harmony of the craniofacial complex but on the temporomandibular articulation. They treated their patients with the Do associated with arthroplasty.[11]

Cavaliere et al.[12] carried out DO in HFM grade III patients with total agenesis of the mandibular ramus and condyle for augmenting the mandible and creating a ramus and neocondyle.[12]

Hikiji et al.[6] observed in their animal study that a collagenous tissue covered the neocondyle that was thinner than the normal articular disc, but this tissue might compensate for the function of the articular disc.[6]

Conclusion

1. DO can accompany with some resorption and remodeling of TMJ but if used correctly, it appears that TMJ be able to accommodate these changes.

2. DO may produce less TMJ problems compared with conventional mandibular osteotomies.

3. According to some studies, DO is beneficial to structure and position of TMJ.

4. DO is proposed for advancement of mandible in patients with TMJ problems and proposed for ramus lengthening for prevention of relaps and TMJ problems.

5. DO can be a valuable technique for reconstruction of ramus and condyle in severe mandibular deformities such as TMJ ankylosis and hemifacial microsomia.

6. Transverse mandibular DO may accompany with TMJ problems and should be used cautiously.

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