Title

The long term skeletodental stability of mandibular symphyseal distraction osteogenesis: tooth-borne versus hybrid distraction appliances

ABSTRACT

Objective: To evaluate and compare the long-term skeletodental stability of mandibular symphyseal distraction osteogenesis (MSDO) achieved with the use of tooth-borne versus hybrid distraction appliances.

Materials and Methods: Posttreatment and follow-up orthodontic records were collected for 33 patients. The 14 patients who underwent distraction with a tooth-borne appliance had a mean follow-up of 5.08 years. The 19 patients who underwent distraction with a hybrid appliance had a mean follow-up of 6.07 years. Records included intraoral photographs, study models, postero-anterior cephalometric radiographs, and lateral cephalometric radiographs. Changes in a total of 16 measurements were analyzed to compare patients who underwent tooth-borne versus hybrid distraction.

Results: Both groups shared several similar and significant (p<0.05) changes from posttreatment to follow-up records. Cast analysis showed a decrease in intercanine width and arch length and an increase in irregularity index. The postero-anterior cephalometric radiograph showed an increase in the width of the interincisal apices. The lateral cephalometric radiograph showed a decrease in the MP-L1 angle. The only
statistically significant difference between the two appliances was the intercentral incisor contact point.

**Conclusion:** Changes found are consistent with those found in untreated and orthodontically treated individuals over time. The long-term changes in the current patient sample can be determined to be expected and acceptable. MSDO is a viable treatment option with the use of either a hybrid or tooth-borne appliance.

**INTRODUCTION**

Mandibular symphyseal distraction osteogenesis (MSDO) is an effective treatment option for the correction of mandibular transverse discrepancies.\(^1\) This technique can be incorporated into a comprehensive orthodontic treatment plan for the correction of maxillo-mandibular transverse discrepancies, a narrow mandibular arch and mandibular dental crowding.\(^2\) The success of distraction osteogenesis (DO) is explained by the Law of Tension-Stress in which the controlled and gradual separation of two bone segments stimulates formation of new bone. The first protocol for distraction osteogenesis was described by Ilizarov for use in limb lengthening.\(^3,4\) His technique involved the surgical division of long bones, a latency period, a distraction phase that initiated the traction forces with distraction at 1mm per day and a consolidation period for remodeling of the bony regenerate.\(^5\) Distraction osteogenesis provides the ability to gradually develop both bone and soft tissue which is associated with increased stability.
In comparison to acute orthopedic movements with fixation, this gradual development reduces the risks of relapse.  

Distraction osteogenesis has been incorporated into the treatment plan of craniofacial abnormalities for its ability to produce stable and dramatic changes in bone and soft tissue. A well-known application of DO in dentistry is surgically assisted palatal expansion. The use of MSDO was first described by Guerrero. Several devices, bone-borne, tooth-borne, and hybrid, are available to achieve MSDO and differ in their attachment sites. Following an osteotomy, the bone-borne device is placed on either side of the mandibular symphysis, the tooth-borne device is attached to selected mandibular teeth, and the hybrid device is attached to both bone and teeth. The tooth-borne and hybrid appliances used in this study are illustrated in Figures 1 and 2 respectively. *Figures used with permission from Niculescu J, King J, Lindauer S. Skeletal and dental effects of tooth-borne versus hybrid devices for mandibular symphyseal distraction osteogenesis. Angle Orthod 2014;84:68-75.

Numerous studies describing the successful use of both tooth-borne and hybrid appliances have been published. Successful dental and skeletal expansion has been demonstrated with both tooth-borne and hybrid distractors. Very few clinical studies evaluate the long-term stability following MSDO. Most studies with follow-up records show good long-term stability with negligible relapse; however, the limitations of these studies include short follow-up time frames, lack of immediate post-treatment records as a reference, or small sample sizes. A clinical trial comparing
posttreatment to follow-up records evaluating a hybrid appliance concluded that no statistically significant transverse changes occurred during the mean follow-up time of 7.5 years after distraction. No long-term direct comparison is available to evaluate the dental and skeletal stability of MSDO achieved with different appliances.

The purpose of this study was to evaluate and compare the long-term skeletodental stability of mandibular symphyseal distraction osteogenesis achieved with the use of tooth-borne versus hybrid distraction appliances.

**MATERIALS AND METHODS**

The University of Tennessee Health Science Center Institutional Review Board granted approval #14-02923-XP to obtain and review the posttreatment and follow-up records of patients who underwent MSDO in conjunction with orthodontic treatment. Informed consent for MSDO as part of a comprehensive orthodontic treatment plan was obtained from 47 patients under the care of one privately practicing orthodontist. From this sample, patients were included in the present study if follow-up records were obtained a minimum of two years following removal of all orthodontic appliances. Patients were excluded from the study if they were older than the age of 18 at the start of treatment or if they were provided fixed retention upon removal of appliances. A total of 33 patients (14 tooth-borne, 19 hybrid) met the criteria and were included in the current study. The 14 patients who underwent MSDO with the use of a tooth-borne appliance were on average 12.92 years of age at the start of treatment and had a mean follow-up time of 5.08 years from the completion of treatment. The 19 patients who underwent MSDO with the use of a hybrid appliance were on average 13.54 years of
age at the start of treatment and had a mean follow-up of 6.07 years. All patients were treated by the same orthodontist and oral surgeon. Each treatment plan involved predistraction orthodontics, a symphyseal osteotomy with placement of the specified distraction appliance, a latency period, a distraction period, a consolidation period, and postdistraction orthodontics. Following the completion of orthodontic treatment, patients were provided with Hawley retainers with instructions to wear full time for 6 months except when eating, brushing and playing contact sports followed by six months at home wear. Following the first year, patients were instructed to wear the retainers nightly.

Posttreatment and follow-up orthodontic records included study models, a lateral cephalometric radiograph, a postero-anterior (PA) cephalometric radiograph and intraoral photographs. From these records, a total of 16 measurements were recorded. The study models provided 8 measurements including inter-second molar width, inter-first molar width, inter-second premolar width, inter-first premolar width, inter-canine width, inter-central incisor width, irregularity index, and arch length. The PA cephalometric radiograph provided 7 measurements including bigonial width, biaxial width, bicondylar width, interbone marker width, interincisor apices width, intercanine width, and intersecond molar width. The lower incisor to mandibular plane angle was measured from the lateral cephalometric radiograph. Descriptions of each measurement can be found in Table 1.

**Statistical Analysis**
A comparison of the changes between patients who underwent MSDO with the use of a tooth-borne distractor and those with a hybrid distractor was analyzed with the use of a paired t-test. A two-sample t-test was used to compare the changes between groups from post-treatment to the time of follow-up records. A significance level of $P<0.05$ was set for both analyses. A power analysis was also used to validate the significance of the results.

**RESULTS**

Average measures at each time point are shown for the tooth-borne and hybrid distractor groups in Tables 2 and 3. Differences in the changes observed over time between the groups are presented in Table 4.

From postorthodontic records to follow-up records, both distraction groups shared several similarities. Study model analysis revealed that both groups experiences changes in the irregularity index, arch length and canine width. The irregularity index increased 2.0mm in the tooth-borne group and 1.67mm in the hybrid group. The arch length decreased 1.54mm in the tooth-borne group and 1.39mm in the hybrid group. The intercanine width also decreased 1.28mm in the tooth-borne group and 0.64mm in the hybrid group. From the PA ceph, the interincisal apices width increased, and from the lateral cephalometric radiograph, the MP-L1 decreased. The interincisal apices width increased 1.11mm in the tooth-borne group and 0.52mm in the hybrid group. The MP-L1 decreased 1.25° in the tooth-borne group and 2.88° in the hybrid group. The only significant difference during the follow-up period was the central
incisor contact point as measured from the study models. For this measurement, patients in the tooth-borne group showed a significant increase of 0.52mm.

The power analysis showed that everything that was concluded to be significant had a high enough power (>0.8) to confirm that the results are valid.

**DISCUSSION**

Both skeletal and dental expansion is achieved with MSDO using tooth-borne and hybrid appliances as part of a comprehensive treatment plan. Due to the differing attachment sites of the distractors, the hybrid distractor’s lower center of resistance produces a more parallel regenerate. The more alveolarly placed tooth-borne distractor rotates the segments resulting in a disproportionate regenerate with greater separation of the alveolus. Numerous clinical studies have demonstrated these differences in the bony regenerate produced by the different appliances. Hybrid distractors provide more parallel expansion of basal and alveolar bone while the tooth-borne distractors create a disproportionate bony regenerate with greater expansion of alveolar bone. A direct comparison between the two appliances also supports that during distraction, a hybrid distractor creates a more parallel expansion of basal and alveolar bone than does a tooth-borne distractor. Furthermore, a hybrid device provides greater skeletal effects while distraction with a tooth-borne device creates greater dental effects. The skeletal and dental differences between the effects of the two appliances leads to consideration of potential differences in long-term stability.
Mean follow-up records of 6.07 years from the completion of treatment for hybrid patients and 5.08 years for tooth-borne patients provides the longest follow-up study available for the direct comparison of posttreatment changes between tooth-borne and hybrid groups. A previous publication studying orthodontic relapse concluded that approximately half of total relapse takes place in the first two years after retention. For this reason, no patients were included in the current study if the follow-up records were less than 2 years after the completion of orthodontic treatment. The same study further concluded that nearly all occlusal traits relapsed gradually over time but remained stable from 5 years postretention. This follow-up range supports that the average follow-up records for the patients in our study should reflect most long-term changes that will occur.

Much research has focused attention on relapse following orthodontic treatment. Studies have found typical posttreatment changes to include increases in incisor irregularity and the decreases in intercanine width and arch length. Findings of the present study are consistent with these changes in incisor irregularity, arch length, and intercanine width. A previous study with a slightly larger patient sample treated under the care of the same orthodontist as in the current study provides an example of the effects of distraction with the use of hybrid and tooth-borne appliances during treatment. Using the same treatment and record protocol, patients who underwent distraction with the use of a hybrid distractor had an irregularity index decrease of 6.6mm. Those who underwent distraction with the use of a tooth-borne distractor had a decrease of 8.1mm. The current study, with a similar patient population, showed an increase in the irregularity index during the follow-up time period in both groups. The irregularity
index increased an average of 1.68mm in the hybrid group and 2mm in the tooth-borne group. Both groups also shared a decrease in the MP-L1 measurement over time. A difference during retention was noted that patients in the tooth-borne group had a greater discrepancy of the central incisor contact point over time than patients in the hybrid group.

Changes noted in our study are comparable to studies of the long-term stability of mandibular incisors. The arch length decrease was comparable to relapse noted in previous studies with an average decrease of 1.39mm in the hybrid and 1.54mm in the tooth-borne groups. A meta-analysis, regarded as a highest level of evidence in research, reviewed postretention intercanine widths and is in agreement with the reduction in intercanine width found in our study. The meta-analysis concluded that mandibular intercanine width tends to decrease postretention by 1.2 to 1.9mm, regardless of pretreatment classification or whether treatment was extraction or nonextraction. Our findings showed an average decrease of 0.64mm in the hybrid group and 1.28mm in the tooth-borne group.

Our study demonstrates changes following treatment that are common to other treatments. Change has also been shown to occur over time in untreated groups. A long-term comparison of treated and untreated groups concluded that from late adolescence through early-to-middle adulthood, lower incisor irregularity increased similarly in both groups.
A posttreatment finding unique to the current study was the increase in the distance of interincisal apices. It is probable that this posttreatment change can be attributed to planned tooth movements during predistraction orthodontics. During this phase, divergence of lower incisors is created to provide space and reduce possible root damage during the osteotomy. Though complications are rare, damage to lower incisors has been encountered.\(^1\) It is our recommendation that the prevention of damage during the osteotomy outweighs the relapse of interincisal apices posttreatment.

**CONCLUSION**

- Changes found in this study are consistent with those found in untreated and orthodontically treated individuals over time.
- The long-term changes in the current patient sample can be determined to be expected and acceptable.
- MSDO is a viable treatment option with the use of either a hybrid or tooth-borne appliance.

**ACKNOWLEDGEMENTS**

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**REFERENCES**


FIGURE LEGENDS:

Figure 1. Tooth-borne appliance. Original source: The Angle Orthodontist

Figure 2: Hybrid appliance: Original source: The Angle Orthodontist

Table 1: Descriptions of Measurements. Modified from original source: The Angle Orthodontist

Table 2: Tooth-borne distraction: dental and radiographic data

Table 3: Hybrid distraction: dental and radiographic data

Table 4: Comparison of tooth-borne distraction and hybrid distraction during follow-up