



Stability and Effects of Mandibular Symphyseal Distraction Osteogenesis: A Systematic Review

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Authors' contributions

This work was carried out in collaboration between all authors. Author AT designed the study and wrote the protocol. Authors NN and FY designed the search protocol and did the systematic search. Authors SS and FY reviewed the articles and chose the included articles. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Expanding mandibular arch for correcting transverse deficiency is a challenging problem in orthodontics. It is believed that mandibular symphyseal distraction osteogenesis (MSDO) is an attractive solution for this problem. The aim of the present study is to review available data regarding stability of MSDO and its effect on temporomandibular joint and teeth and their surrounding tissues, in a systematic approach.

Study Design: The study is a systematic review of available evidence.

Place and Duration of Study: Department of Orthodontics of Dental school at Shahid Beheshti

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Methodology: Electronic searching was done in Medline, Embase and CENTRAL databases. Published clinical studies and case series in English language which had used tooth borne, bone borne or hybrid distractors and had follow up period of 1 year or more were included. Review article, case reports, and letters were not included. Presence of samples with syndromic problems or mandibular cleft and simultaneous other surgical procedures in mandible were reasons for excluding articles. Data were extracted from selected articles. Risk of bias was assessed in articles.

Results: A total of 77 articles were found, from which, 10 met the inclusion criteria. 5 articles had assessed stability and none had reported instability. The effect of MSDO on temporomandibular joint was evaluated in all of the included studies, all of them stating that MSDO would not cause permanent changes in temporomandibular joint status. Gingivitis, root injury, mobility, pseudo-pocket and irresponsiveness to cold stimulus were reported in 6 studies. Risk of bias was assessed to be high in the included studies.

Conclusion: Within the limits of this review it is concluded that MSDO would be a stable procedure and it may not cause temporomandibular joint disorder, provided that proper technique is used. Risk of injury to tooth is not so common; however, great care should be taken in order to prevent these injuries. Well-designed randomized clinical trials are highly recommended to clarify these issues.

Keywords: Distraction osteogenesis; temporomandibular joint disorder; orthodontics; mandible.

ABBREVIATIONS

MSDO: Mandibular symphyseal distraction osteogenesis; TMJ: Temporomandibular joint; TMD: Temporomandibular joint disorder.

1. INTRODUCTION

Transverse deficiency of mandibular symphysis, leading to incisor crowding, functional and esthetic concerns, has been always a challenging problem in orthodontics [1]. Many orthodontists have attempted by different methods to expand mandibular arch, including Schwarz plate, adjustable lingual arches, arch wires, and conventional surgical methods. However, limited amount of arch expansion, inevitably adverse effects on periodontal health and questionable long term stability of these methods had given rise to uncertainty over the applicability of mandibular arch expansion [1,2].

Adaptation of distraction osteogenesis (DO) methods to craniofacial surgery has opened new horizon in mandibular arch expansion. Considering the recent concepts regarding the effect of functional matrix and soft tissue on the stability of treatment, it seems sound that DO may prove to be a remarkable help in cases with high susceptibility to post treatment relapse. Mandibular symphyseal distraction osteogenesis (MSDO) would be the treatment of choice in cases with mandibular transverse deficiency. Various authors have proposed MSDO as a reliable technique which may show stable results

on long term follow-ups [3]. Although the theory is convincing, some clinicians have debated over the long term stability. In theory, MSDO would change the position of condyles in relation to cranium and some authors have made questions regarding the effect of MSDO on temporomandibular joint (TMJ) [4]. In addition, periodontal condition of incisors would be affected by the procedure as well [5].

The aim of present study is to review available data regarding long term stability and adverse effects of MSDO on TMJ and health of teeth and periodontium.

2. MATERIALS AND METHODS

2.1 Search Strategy

A literature survey was carried out through the online medical databases including Medline (Entrez PubMed, <http://www.ncbi.nlm.nih.gov>), EMBASE and CENTRAL for finding articles published from 1 January 1966 to March 2014. The free text words and heading sequence of the keywords used for electronic searching include: "symphyseal distraction osteogenesis" OR "mandibular midline distraction osteogenesis" OR "transmandibular distraction osteogenesis" OR "mandibular widening" AND "stability" OR

"temporomandibular joint disorder" OR "disk displacement" OR "periodontium" OR "root injury". There were not any MeSH words for this concept.

2.2 Study Selection

Inclusion criteria include: (1) clinical studies and case series, (2) English articles, (3) tooth borne, bone borne or hybrid distractor,(4) follow up period of one year or more for assessing stability, however, studies with less than 1 year period were included for evaluating TMJ and periodontium status. Exclusion criteria were: (1) review article, case reports, and letters, (2) samples with syndromic problems or mandibular cleft, (3) simultaneous other surgical procedures in mandible (for assessing stability and effect on TMJ). After considering the inclusion and exclusion criteria, finally two researchers (SS and FY) analyzed the full-text version of all included studies independently, and the studies were catalogued on the basis of the type of distractors.

2.3 Study Question

Primary outcome measurement was to assess the long term stability of mandibular symphyseal distraction osteogenesis. Parameters such as intercanine, intermolar, inter-symphyseal and inter-condylar width were used for outcome measurement.

Secondary outcome measurements were to evaluate adverse effects of mandibular symphyseal distraction osteogenesis on temporomandibular joint (assessed by TMD symptoms such as pain, joint sounds, and limitation in movement, and changes in biconcylar width), periodontal health and teeth (such as changes in the amount of attached gingiva, mobility, pocket depth, tooth vitality, gingival health, attachment level, responsiveness to cold stimulus and root injury).

2.4 Data extraction

Data extraction forms were used for data collection. The relevant data were extracted from each article by one author and rechecked by the second author. Bibliographic data of articles were eliminated and a number was assigned to each article. Inter-examiner disagreements were resolved by consensus. Number of samples, distractor type, follow-up period, stability, TMJ

condition, periodontium and tooth status were extracted from articles.

2.5 Assessment of Risk of Bias

Risk of bias was assessed according to AHRQ guidance for case series studies and was reported separately as selection, performance, detection, attrition and reporting bias. Selection bias is systematic differences caused by self-selection of treatment or treatment choice according to characteristics of patients. For case series, addressing important confounding and modifying variables would lead to low bias.

Systematic differences in care and protocol conducted on participants would cause performance bias. Low bias studies can prove that simultaneous interventions and unintended exposures and variations from the study protocol would not have an impact on the results of the study.

Differences in outcome assessment among participants would cause detection bias. Blindness of outcome assessor regarding intervention status of the participants and reliability and validity of inclusion/exclusion criteria, intervention/ exposure, primary outcome and confounding variables would determine detection bias.

Attrition bias is caused by withdrawal from the study. Differences in group characteristics between baseline and follow-up, caused by attrition, may lead to high attrition bias. Reporting bias is defined as systematic differences between reported and unreported results. In fact, significant differences between groups are more likely to be reported, hence, causing reporting bias. In low bias studies, researchers pre-specify the potential outcome and report all specified outcome.

Each included article is evaluated independently by each reviewer. The reviewers apply (√) sign for high risk, (-) sign for low risk of bias.

3. RESULTS

A total of 77 articles were found. All of the articles were assessed for more details. Finally, 10 articles met the inclusion criteria. The details of study selection process are summarized in Fig. 1. Due to great heterogeneity between studies, it was not possible to perform meta-

analysis. Characteristics and results of selected articles are shown in Table 1.

Some articles had assessed more than one issue. So that, the number of articles which had evaluated stability, TMJ status and teeth and periodontium health were five [1,3,6,7,10], ten [1-10] and six [2,3,5,8-10], respectively.

3.1 Long Term stability of MSDO

5 articles had assessed post treatment stability, of which none had observed post treatment relapse [1,3,6,7,10] Gunbay et al. [10] reported that the results of MSDO were stable during their 3 years follow up period. They did not report the exact amount of skeletal and dental changes which were occurred during post-operation period, however they stated that relapse was not observed in none of their patients. According to Del Santo, transverse changes (neither skeletal, nor dental) were not significant in long term follow up [3]. King et al. and Iseri et al. observations were similar to those of Del Santo [1,3,6]. Nevertheless, the irregularity index increased in post-retention period and mild to moderate crowding was reported in King's patients [1].

3.2 Effect of MSDO on TMJ

All of the included studies had addressed TMJ status. In none of the articles, MSDO caused permanent TMD (temporomandibular joint disorder) symptoms [1-10]. Braun et al stated that during MSDO the condyles displace laterally but TMJ was adaptive to these changes and TMD was not developed in none of their patients [4]. In Gunbay et al study, 3 patients experienced mild TMD symptoms during distraction period; however in all of them the symptoms were resolved. In the CT scans, it was observed that the procedure led to a distolateral rotation of 2.5° to 3° in condyles. Mean increase in bicondylar width was 0.35 mm. In a follow up period of 1 year, no signs of disk displacement were seen in CT scans and no TMD symptom was reported [10].

Del Santo et al. Iseri et al. and Malkoc et al. did not address TMD symptoms directly but bicondylar width as a measure of TMJ status, did not show any significant changes [3-7]. In Iseri and Malkoc articles a significant decrease in bicondylar width during distraction and consolidation phase was followed by a significant increase during follow-up period, leading to an

insignificant change in the parameter from pre-operative to post-follow-up period [6,7]. In Del Santo study, the direction of changes was reverse but the final result was the same: "stable bicondylar width" [3].

In Kewitt et al. [2] study, 7 patients had TMJ symptoms preoperatively. Of them, 5 patients reported an improvement in TMD symptoms with 3 of them reporting complete resolution of the problem. In 2 patients with previous click and pop, MSDO caused no change, while in 1 patient with the same symptoms, post-operative pain in TMJ was observed. In one patient with severe TMJ problem preoperatively, closed lock was occurred. All of the TMJ problems were resolved and no permanent TMD symptoms were observed neither in patients with previous TMD nor in healthy patients.

Landes et al. [8] excluded TMD patients from their study and find out that by precise planning, MSDO may decrease bicondylar distance whereas condyle position and angulation relative to the fossa remained unchanged.

According to Mommaerts et al. [5] although in few cases osteodistracted was greater at coronal level, no TMJ problem was developed. In another study, Mommaerts et al. [9] reported that one patient experienced TMD but it was resolved by physiotherapy.

Some patients in these studies experienced TMD during MSDO; however none of the symptoms were persistent. In patients with previous history of TMD it seems that MSDO does not affect the situation since during DO symptoms were disappeared in some patients but continued in the others which is not surprising with the fluctuating nature of TMJ problems.

3.3 Effect of MSDO on Teeth

6 articles had evaluated the effect of MSDO on tooth and periodontium [2,3,5,8-10]. Gingivitis was observed in some of the patients during activation phase [10]. However, it seems that MSDO may not jeopardize tooth or periodontium, provided that great care is taken to avoid root damage during osteotomy [2,3,5,8-10]. In Gunbay et al study, vertical osteotomy caused damage to the central incisors in one patient. Chronic gingivitis was observed in all of their patients around activation rods, which was attributed to poor oral hygiene [10]. Del Santo et al reported that gingival status seemed normal in

long term follow up [3]. According to Kewit et al, MSDO did not lead to gingival recession, crestal bone loss or a decrease in the amount of attached gingiva. A pocket of 4mm and root blunting was seen in one patient. CI II mobility was seen in 2 teeth and in 3 patients incisors became nonvital [2]. Mommaerts et al observed that mean pocket depth increased during consolidation period but returned to normal during 1 year follow up. In addition, they observed that lower anterior teeth showed increased mobility. Canines and lateral incisors became mobile during consolidation phase, whereas central incisors mobility increased during distraction phase. Some teeth were unresponsive to cold stimulus during and after treatment. However, all but except one became responsive after 1 year. Root injury was seen in one tooth [5] in another study, Mommaerts et al. [9] reported necrotizing gingivitis, root injury and loss of vitality in their patients.

3.4 Assessment of Risk of Bias

All of the included articles were case series. The quality score of all the aforementioned case series were assigned as low level mostly due to lack of application of valid measurement methods and absence of blinding, case controls. The result of risk of bias assessment is shown in Table 2.

4. DISCUSSION

4.1 Long-term Stability

The hypothesis regarding MSDO stability addresses its effect on basal bone and soft tissue envelope, thus explaining its stability. In theory, DO stretch soft tissue envelope, bringing an opportunity for more stability. Although most of the studies have reported stability, it is difficult to draw a clear conclusion.

As we know, structure beyond mandibular body and its soft tissue coverage, including pressure from tongue and peri-oral muscles play a crucial role in stability of lower incisors [11,12,13]. There is not sufficient data regarding the effect of MSDO on these structures, so that further studies may contradict previous data.

Distractor type can be an important consideration in this regard. Bone borne distractors cause a proportional movement of segments, while tooth borne distractors, and to some extent hybrid

distractors, create disproportional gap, which is not supported by basal bone. It is believed that this may represent a risk of relapse [3].

It seems that definition of stability among studies lacks a common state. Does a stable surgical procedure means occurrence of no changes in mandibular width in different planes? Or having a well aligned arch in post-retention period means stability? King et al study is a good example. They observed no significant differences in skeletal and dental dimension during post-retention period, meanwhile, irregularity index increased during the same phase [1].

Another challenge in this field is that it is not clear that how many years should be passed to, by certainty, call a procedure stable. Most of the included studies have less than 5 year follow-up studies. Interestingly, the above mentioned article by King et al. [1] is the only one which recruited patients 7.5 years later, which can explain their somehow different results compared with other articles.

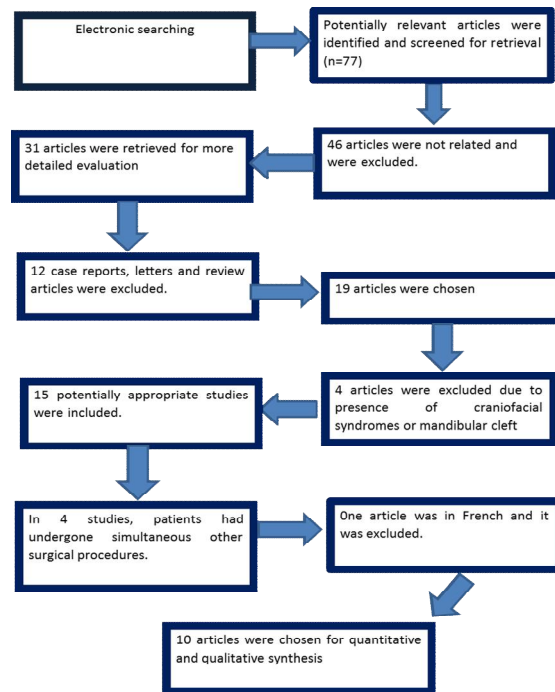


Fig. 1. Summary of study selection process

These inherited shortcomings in studies which are assessing stability and multifactorial, and somehow unknown, nature of the relapse, raise questions regarding applicability of results extracted from previous studies.

Table 1. Characteristics and results of included studies

Study/ year	Number of samples	Type of distractor/ follow-up period	TMJ*	Stability	Tooth and Periodontal health
1 Kewitt GF 1999 [2]	15	Tooth borne/ Mean 24 months	No TMD** reported.	Not mentioned	*No decrease in amount of attached gingiva *No recession *A pocket of 4mm in 1 patient *2 teeth became nonvital. *CI II mobility in 2 patients
2 Del Santo M Jr 2000 [3]	20	Tooth borne/ 1 year and 3 months	Increase in bicondylar width was not significant.	Stable Post <i>MSDO</i> *** intercanine width: 33.5±3.7 mm, and at follow up: 33.8±2.8 mm Post <i>MSDO</i> intermolar width: 64.9±4.0 mm, and at follow-up: 64.4±3 mm	The gingival tissue seemed normal clinically.
3 Braun S 2002 [4]	12	10-Tooth borne 2-Bone borne/ not mentioned	No TMD reported.	Not mentioned	Not mentioned
4 Iseri H 2005 [6]	20	Hybrid distractor/ Mean 21 months	*Bicondylar width was decreased during distraction and consolidation period but it was increased in follow up period.	Stable Post <i>MSDO</i> intersymphyseal implant distance 18.67±3.37 mm and at follow-up 17.95±3.85 mm Post <i>MSDO</i> bimolar width 67.73±4.34 mm, and at follow-up: 67.83±3.96 mm	Not mentioned
5 Mommearts MY 2005 [5]	12	Bone borne/ 1 year	No TMD reported.	Not mentioned	*Mean pocket depth was increased during consolidation period but returned to normal during follow up period. *Mobility increased. *No response to cold test *Root injury in one tooth.
6 Malkoc S 2006 [7]	20	Hybrid distractor/ Mean 24 months	*Bicondylar width was significantly decreased during distraction period while it increased in follow up period.	Stable Post <i>MSDO</i> intercanine width: 31.2±2.1 mm, and at follow-up: 28.7±1.5 mm	Not mentioned

Study/ year	Number of samples	Type of distractor/ follow-up period	TMJ*	Stability	Tooth and Periodontal health	
				Post <i>MSDO</i> intermolar width 45.9±3.4 mm, and at follow-up 46.3±3.3 mm		
7	Landes CA 2008 [8]	9	Bone borne/ 3 months	*No TMD observed	Not mentioned	*No major vertical loss in attachment level.
8	Mommaerts MY 2008 [9]	23	Bone borne/ 1 year	1 patient with TMD which was resolved.	Not mentioned	*1 case of necrotizing gingivitis. *1 case of root damage. *1 tooth became nonvital.
9	Gunbay T 2009 [10]	7	Bone borne/ 3 years	*No permanent changes *3 patients with mild TMD during distraction period.	Stable	*In 1 patient, damage to central incisor during osteotomy *Chronic gingivitis around the activation rod in all patients.
10	King JW 2012 [1]	16	Hybrid distractor/7.5 years	*1 patient experienced transient TMJ clicking which was dissipated by occlusal adjustment. *Increase in bicondylar width was insignificant	Stable Post <i>MSDO</i> intercanine width: 33.43±1.07, follow-up 34.42±1.19 Post <i>MSDO</i> bicondylar width 127.79±4.60 mm, and at follow-up: 126.66±6.08 mm	Not mentioned

*TMJ: temporomandibular joint; **TMD: temporomandibular joint disorder; ***MSDO: mandibular symphyseal distraction osteogenesis

Table 2. Assessment of risk of bias in selected articles

Study	Selection bias	Performance bias	Detection bias	Attrition bias	Reporting bias
Kewitt GF 1999 [2]	✓	✓	✓	✓	-
Del Santo M Jr 2000 [3]	✓	✓	-	-	✓
Braun S 2002 [4]	✓	✓	✓	-	-
Iseri H 2005 [6]	✓	✓	-	-	-
Mommearts MY 2005 [5]	✓	✓	✓	✓	-
Malkoc S 2006 [7]	✓	✓	✓	-	-
Landes CA 2008 [8]	✓	✓	✓	-	-
Mommaerts MY 2008 [9]	✓	✓	✓	-	-
Gunbay T 2009 [10]	✓	✓	✓	-	-
King JW 2012 [1]	✓	✓	✓	✓	-

✓ signifies High risk, - signifies low risk

4.2 Effect of MSDO on TMJ

Since the introduction of MSDO, some clinicians questioned the effect of it on TMJ. The problem is that, when widening the mandible in anterior portion, position and orientation of condyles may change, predisposing the patient to TMD. Some authors had debated existence of these changes and some had stated that TMJ is adaptable to these displacements.

Considering the 3 dimensional shape of the mandible, widening in anterior portion would cause various changes in condylar area. Weil et al. [14] had introduced a geometric model, indicated the axis of rotation in a point 4 mm to the center of condyle. This means that in MSDO each half would rotate around this axis. In a computer model, Samchukov et al. [15] presented that 0.34° of condyle rotation occurs for each 1mm of mandibular widening, and subsequently, this can produce overloading on articular surface and initiation of degenerative changes. They proposed condylectomy or incorporation of a hing in distraction appliance for compensation. In an animal study, Harper et al observed the creation of histologic changes in the fibrous and cartilaginous layer and at cartilage-bone interface of monkey's joint, which its severity was correlated with rotational forces at posterolateral and anteromedial surfaces [16]. However, none of the articles included in this review present permanent changes in TMJ or persisted symptoms of TMD [1,2,4,5,8-10]. These may be related to the adaptability of the

joint and also, biological differences between real specimen and computer models and also between human joint and monkey joint.

The results of studies regarding the direction and amount of joint displacement were different among studies. In Braun et al study, condyles displaced laterally in a linear pattern in proportion to the amount of distraction. These observation were seen both in tooth-borne and bone-borne distracters [4].

In Del-Santo study, tooth-borne distractors caused an insignificant increase in bicondylar width (0.7mm±1.8); however, after the follow up period, bicondylar width decreased insignificantly (0.2mm±3.1), making the overall changes from pre-treatment to follow up period insignificantly [3]. Hybrid distractors in Iseri et al. and Malkoc et al. [6,7] studies caused changes reverse of those seen by Del-Santo; however, similar to Del-Santo study, overall changes in bicondylar width were insignificant.

Gunbay et al. [10] reported that bone-borne distractors increased bicondylar width by 0.35 mm. In addition, 2.5 to 3° of distolateral rotation occurred in condyles. King et al reported continuous decrease in bicondylar width from pre-treatment to follow up period in samples with hybrid distractors. However, the changes were not statistically significant [1]. In Landes study with bone borne distractors, bicondylar width decreased by 1±0.1mm and condylar angulation to midline was declined by 0.28±4.34° with

0.007° of condylar rotation per millimeter distraction [8].

These differences may be caused by differences in mandibular shape and size, muscle and soft tissue attachment, and device placement [8].

In a systematic review, Gijt et al. [17] claimed that rigidity of distractor is a crucial factor in determining parallelism of segments. Mommaerts et al stated that bone borne devices with low axial rigidity decrease condyle lateral displacement [5]. This observation was confirmed by Gunbay et al. [10]. Gijt review concluded that rigid bone borne and hybrid distractors cause medially displaced condyle while tooth borne distractors displaced condyles laterally [17]. Considering the geometry of mandibular bone and distractor placement, it appears that tooth borne distractors apply force from a point nearer to the condyles, thus changing the direction and amount of condyle movement. It seems that in most of the studies, the changes were reversible and condyles return to their original position in follow up period [1,3,6,7].

At last it worth emphasizing that TMD is a multifactorial problem which may occur as a result of physical changes in the joint, as well as some other related problems, including occlusal changes. In MSDO patients TMD may occur or even resolve as a result of many causes: condyle lateral displacement, condyle rotation, muscle and tendon stretches, disk displacement, and occlusal changes. Most of the articles have addressed TMD symptoms; however, none has used any defined index or classification for it. TMD patients were excluded from the samples in some of the articles [8], eliminating the people who may have the least adaption capability. Also, changes in occlusal pattern were not assessed during DO phase which can be a transitory phase with many occlusal interferences. It can be understood from the studies that TMD incidence in normal population without previous TMD, is low and temporary. However, still it seems sensible to be cautious in doing the procedure in TMD patients with little adaptability to new environment.

4.3 Effect of MSDO on Teeth

4.3.1 Injury to roots and loss of vitality

In 3 studies root injury was reported (3 teeth) [5,9,10]. Interestingly, all of them had used bone-

borne distractors. In spite of the fact that placing bone borne distractors dictates more preparation in bone, these studies had mentioned that iatrogenic injury to root was happened during vertical osteotomy [5,9,10]. However, since these distractors and also hybrid ones are fixed with screws on the bone, it seems logical that root injury is somehow more possible. It has been suggested that by creating a diastema between central incisors during pre-surgical orthodontics the risk of injury to roots would be minimized [18]; however, achieving this goal in a crowded arch without extraction would be quite difficult. Mommaert et al. [9] proposed a method of step osteotomy in which midline osteotomy below the roots of teeth connects to an interdental osteotomy in a site where there is a natural diastema between roots.

In Kewit et al. [2] and Mommaert et al. [9] (3 teeth) studies loss of tooth vitality was reported Mommaert et al. [9] attributed the problem to contusion and Kewit stated that surgical trauma and also recent orthodontic treatment may be the cause [2].

Irresponsiveness of some teeth to cold stimulation in Mommaerts study was explained by the authors as a cause of migration and apical contusion [5].

4.3.2 Periodontal and gingival problems

Gingival inflammation was reported by Gunbay et al. [10] which was attributed to poor oral hygiene in presence of distractors. Mommaerts et al. observed a case of necrotizing gingivitis which was treated by mouth rinses that consisted PerioGard and H₂O₂ solutions. 9 Both of these articles had used bone borne devices [9,10]. Due to the place of distractors it seems that bone borne devices increase the potential of soft tissue irritation. This result is in agreement with those of Gijt in their systematic review [17].

Some authors had debated the effect of tooth borne devices on extreme tipping of teeth. One may assume that this tipping may cause gingival recession. However, Kewit et al. [2] reported that none of their patients with tooth borne distractors had gingival recession and decrease in the amount of attached gingiva.

The overall incidence of periodontal disease was somehow low. Mommaerts et al. [5] observed pocket formation in central incisor and attributed this mainly to edematous gingival tissue rather than crestal bone loss and defined it as pseudo-

pockets. This was similar to Kewit et al. [2] observation who reported a 4mm pocket depth in one patient on distobuccal surface of lateral incisor which was due to inflamed tissue. Also, they mentioned that since lateral incisor is far from the osteotomy line this may be as a result of orthodontic treatment.

Increased mobility in Mommaerts study was seen in central incisors during distraction phase which was attributable to rapid migration into immature callus and also proximity of osteotomy to the PDL of these teeth [5]. The later is the reason which was justified by Kewit et al. [2] who observed that 2 patients had mobility of central incisors. Increased mobility of canine and lateral incisors in consolidation period of Mommaerts study was explained by occurrence of late migration and strain in transseptal fiber system [5].

4.4 Assessment of Risk of Bias

Since all of the included studies were case series, selection bias, performance bias and detection bias were quite high among the articles, while attrition bias and reporting bias were rather low. It seems that quality of available evidence regarding MSDO is low and any conclusion drawn from these studies should be interpreted with caution.

5. CONCLUSION

It seems that available data regarding MSDO is not enough and this review is completely based on available case series. Within the limits of this review, it appears that MSDO causes stable results; however, they do not lead to TMJ problems. Incidence of injury to teeth and potential of periodontal defects is not so much. Do the procedure is more stable than other available methods? Do we have long term effects regarding MSDO effect on TMJ? Presence of Randomized Clinical Trials with good study design is needed to clearly answer these questions.

CONSENT

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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