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Mandibular distraction osteogenesis: a systematic review of stability and the effects on hard and soft tissues

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Abstract. Mandibular distraction osteogenesis (MDO) has been widely adopted in modern maxillofacial surgery due to its less invasive approach and the consistent aesthetic and functional improvements obtained. The aim of the present systematic review was to analyze the available evidence on the skeletal and soft tissue effects of MDO. The medical literature was searched to identify all peer-reviewed papers meeting the selection criteria for the final review process. A three-point grading system was used to rate the methodological quality of the selected papers. The PICO approach was used to extract data from the selected papers. The search strategy yielded eight relevant publications. The quality of the collected evidence was low to moderate. Vertical and sagittal skeletal dimensions increased significantly, by a mean of 5–10 mm ($P < 0.05$). Regarding the sagittal positioning of the lips and surrounding structures, a 90% correspondence between skeletal and soft tissue cephalometric points was observed. Significant skeletal relapse was reported, however it did not worsen the results of treatment significantly.

Key words: mandibular distraction osteogenesis; orthognathic surgery; mandibular advancement; orthodontic class II.

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In recent years, new techniques have been adopted for the surgical treatment of class II patients. One such technique is mandibular distraction osteogenesis (MDO), which is a less invasive approach and is associated with consistent aesthetic and functional improvements.[1,2] MDO was first presented by Rosenthal in 1927, who performed the first mandibular distraction with a tooth-borne appliance that was gradually activated over a period of 1-month.[3] This technique was adopted due to the good results obtained in the treatment of syndromic patients with bone length discrepancies ranging from 15 to 50 mm. MDO was then also applied for the correction of significant orthognathic problems (e.g. skeletal class II discrepancies requiring less than 20 mm of mandibular advancement).[4]

According to modern orthodontic guidelines, the primary objective of orthognathic surgery has changed from the restoration of normal occlusion to the correction of frontal and profile aesthetics.[5,6] Thus, treatment planning starts from the newly defined endpoint of a patient's soft tissue profile, and the necessary dental and skeletal movements are derived from this. On the basis of the aesthetic paradigm, different segmental osteotomies are chosen by the surgeon to achieve the best aesthetic results.[5] An accurate prediction of the postoperative facial profile is also an essential step in the treatment planning process for combined surgical–orthodontic therapy.[5]

The aim of the present systematic review was to answer the following clinical research questions: (1) What are the skeletal effects of MDO, after surgery and after long-term follow-up? (2) What are the effects of MDO on the soft tissues, after surgery and after long-term follow-up? (3) To what degree do the skeletal and soft tissues relapse after MDO?

Materials and methods

The systematic review protocol was registered in PROSPERO (the International Prospective Register of Systematic Reviews, http://www.crd.york.ac.uk/PROSPERO/; CRD42015024635).

The available scientific literature was searched in May 2015 to identify all medical articles reporting the effects of MDO on the soft and hard tissues. The following search strategy was used and adapted to the principal medical databases (MEDLINE, Embase, Scopus, Cochrane Oral Health Group Trial Register and Cochrane Register of Controlled Trials, Web of Science, LILACs, SciELO, and Google Scholar): ((''MDO'' OR ''mandibular distraction osteogenesis'' OR ''orthognathic surgery'') AND ((skeletal OR hard tissue* OR soft tissue*) AND (profile OR relapse OR effect* OR stability))). A hand-search was performed in the authors' personal libraries and in the references of the studies included to identify additional papers.

The inclusion and exclusion criteria applied in this systematic review are reported in Table 1. Two of the authors (RR, BV) independently removed duplicate papers and selected the studies for final inclusion.

The data extraction was performed independently by two of the authors (GR, BV) using the PICO approach (Population, Intervention, Comparator, and Outcomes). For the purposes of this systematic review, the PICO format was modified adding the study design field (PICOS).[7] In the case of missing information on the characteristics of an included study, the authors of that study were contacted.

The primary outcome was the analysis of soft and hard tissue modifications occurring after MDO. The secondary outcomes were the stability of the treatment and other collateral factors (e.g., patient compliance, costs).

According to the CRD (Centre for Reviews and Dissemination, University of York, York, UK)[8] and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[9] statements, the evaluation of methodological quality gives an indication of the strength of evidence and of the risk of bias present in the study. However, no single approach for assessing the risk of bias best fits all systematic reviews.[9] A three-point grading system, described by the Swedish Council on Technology Assessment in Health Care (SBU) and the CRD, was used to rate the methodological quality of the selected papers; this was done by two authors (RR, BV) (Tables 2 and 3).[8,10]

Results

The search strategy yielded eight relevant publications.[11–18] One study was prospective and non-randomized[11] and seven studies were retrospective and non-randomized[12–18] (Table 4). The article selection process is illustrated in the PRISMA flow diagram given in Fig. 1.

The sample size of the individual studies ranged from 10 to 40 subjects, with a total of 181 subjects. Mean age at the start of treatment in the evaluated samples ranged from 7.7 to 29.8 years.

From a methodological point of view, the selected papers used different procedures to detect treatment effects: six studies used measurements on cephalometric tracings,[11–14,17,18] one study adopted computed tomography (CT),[16] and one study used panoramic and lateral cephalometric radiographs.[15]

Soft tissues parameters were analyzed in three studies,[11,14,17] while all the other papers focused on hard tissues.[12,13,15,16,18]

Quality analysis

According to the SBU tool,[10] the quality of the collected evidence was moderate (grade B) in four studies,[11,16–18] and low (grade C) in the other four.[12–15] Thus, conclusions with a limited level of evidence could be drawn from the review process. The most important sources of bias were the absence of information on randomization procedures, the lack of adequate blinding procedures, and method error analysis in all of the studies graded C. The quality grading of the selected papers is shown in Table 4.

Skeletal vertical dimension

Using panoramic radiographs, Aizenbud et al. (2010) recorded a mandibular modification of 12.03 mm for the right side and 10.87 mm for the left side ($P < 0.0001$).[15] At follow-up, a relapse of 2.04 mm on the mandibular right side was seen on panoramic radiographs ($P = 0.018$). On analysis of lateral X-rays, the right mandibular side height increased 10.43 mm and the left side increased 10.45 mm after treatment ($P < 0.0001$). A relapse of 1.22 mm was registered for the mandibular left side on cephalometric analysis ($P = 0.039$).

Breuning et al. reported the results of two studies in 2004; they observed significant changes in the palatal plane–mandibular plane angle (SpP/MP) after MDO (3.9°, $P < 0.001$).[12,13]

In 2012, Metzler et al. demonstrated an occlusal plane inclination of 1.9° ($P < 0.01$) together with a vertical bone loss of 3.5 mm ($P < 0.01$) after surgery.[16]

El-Bialy et al. (2013) reported a significant increase in mandibular plane angle immediately after MDO and at follow-up (T1–T2 5.3°, T1–T4 4.3°) ($P < 0.05$), while a relapse occurred after 8 years (T2–T4 −1.0°).[11] Furthermore, total anterior facial height (TAFH) and lower anterior facial height (LAFH) increased significantly after MDO and at follow-up (TAFH: T1–T2 5 mm, T1–T4 4.8 mm; LAFH (%): T1–T2 2.0, T1–T4 1.7; LAFH (ANS–Me) (mm): T1–T2 4.7, T1–T4 4.1).

Table 1. Selection criteria.

Inclusion criteria	Exclusion criteria
• Human clinical trials • Sample with at least 10 subjects • MDO with intra-oral distractors, and accepted genioplasty • Evaluation of immediate and/or long-term skeletal and/or soft tissue effects of MDO	• Syndromic or medically compromised patients • Case reports, case series of fewer than 10 patients, descriptive studies, review articles, opinion articles • Any surgical intervention other than MDO (i.e., Le Fort I, other types of mandibular surgery, etc.)

MDO, mandibular distraction osteogenesis.