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Mandibular sagittal split osteotomy vs mandibular distraction osteogenesis in treatment of non-syndromic skeletal class II patients

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ABSTRACT

Introduction: Mandibular retrognathia is a common skeletal congenital dysgnathia. In many cases of skeletal class II patients require the surgical operation. Orthognatic surgery offers mandibular bilateral sagittal split osteotomy (BSSO) as the most common procedure to make the advancement of the mandible. However, the alternative, mandibular distraction osteogenesis (MDO), is prevalent nowadays and beneficial in particular cases.

Aim: The purpose of this study is to show the effect of MDO and BSSO done on 20 patients at Specialist Children's Hospital in Olsztyn, Poland between 2011 and 2013, performed by the same surgeon – KD. Authors would like to present the details of treatment planning and management of these methods as well as the protocol of usage of the distraction device.

Material and methods: The sample consisted of 74 lateral cephalometric X-rays. Criteria for cephalometric comparison were angular cephalometric variables: SNB and SN/GoGn (Steiner analysis). The criteria for inclusion into this study were as follows: males and females with skeletal class II pattern plus dentofacial and dental abnormalities like skeletal open bite. The mean age of the subjects was 17.9 years.

Results and discussion: Our comparison study showed that there was no statistically significant difference between results of BSSO postoperatively and MDO post-distraction. However, there is a need of long-term data on stability of both methods.

Conclusions: Study shows that MDO may offer another option for treatment of skeletal class II malocclusions in growing patients and after growth spurt.

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1. Introduction

Skeletal class II pattern is mostly characterized by skeletal malformation of mandible which is small or retruded.[1–3] In skeletal class II there are various types of corrective surgical approaches: maxillary set back, segmental osteotomy of maxilla with extraction of maxillary premolars, mandibular advancement, bilateral sagittal split osteotomy (BSSO), genioplasty and mandibular distraction osteogenesis (MDO). The most common orthognatic surgical procedure to treat class II dento-skeletal deformities is BSSO with or without genioplasty.[1,4,5]

BSSO is performed to make the advancement of the mandible and maintains its popularity because of its versatility. At Maxillo-Facial Clinic the maxillofacial surgeon performs BSSO with Epker modification. The major advantage of BSSO is stable and predictable procedure for advancements of less than 6 mm in patients with low or normal mandibular plane angle.[4–6] Costs of operation are much smaller than MDO. Stable rigid fixation techniques (miniplates and screws instead of wires) improve the skeletal stability of BSSO and in consequence minimize the relapse.[1,5] One of the most predictable limitations of BSSO is the risk of relapse in cases with high mandibular plane angle and when used for larger advancements of more than 7–10 mm due to the inability of the muscles to be acutely stretched.[4,7] It is reported that relapse occurs in up to 30% of BSSO cases (an average of 2 mm).[1,2] For greater advancements bone grafting is needed. Another major concern of BSSO is represented by neurosensory disturbances (NSD) and possible inferior alveolar nerve (IAN) damage.[1] Incidence of NSD of IAN ranges from 9.0% to 84.6% objectively and 100% subjectively in the first week after operation to 0%–87% at one year after surgery.[1] Occasionally BSSO causes temporomandibular joint (TMJ) damage – remodeling, resorption of the condyle of mandible or progressive condylar resorption (PCR)[5,6,8] due to striping of periosteum and musculature off the proximal segment, what decreases its vascularity.[9] Lateral flaring of the proximal segment of mandible leads to lateral shift of the mandibular condyle, causing its lateral torque. A common operative complication represents unfavorable fractures, known as 'bad splits', occurring in 0.5%–5.0% cases, for example when third molars are extracted.[10] Indications to perform BSSO are: patients after growth spurt with maxillomandibular hypoplasia, facial asymmetry, congenital micrognathia and skeletal class II cases.

The technique of MDO became a prevalent surgical treatment of retrognathia and mandibular asymmetry.[1,11] It has a history of more than 100 years; Ilizarov developed main concepts in the animal experiments in 1952, but in maxillofacial surgery MDO was used for the first time in 1992 by McCarthy for bony expansion in patients with complex skeletal abnormalities like hemifacial microsomia and Nager's syndrom.[12] MDO is a surgical-orthopedic method for bone lengthening based on a new bone formation between two bones in the osteotomy site stimulated by gradual traction, parallel to the vector of distraction.[11,13–15] The traction generates tension within the callus, forming the reparative callus/bone. Bone regenerate consists of three zones: two zones of mineralization and fibrous interzone with collagen bundles.[16] Gradual forces made by two bones pulled by screw-driven appliance stimulate proliferation of the osteoblast precursor cell population in the center of the distraction gap. Differentiation and recruitment of osteogenic cells at the host bone margins causes new osteoid deposition and mineralization,[14–17] forming the bone of woven type. Additionally, the process of bone distraction has an impact on surrounding tissues (skin, fascia, blood vessels, nerves, muscle, ligament, cartilage, and periosteum) initiating a sequence of adaptive changes called distraction histogenesis.[14]

Distraction appliances can be classified into: extraoral (unidirectional, bidirectional, multidirectional) and intraoral (tooth-borne, bone-borne, hybrid).[18]

Advantages of MDO method are: long-term stability of the final effect of treatment due to osteogenesis and histogenesis, inducing soft-tissue adaptation and minimizing the relapse.[5,19] The possible advancement of mandible is high due to gradual amount of bone formation during an active phase, even 20 mm.[1,4] Further, the site of osteotomy is placed behind lower second molars, distally to the pterygo-masseteric muscular sling what prevents from IAN damage and provide a safe procedure.[6] Additionally, no bone graft is needed and less periosteal stripping occurs in comparison with BSSO method.[8,14] MDO can be performed at any age, including young children.[7] MDO is considered to reduce the incidence of IAN dysesthesia.

The main disadvantage represents high costs of distraction devices.[13] Moreover, MDO treatment requires two operations: to apply the appliance and to remove it. The device may cause patient discomfort during treatment and shortly after operation, for example: sounds at TMJ, muscle tenderness and difficulty in jaw opening. Furthermore, MDO without a proper device orientation can develop an occlusal impairments like open bite and asymmetries.[19,20]

Indications to use MDO method are: growing patients and after growth spurt with severe malocclusions – non-syndromic mandibular retrognathia, maxillofacial syndromes, congenital diseases, dyzostozes (e.g., Pierre Robin, Treacher Collins, Goldenhar syndrome) or congenital micrognathia. MDO is commonly used to treat obstruction sleep apnea in newborns, rarely adults.[21] Major contraindications represent: children under six years of age, osteoporosis, allergy to metals, oncological treatment and patient's mental disorders.

It is stated that postoperative neurosensory disturbances and condylar resorption was reported in BSSO and MDO groups and differences were not significant.[1,22]

2. Aim

The aim of our study is to assess the postoperative results of two methods of treatment: MDO and BSSO by means of cephalometric analysis regarding 20 patients, who undergone the procedures at Specialist Children's Hospital in Olsztyn, Poland between 2011 and 2013.

3. Material and methods

The reliability test (paired Student *t*-test with a significance level of $P < 0.05$) and error analysis test (Dahlberg formula)

from the two sets of measurements were performed. The error of measurements represented no clinical value.

The sample consisted of 74 lateral cephalometric X-rays. The mean age of subjects was 17.9 years (MDO 17.14; BSSO 19.85). Criteria for cephalometric comparison were angular and linear cephalometric variables: SNB and SN/GoGn (Steiner analysis). The criteria for inclusion into this study were as follows: males and females with skeletal class II pattern plus dentofacial and dental abnormalities like skeletal open bite.

All radiographs were traced by the same examiner twice using LightningCeph software. In both groups cephalograms were taken: (1) preoperatively, (2) postoperatively, (3) post-distraction, (4) post genioplasty, and (5) follow-up: one year after operation.

3.1. *Clinical protocol*

(1) Patient qualification

Maxillofacial surgeon in cooperation with specialists qualified the patient to operation. Tasks to consider were: the patient's age, severity of defects, potential increase in bone, esthetic and functional goals, secondary deformities and the mental state of the patient.

Clinical preparation involved medical records like face images, tomographic images, craniofacial 3D photos, dental models in the articulator, stereolithographic 3D models.

(2) Clinical protocol before surgery BSSO/MDO

Orthodontic phase included fixed appliance therapy (leveling, alignment, decompensation, and correction of curve of Spee). Patients with TMJ disorders were required to undergo splint and physical therapy.

(3) Surgical procedure of BSSO

Patient was prepared anesthesiologically. The intraoral vestibular incision from premolars to the area behind molars was made. The muco-periosteal flaps were prepared, exposing mandibular trunk and the ramus laterally. Later, the coronoid process and the medial site of mandible were dissected. The entrance of IAN was reached. Then, the sagittal osteotomy was performed. The mandible was fixed to maxilla with intraoral maxillary fixation: titanium screws – intermaxillary fixation (IMF) and elastics. The mandibular condyle was firmly seated centrally in the glenoid fossa. Separated mandibular fragments were fixed with miniplates (Synthez) and screws. The wound was closed and sutured. The procedure was repeated on the on the other side of the mandible.

(4) Surgical procedure of positioning distractors (MDO)

The sequence of presurgical preparation was identical like in BSSO method. Bilaterally vestibular incision and muco-periosteal flaps were prepared, exposing mandibular trunk and the ramus. Then, the horizontal corticotomy behind second molars was made. The distractor was placed at the alveolar ridge and fixed with screws. Then the appliance was removed, and sagittal split osteotomy was performed. After the exploration of the continuity of the IAN, irregular fragments of bone were trimmed with burs. Then, the mono-directional distractor (Zurich Pediatric Ramus Distractor, KLS Martin, LP, Tuttlingen, Germany) was firmly fixed to the bone with miniplates (Synthes) and screws. The activation of the device was performed. The wound was closed and sutured. The IMF was removed and the control of proper mandibular movements in mandibular fossa was accomplished.

(5) After the surgery

BSSO: 6–8 weeks of maxillomandibular fixation (MMF) postoperatively was required. Physiotherapy of the operation site was introduced to patient: biostimulation, Bioptron light therapy and laserotherapy during the hospitalization and later for 4 weeks. Postoperative diet for 6 weeks required and absence from work.

MDO: Latency phase of 5–7 day (maximum 10 days) was preferable. Then an active phase started by activating the device twice a day at the rate of 1 mm per 24 h. An active phase lasted until the slight class III overcorrection was obtained – it took usually 2–3 weeks. Consolidation phase was followed by an active phase and lasted 8–12 weeks. Orthodontic appointments after surgery included regular check-ups of guiding elastics, if needed. Treatment started 3–6 months after surgery: finishing phase in order to set the occlusion and start the retention phase. Additional procedure like genioplasty was performed in the moment of distraction device removal. Postoperative diet required for 8–10 weeks and absence from work.

4. Results

Results of this study showed that there was no statistically significant difference between the postoperative results of both methods regarding SNB angle ($P > 0.05$; $P = 0.10738$), but the increase of SNB in every group was statistically significant ($P < 0.05$): in BSSO group $P = 0.04292$ and in MDO group $P = 0.12387$.

Due to severe type of malocclusion of patients, the one-year follow-up results show the improvement of SNB angle in BSSO group (3.4°) and MDO (2.62°), respectively. One-year follow-up shows relapse in 30% of BSSO patients by an average of 0.13° and 50% of MDO patients by an average of 0.68°.

5. Discussion

SNB angle determines whether mandible is protrusive or recessive in relation to cranial base. The mean SNB reading is 80° with a range of 2°.[23] With regard to our BSSO patients the mean value of SNB before treatment was 73.6° (ranged from 68.9° to 78.05°) and according MDO patients was 77.0° (ranged from 72.7° to 80.0°), what indicates the severity of malocclusion.

Post-treatment measurements of BSSO and MDO show that in every case the SNB increased markedly and many reports show the same inference.[1,4–7,9,18,21,24,25]

One year after operation 30% of BSSO individuals showed skeletal relapse – SNB decreased by an average of 1.43° (mean value). Such skeletal relapse was reported in many studies. Ow et al. stated that all eight BSSO patients had the relapse of 20.3% in 1-year follow-up. Baas et al. reported 0.81° relapse in BSSO group 7 years postoperatively.

With regard to MDO patients, in three cases (37.5%) the skeletal relapse was noted: by an average of 1.35° of SNB angle one year after removal of the distractor. However, three cases showed an increase of SNB of 0.92° (mean value). Comparing with the literature, El-Bialy et al. observed an increase of SNB by 0.5° in the 8-year follow-up.[18]

For example, Koide et al. reported the 1° decrease of SNB in the MDO case report in a 10-year follow-up.[17] Takahashi reported the relapse in MDO case-report of 3.8° after 2-year follow-up[26] in his case report. Baas et al. showed the average of 0.6° decrease at B point in MDO group from 35 patients in 7-year follow-up.[4] van Strijen described 22% relapse in MDO subjects, mostly with high mandibular plane angle.[25]

In this study five out of twelve BSSO patients represented increased facial height what is considered as a major factor contributing to a skeletal relapse after BSSO,[3,6,7] but three of them expressed increased SNB after 12 months in comparison to postoperative X-rays by an average of 1.4°. One of them had an additional genioplasty, what enhanced the mineralization on the frontal bone surfaces adjacent to the osteotomy up to a high of about 1.6 cm above the osteotomy, forming a new bone in the region of B point, similar to the case report which described by Triaca.[27]

Results of this study showed that there was no statistically significant difference between the postoperative results of both methods regarding SNB angle. Vos et al. reported the same conclusion, that there was no significant difference in relapse between BSSO and MDO 10–49 months after mandibular advancement.[3]

6. Conclusions

Study shows that MDO may offer another option for treatment of skeletal class II malocclusions in growing patients and after growth spurt. The advantages of MDO over the BSSO method were described. Safe application of forces, shorter treatment time and gradual loading of TMJ (preventing from the condyle resorption) made MDO attractive and the ''method from choice'' in actively growing individuals and after the growth spurt. However, the type of method (BSSO or MDO) and the result of treatment depend on age, gender, severity of the malocclusion and expected individual response to them.

Conflict of interest

None declared.

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