Role of Different Rigid Fixation in Stability after Bilateral Sagittal Split Osteotomy Advancement Surgery: A Systematic Review

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Abstract

Bilateral sagittal split osteotomy (BSSO) for mandibular advancement is the treatment option for mandibular retrognathia. Major concern in the surgical correction of skeletal class II is postsurgical relapse. The etiology of relapse is multifactorial, involving the proper seating of condyles, the amount of advancement, the soft tissue and muscles, the mandibular plane angle, the remaining growth and remodeling. Through the use of the modern metal plates and screws after osteotomy, the stability can be already achieved in a technique so-called "rigid internal fixation" (RIF), without using "intermaxillary fixation" (IMF). RIF methods contribute to postoperative bone healing and masticatory function. Furthermore, using RIF method, instead of intermaxillary rigid fixation, can initiate the early improvement of oral hygiene. Usually bicortical bone fixation screw or miniplates with monocortical bone fixation screw were used to gain stability after BSSO. On the other hand, the use of resorbable screw materials had been reported. Here we presented a systematic review on Role of different rigid fixation in stability after bilateral sagittal split osteotomy advancement surgery and concluded that bicortical screws (stainless steel, titanium, bioresorbable) and miniplates fixation after mandibular advancement there is no statistically significant difference in skeletal stability and a favourable relationship between the amount of relapse and amount of advancement.

Keywords: BSSO advancement, Rigid internal fixation, Skeletal stability, Relapse.

INTRODUCTION

Bilateral sagittal split osteotomy (BSSO) is the most frequent used surgical method for correcting mandibular deformities and is known as a highly stable and predictable surgical orthodontic procedure for mandibular advancement. The BSSO procedure has been widely used for mandibular repositioning, with the goal of achieving functional and aesthetic improvement by modifying the relationship between the maxilla and mandible. The specific anatomy of the human mandible is unique and lends itself to splitting the ramus in a sagittal plane. In 1957, Trauner and Obwegeser described a basic surgical design to reposition the mandible by means of a sagittal split of the mandibular ramus. is technique was later modified by Dal Pont, further refined by Hunsuck in 1968, and later by Epker in 1977.

It is currently the surgical technique of choice for repositioning of the mandible in most cases, which allows either setback or advancement. The ingenuity of the surgical design, development of special instruments, improvement of surgical skills, and surgeon experience have made it now possible to achieve our treatment goals relatively quickly and atraumatically. With the introduction of internal rigid fixation by Spiessl in 1974, stability was increased, and because no intermaxillary immobilization was required, the safety of the procedure increased.[2] The sagittal split ramus osteotomy (SSO), however, remains a technique sensitive and challenging procedure The major indication for the bilateral sagittal split osteotomy (BSSO) is the advancement of the mandible to correct a skeletal class 2. Moderate to severe mandibular retrognathism often require a combined orthodontic and surgical approach for optimal function and best esthetic results.

Despite the popularity of BSSO, new methods, such as segmental distraction of the anterior alveolar process and anterior apical base augmentation for the correction of the retrognathic mandible, have been proposed and performed successfully. Through the use of the modern metal plates and screws after osteotomy, the stability can be already achieved in a technique so- called "rigid internal fixation" (RIF), without using "intermaxillary fixation" (IMF). RIF methods contribute to postoperative bone healing and masticatory function. Furthermore, using RIF method, instead of intermaxillary rigid fixation, can initiate the early improvement of oral hygiene.[2] Usually bicortical bone fixation screw or miniplates with monocortical bone fixation screw were used to gain stability after BSSO. On the other hand, the use of resorbable screw materials had been reported. Bilateral sagittal split osteotomy (BSSO) Long-term postsurgical skeletal stability is essential for successful correction of functional and aesthetic abnormalities in mandibular retrognathic patients.

Skeletal stability after BSSO advancement with rigid internal fixation has been assessed in a systematic review demonstrating that relapse is a multifactorial phenomenon affected by many different variables. Possible factors for relapse are: the amount of advancement, the type and material of fixation, low and high mandibular plane angle (MP-angle), condylar resorption, control of the proximal segment, soft tissue and muscle tension, remaining growth and remodelling, skills and experience of the surgeon.[9] Moreover, a positive correlation between the amount of advancement and skeletal relapse has been described in several studies. A major concern in the surgical correction of a skeletal Class II is potential postsurgical relapse. To minimize relapse, careful selection of patients has been advocated, so that isolated mandibular advancement is not used for patients with high mandibular plane angles and open bites.

Aim

The aim of the study is systematic review of the literature on stability after bilateral sagittal split osteotomy advancement surgery of mandible with different types of rigid internal fixation methods.

Materials and Methods

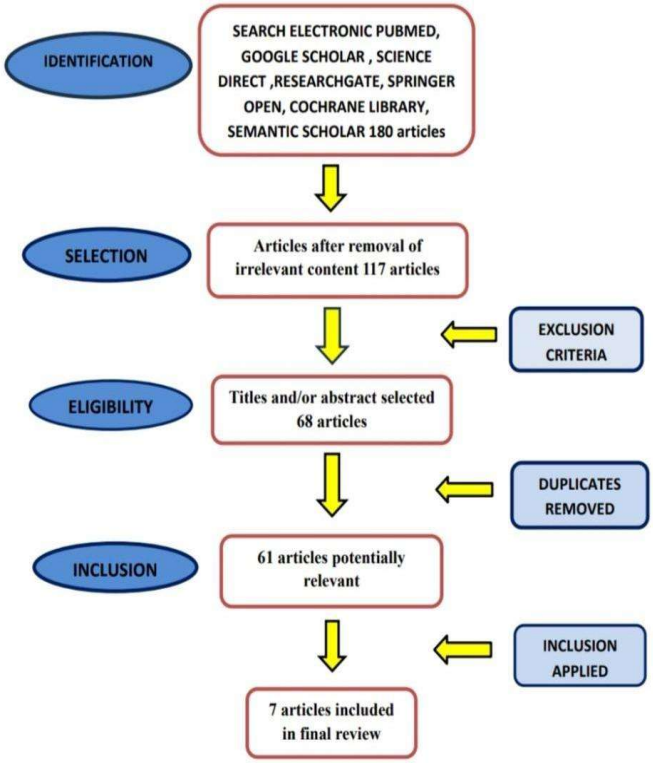
Search Approach

A rigorous search for the articles on the stability after bsso advancement surgery with different rigid internal fixation method was conducted. The search was conducted in multiple stages. The initial step involved a search for existing systematic review of literatures on the subject with the help of electronic databases like PUBMED, SCIENCE DIRECT, RESEARCHGATE, SPRINGER OPEN, COCHRANE LIBRARY, SEMANTIC SCHOLAR.

The search terms were bsso advancement surgery, stability in bsso advancement, rigid fixation methods in bsso. The next step involved a manual search of reference articles to identify other relevant articles for the final selection.

Search Results

A total of 180 articles were found by searching through electronic databases like PUBMED, GOOGLE SCHOLAR, SCIENCE DIRECT, RESEARCHGATE, SPRINGER OPEN, COCHRANE LIBRARY, SEMANTIC SCHOLAR. On further screening of articles for titles, abstracts and on application of exclusion criteria, 68 articles were selected. 61 potentially relevant articles were removed after removal of duplicates. 7 articles were taken for the final systematic review after applying the inclusion criteria.



Inclusion Criteria 1. Cross sectional studies, observational studies, prospective studies, retrospective studies 2. Case control and cohort studies 3. Controlled Clinical trials 4. English Language 5. Adult patients

Exclusion Criteria 1. Inaccurate data for analysis 2. Incomplete data for analysis 3. Insufficient description of post-operative outcomes. 4. In vitro studies 5. Animal studies.

TABLES

TABLE 1: The study design of included studies

Sr No	Author	Year of publication	Study Design
1	Sato et al	2014	RS
2	Nooh et al	2009	RCT
3	Bector et al	2008	RS
4	Kahnberg et al	2007	CT, RS
5	Turvy et al	2006	CT, RS
6	Ferretti et al	2002	CT, PS
7	Borstlap et al	2004	CT, PS

TABLE 2: Summarized data with Bicortical screws and follow-ups

Study	Surgery (eg. Type of RIF, genioplasty,MMF)	No.of patients	Mean age and range	Follow up	Mean Advancement (mm)	Relapse (mm)
Turvy et al 2006	Group with 4 Ti screws (2mm), Genioplasty in 9 patients	35	26.8 (SD, 11.2)	1 yr	4.96 (B) 6.89 (Pg)	0.33 (B) 0.14 (Pg)
Ferretti and Reyneke, 2002	3 Ti screws (2mm), no MMF, no Genioplasty, Condylar positioning device	20	-	6 months	4.7 (B)	0.25 (B)
Kahnberg et al, 2007	Lag screws, splint, and some patients with Genioplasty	17	31 (21-42)	1.5 yr	6.5 (B) 7.8 (Pg)	0.8 (B) 0.5 (Pg)
Sato et al, 2014	3 linear bicortical screws inserted transbucally at a 90 angle above the mandibular canal around the retromolar area, MMF	6	34.57	6 months	NM	0.17 (B) 1.17 (Pg) 1.50 (Me)
Nooh et al, 2009	Bico:2-mm wide and 12mm in length	8	23	1 yr	6	1.062(Pg)

TABLE 3: Summarized data with Bioresorbable bicortical screws and follow-ups

Study	Surgery (eg. Type of RIF, genioplasty,MMF)	No.of patients	Mean age and range	Follow up	Mean Advancement (mm)	Relapse (mm)
Turvey et al, 2006	4 self-reinforced polylactate (PLLDL 70/30) biodegradable bicortical screws, genioplasty in 7 patients.	34	27.5 (SD, 13.0)	1 yr	5.20 (B) 6.19 (Pg)	0.54 (B) 0.26 (Pg)
Ferretti and Reyneke, 2002	3 copolymer (PLLA/PGA Lactosorb) screws (core- diameter: 2.0 mm, thread- diameter: 2.5 mm), no MMF, no genioplasty,	20	-	6 months	5.5 (B)	0.83 (B)

TABLE 4: Summarized data with Miniplates and follow-ups

Study	Surgery (eg. Type of RIF, genioplasty,MMF)	No. of patients	Mean age and range	Follow up	Mean Advancement (mm)	Relapse (mm)
Kahnberg et al 2007	Miniplates (6 hole for marginal part and another 3 hole or 4 hole plate inferior to the 1st plate), splints, some patients with genioplaty	15	28 (18-67)	1.5 yr	6.5 (B) 6.4 (Pg)	0.1 (B) 0.1 (Pg)
Borstlap et al 2004	Ss or Ti miniplates (additional plates in bad splits), splints, no genioplasty, plates removed after 6 months	222	25.2 (13-53) (SD, 8.2)	2 yr	5.6 (Pg)	0.9 (Pg)
Sato et al 2014	2.0-mm titanium miniplate and 4 monocortical screws system along the oblique ridge of the mandible, MMF,	7	23.67	6 months	NM	0.71 (B) 0.28 (Pg) 0.14 (Me)
Nooh et al 2009	Plate:2-mmplating system with four screws, two anterior of5mmlengthand twoposteriorof7mm length	8	23	1 yr	6	1.23 (Pg)

Description of the Studies

1. Seung Yu et al (2014)[6] conducted a study named can Resorbable Screws Effectively Be Used In Fixating Bilateral Sagittal Split Osteotomies For Mandibular Advancement and concluded resorbable screws can be used effectively for fixation of BSSO for mandibular advancement. There was a statistically significant difference in postoperative elastic rubber band use, although there was no case of relapse after the completion of treatment in patients who received resorbable screws. Further studies are necessary to determine the long-term outcome of resorbable versus metal fixation materials, as well as long-term patient satisfaction.
2. Nooh et al (2009)[8] conducted a study to evaluate stability of the mandible after bilateral sagittal split osteotomy comparison between positioning screws and plate and concluded the use of positioning screws or plate and monocortical screws with IMF to stabilize the mandible after BSSO in mandibular advancement showed no significant difference in terms of re lapse. However, we showed significant difference between the two methods of fixation in terms of setback.
3. Sato et al (2013)[9] conducted a study to evaluate comparison of postoperative stability of three rigid internal fixation techniques after BSSO advancement surgery and concluded the results suggests that the stability amoung the groups was similar in the postoperative period with good stability of the mandibular advancement for all three groups. There is also evidence that the amount of advancement is positively releted to the amount of relapse.
4. Ferretti et al (2002)[5] conducted a study to compare skeletal stability following bilateral sagittal split osteotomy (BSSO) advancement of the mandible fixed with titanium or biodegradable bicortical screws and concluded There was no statistically significant difference in long-term stability between the 2 groups. No clinical or radio graphic evidence of wound healing problems were noted and resorbable poly-Llactic/polyglycolic acid copolymer bicortical screw fixation of a BSSO is a viable alternative to titanium screws for the fixation of advancement BSSO.

5. Becktor et al (2008)[7] conducted a study to compare lag screw fixation versus miniplates with monocortical screw technique with respect to the amount of transverse displacement of the proximal segment after bilateral sagittal osteotomy (BSO) for mandibular advancement surgery and concluded that transverse displacements of the proximal segments occur after BSSO surgery with both miniplate or lag screw fixation technique. Attention and future studies should focus on possible complications that transverse displacement of the proximal segment may cause.
6. Kahnberg et al (2007)[10] conducted a study to compare relapse after two different rigid fixation method and concluded The use of bicortical screws may have some deleterious effects on the inferior alveolar nerve, as the method compresses the fragments considerably more than miniplate osteosynthesis. A previous study focused on the incidence of disturbances of the alveolar nerve and the results support the use of miniplate rigid fixation. Its use in the sagittal split procedure of the mandible has also made the operation a little less complicated.
7. Turvey et al (2006)[11] conducted a study to compare the skeletal stability and treatment outcomes of 2 similar cohorts undergoing bilateral sagittal osteotomies of the mandible for advancement. The study groups included patients stabilized with 2-mm self-reinforced polylactate (PLLDL 70/30), biodegradable screws (group B), and 2-mm titanium screws placed in a positional fashion (group T) and concluded Two-mm self-reinforced PLLDL (70/30) screws can be used as effectively as 2-mm titanium screws to stabilize the mandible after bilateral sagittal osteotomies for mandibular advancement. The difference in 1-year stability and outcome is minimal.

RESULTS

The extracted data and the characteristics of the studies included in the final analysis. It includes 7 studies, from these 4 studies were retrospective, 1 study was randomised control trial, 2 studies were prospective and 4 were controlled clinical trials. Considering the confounding variable "genioplasty" 7 studies declared that additional genioplasty was performed in only a few patients. In one study a mandibular template was used to eliminate the effect of genioplasty. Another confounding variable was the presence of a splint in the immediate postsurgical radiographs. Several studies did not compensate for or comment on the presence of a splint in the immediate postsurgical radiographs. Hence, the autorotation of the mandible caused by removal of the splint, depending on its thickness, would result in a relative anterior displacement of the mandible, which must be considered when assessing relapse. Therefore, in some studies, a template of the mandible was made and rotated around the mid condylar point until the upper and lower incisors occluded, to compensate for the error that would otherwise occur. The range of follow-up period was 6 months to 1.5 yrs. In total 493 participants were treated for BSSO advancement surgery. Out of 392, bicortical screw fixation were used in 86 patients, miniplate osteosynthesis were used in 252 patients and in 54 patients resorbable screw fixation were used. The mean age of the patients was 25 year in this study. The average relapse was 0.38 mm (B), 0.717 mm (Pg) and 1.50 mm (Me) in patients with bicortical screw fixation on average 1 year follow up period. For patients with miniplates fixation the average relapse was 0.76 mm (B), 0.62 mm (Pg) and 0.11 mm (Me) in 1 year average follow up period and patients with resorbable screw followed by bsso advancement the average relapse was 0.68 mm (B) and 0.26 mm (Pg) in 1 year average follow up period. The mean relapse as a forward instead of backward movement of point B and pogonion was described in studies that involved bicortical screws,

and in one study that involved miniplates. An anterior movement of more than 3 mm is difficult to explain by mandibular autorotation alone as a result of splint removal and orthodontic finishing. Mandibular growth could explain this finding, The average advancement was 5.54 mm (B) and 7.3 mm (Pg) in patients fixed with bicortical screws. For patients with miniplate fixation the average advancement was 6.5 mm
(B) and 6 mm (Pg) and patients with resorbable screw the average advancement was 5.3 mm
(B) and 6.19 mm (Pg). Scheerlinck et al found that the amount of advancement correlated positively with progressive condylar resorption (PCR) evaluated on orthopantomograms after BSSO advancement with miniplates. The risk of experiencing PCR was 5.2 times higher for those with a mandibular advancement between 5 and 10 mm than for those with an advancement of 5 mm or less. For 10 mm or more, the risk was as much as 20 times higher, compared with 5 mm or less. The incidence of PCR can be as high as 7%. It usually manifests during the second half of the year after the BSSO procedure, and can amount to total relapse.

DISCUSSION

Mandibular advancement with BSSO in healthy skeletal Class II patients is considered a stable procedure in long-term follow-up (Paunonen et al., 2018). It has also been shown earlier that a major part of the relapse takes place shortly after surgery, and no significant antero-posterior change has been seen in the first year post-surgery (Joss and Thuer, 2008). In their systematic review in 2009, Joss and Vassalli listed eight factors influencing relapse following mandibular advancement with BSSO (Joss and Vassalli, 2009).[2] From strongest to weakest evidence, the first three were as follows: 1) amount of advancement, 2) type and material of fixation and 3) low and high mandibular plane angle. In the current study, the amount of advancement and the direction of jaw movement were more dominant than the type of fixation. In a recent overview of systematic reviews concerning the hierarchy of surgical stability in orthognathic surgery, mandibular advancement with plate fixation was considered highly stable and more stable than the same movements when performed in the maxilla, even though the mandible will always be subject to instability because it is a mobile bone structure (Haas Junior et al., 2019).
In the systematic reviews and meta-analyses, it has been stated that CCW rotation is a skeletally stable procedure both vertically and horizontally in the absence of pre-existing temporomandibular joint pathology (Al-Moraissi and Wolford, 2016; Hasprayoon et al., 2019). However, the amount of CCW rotation has a significant adverse effect on mandibular stability (Hasprayoon et al., 2019).[3] On the other hand, there are results that suggest that the amount of rotation does not affect the post-surgical stability of the mandible (Hasprayoon and Liao, 2020). Patients with a low mandibular plane angle undergo increased vertical relapse according to a systematic review (Joss and Vassalli, 2009).[2] There has been some debate as to whether muscular activity causes relapse after surgery. In earlier studies, it has been stated that muscular activity tends to pull the proximal segment to its original inclination, resulting in posterior movement of the chin (Epker and Wessberg, 1982; Proffit et al., 1996; Mobarak et al., 2001). Others believe that CCW rotation of the maxillomandibular complex does not affect the original length and position of the muscles of mastication (Al-Moraissi and Wolford, 2016).[3] In large surgical advancements, the force of the muscles under the jaw might cause stretching, which rotates the jaw open. When using rigid plate fixation, some pressure is applied to the screws, which causes resorption between the screw and the bone, inducing rotation (Pittman et al., 2014; Lee et al., 2017). That was also seen in the present study: an increase in the gonial angle during the follow-up despite no evident hardware failure, plate bending or problems with ossification. Relapse seems to be a multifactorial phenomenon affected by many different variables. Good surgical training,

lengthy experience in orthognathic surgery, and technical refinements by the surgeon are necessary for good postoperative results in regard to stability and esthetics. Presurgical orthodontics is another important factor for stable results which allows, when performed correctly, good interdigitation after surgery.

A higher number of studies with larger skeletal long term relapse rates involved patients treated with bi cortical screws instead of miniplates. One explanation could involve longer follow-up periods in long term studies on bicortical screws compared with miniplates. In general, there is a trend toward increase in relapse from short-term to long-term studies when bicortical screws are used. Only small differences between short-term and long-term relapse rates in miniplates were evident. Changes in condylar position after BSSO and mandibular advancement with RIF are frequent findings. The importance of correct positioning of the condyles before fixation is well-known. Improper positioning of the condyle in the glenoid fossa at time of surgery, when the soft tissue undergoes considerable stretching, can cause relapse. It is believed that the magnitude of advancement is a factor in the proper seating of condyles. Thüer et al showed that it was easier to manipulate the proximal segment in patients with small advancement who had their condyles set a bit too far posteriorly, with subsequent anterior relocation after surgery. It is obviously less difficult to obtain a stable result after surgical setback than after mandibular advancement. A possible explanation for this difference is that it is easier to set the condyles correctly in the fossa before rigid fixation, when the soft tissues, as in the case of setbacks, are not extensively stretched. When RIF is used, it is possible to check passive condylar function and occlusion intraoperatively, before incisor closure. This should help reduce the incidence of condylar distraction. As a consequence of intraoperative swelling and inflammation within the joint because of manipulation of the proximal segment, an increase in vertical joint space is a common finding. When assessing condylar distraction, Gassman et al showed about twice the amount of gonial arc displacement in their relapse group (more than 25% of relapses) versus their control group with no relapses. Relapse has been attributed largely to increased soft tissue and muscular tensions because of the advancement of the mandible. Simply put, the greater the advancement, the greater the stretching of the soft tissue. To find evidence of this topic in the reviewed articles was rather difficult. Strong evidence can be found where a positive correlation between the amount of advancement and the relapse rate was shown. This was demonstrated in several studies.

CONCLUSION

In conclusion, this systematic review suggest that, bicortical screws (stainless steel, titanium , bioresorbable) and miniplates fixation after mandibular advancement there is no statistically significant difference in skeletal stability and a favourable relationship between the amount of relapse and amount of advancement.

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