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RESEARCH ARTICLE

STABILITY OF THE MAXILLARY INCISOR AFTER CLASS III SURGERY : SYSTEMATIC REVIEW

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ABSTRACT

Introduction: The purpose of this study was to systematically reviewthe stability of maxillary incisors after class III malocclusion surgery. **Objective:** Our study aimed to evaluate the stability of maxillary incisors after class III malocclusion surgery through a systematic review. **Materials and methods:** An electronic search of databases retrieved 189 publications concerning our topic. Following the application of inclusion and exclusion criteria, four studies remained. Among other data, treatment methods, outcome measures during treatment, and time at follow-up were all extracted from the relevant articles. A subjective assessment of study quality was performed. The heterogeneity of the samples and treatment methods refrained us from performing a meta-analysis. **Results**: One hundred and sixty-seven patients with class III malocclusion underwent orthognathic surgery, seventy-eight of them benefited a bimaxillary surgery. Concerning the maxillary incisor stability, the studies suggest that performing the First Approach of the surgery is as stable as the conventional approach one. **Conclusions**: To evaluate the real stability of the maxillary incisor, further research with longer follow-up periods is required.

INTRODUCTION

Class III malocclusions are abnormalities characterized by an excessively anterior position of the mandibular arch with the maxillary arch may be normal or posterior position. Skeletal and occlusal Class III malocclusions are most often associated (1). These dysmorphoses are characterized by often severe aesthetic damage and a late evolutionary potential, linked to mandibular growth, which leads more frequently to orthodontic surgical treatment compared to other dysmorphoses (1,2). Historically, the isolated mandibular setback is frequently used to correct a Class III skeletal malocclusion, but recent reports indicate that bimaxillary procedures have become more frequent (2,3). The technique widely used to correct mandibular prognathism is known as a bilateral sagittal split osteotomy (BSSO), which was introduced by Schuchard and modified by Dal Pont, Trauner, and Obwegeser (4). This technique, alone or in combination with maxillary osteotomy, is widely practiced worldwide (5).

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Bimaxillary surgery first appeared in 1959 thanks to the work of Köle, and Obwegeser popularized the technique by publishing his method of combined osteotomy of the maxilla and mandible in 1970 (6). However, before surgical removal, decompensation of the incisors during pre-surgical orthodontic therapy is often required. According to several studies, the bone stock of the incisors in general, (7-9)and that of the vestibular surface of the maxillary incisors in particular, is reduced.To date, no systematic review has been performed to evaluate the short- or long-term stability of maxillary incisors after class III surgery.

Objective: Our study aimed to evaluate the stability of maxillary incisors after class III malocclusion surgery through a systematic review.

MATERIALS AND METHODS

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement for reporting systematic reviews. The PubMed Central, Cochrane Library, Google Scholar, and Ebscohost databases were considered.

The PICOT format (Table 1) was used to develop the search strategy search and the application of inclusion and exclusion criteria. Articles published since 2010 were analyzed. No limitations on the language of publication were imposed. Boolean operators "OR" and "AND" were used to define and connect search terms.

Study selection: Systematic searches were conducted by one author (AHR). Study selection was performed by two authors (AHR and HB). Titles and abstracts were read and the studies were then assessed against the eligibility criteria. The two authors independently evaluated the selected studies for eligibility. Articles that satisfied the criteria were selected for full-text reading. In case of disagreement between authors, the study selected for full-text reading. The inclusion criteria were as follows: studies published from 2010 to 2020, meta-analysis studies, randomized and non-randomized controlled trials, prospective and retrospective studies, studies concerning Ortho-surgical management of skeletal Class III malocclusion in adult patients with permanent teeth, an article that allowed the extraction of data on maxillar incisor stability based on specific cephalometric points. We excluded all publications on animal studies, literature reviews, narrative reviews, opinion articles, studies on patients with syndromic or severe facial deformities.

Search strategy: The terms used in the PubMed search were: (surgery) AND (orthognathic OR orthodontics) AND (incisor stability Or incisor relapse) AND (class III malocclusion). The terms used in the Cochrane Library search were: ("orthognathic" OR "orthodontic"). The terms used in the Google Scholar search were: ("surgery") AND ("orthognathic" OR "orthodontic") AND ("incisor stability" OR "incisor relapse") AND (class III malocclusion). And finally, the terms used in the EbscoHost search were: (class III) AND (stability OR relapse).

Data extraction: To extract data from the selected articles, we used a table to report for each article the names of the authors and year of publication, type of study, sample size and treatment strategy, pre-surgical measures, post-surgical measures, length of follow-up, and authors' conclusions (Table 2). Demographic, methodological and stability results data were independently extracted by the same authors. In case of disagreement; the article was discussed with the other authors.

RESULTS

The search with keywords gave the following results: PubMed produced 58 publications, Google scholar 90, Cochrane Library 33, and Ebscohost 8 publications. After excluding 105 repeat articles, all titles and abstracts were read and those found to be unrelated to the journal were eliminated, fourteen pre-selected articles were read in their entirety, and after applying the inclusion and exclusion criteria, four references were selected for this systematic review (Fig 1). The four studies included in the systematic review were all retrospective studies. (10-13). The data extracted from the studies are listed in Table 2. The Newcastle-Ottawa scale (14) was used to assess the quality of the cohort studies (Table 3). This scale is used to rate studies according to three criteria: selection, comparability, and outcomes as shown in Table 3. In our study, scores ranged from 4 to 7 out of a possible 9, representing fair/high quality. The four eligible studies included a total of 167 patients who underwent the surgical correction of a class III malocclusion treated with bimaxillary surgery (10,11)(BMS, n = 78) or the one-jaw approach (12,13)(1-JS, n = 89). Approximately 52% of the patients were female with a mean age range of 20.9 years (10) to 23.9 years (12). One article (10) described a combination of Lefort 1 osteotomy of advancement in the maxilla and bilateral sagittal split osteotomy (BSSO) of the mandible. While one study (11) performed Lefort 1 osteotomy with posterior impaction in the maxilla and bilateral sagittal split osteotomy (BSSO). As for one-jaw surgery, no study has performed surgery on the maxillary arch alone. All single-maxillary procedures were performed in the mandible. One study described intraoralvertical ramus osteotomy (IVRO) (12), instead of a bilateral sagittal split osteotomy (BSSO). (13). Post-surgical stability analysis of the maxillary incisor was performed using lateral cephalograms. The horizontal reference planes were the Frankfurt horizontal plane (FH), the sella-nasion line (SN),upper central incisor axis (U1),nasion- subspinale line(NA), and the palatal plane (PP).

Maxillary incisor relapse was defined as late post-surgical cephalometric measurements (6 months, one year, or 22 months) minus immediate post-surgical measurements (3 days, one week, 8 weeks). The measures most commonly used to evaluate maxillary incisor outcomes were the overjet measurement (10-13), followed by U1/NA (11,12), U1/PP (10), U1/SN (11), and finally U1/FH (13). The four selected studies reported the following results (Table 2). Instability of the maxillary incisor by palatoversion after double-jaw surgery (DJS) is in one study (10) 2.47° for patients with a mean of three months of surgery first approach (SFA) compared to 3.98° for those with eighteen months of conventional approach (CA) orthodontics. While one study (11) found a buccal version recurrence of 1.71° for the one-month surgery first approach (SFA) versus 2.59° for the eleven-month conventional approach (CA) orthodontics. As for one-jaw surgery, one study (12) found retroclination of upper incisor of 0.04 mm for a sample exclusively benefiting from CA orthodontics ranging from six to eighteen months. Whereas one article (13)found forward recurrence of 0.9° for the 13-month conventional group versus 0.4° for the group with only one month of active pre-surgery orthodontics.

DISCUSSION

Pre-surgical decompensation of class III should allow the buccal version of the mandibular incisors and reposition by palatoversion of the maxillary incisors, and also allows a greater range of surgical movement (15). Extractions may be performed at the maxillary arch to facilitate the repositioning of the incisors. Extractions to either of the arches are to be performed if the amount of crowding so indicates. The authors of all the studies included in this review adopted a non-extraction strategy. The functional and esthetic role of the incisors will require increased attention to their angulation before, during, and after surgery. The orthodontist and maxillofacial surgeon will have to pay particular attention to incisor repositioning, which determines: the position of the lips, the opening of the nasolabial angle, the labial covering of the vestibular faces of the incisors. According to Raberin (15), the optimal preparation of the maxillary incisors is 111° to the palatal plane. In the articles reviewed, the FH and SN planes were used as horizontal reference planes. The SN plane is useful for evaluating the craniofacial relationship, while the FH plane is appropriate for evaluating the face.

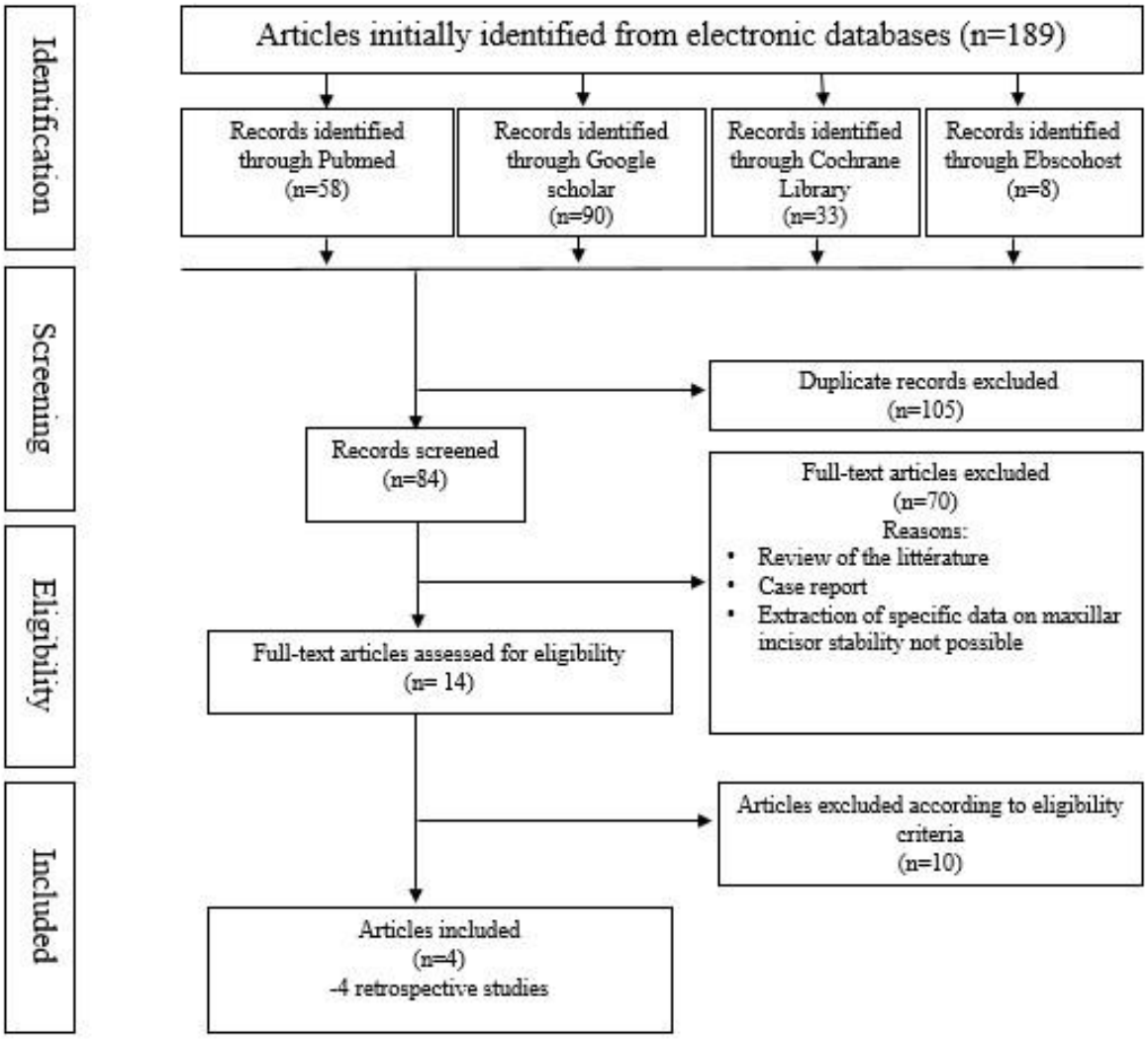

Figure 1. Flow Diagram

Table 1. PICOS criteria

Component	Description
Population	Patients requiring orthognathic surgery for the correction of a dentofacial deformity
Intervention	Bimaxillary surgery
Comparaison	One-jaw surgery
Outcome	Maxillary incisor stability or Maxillary incisor relapse
Study design	No clinical case reports, interventional or observational human studies with specific data on stability or recurrence of the upper central incisor after orthognathic surgery

However, due to the poor reproducibility and accuracy of the porion and orbit, which are the reference points of the FH plane, the SN plane is more often used (16,17). All authors used lateral cephalograms for the analysis of the results. The definition of recurrence after class III orthognathic surgery would correspond to a decrease in post-surgical maxillary incisor repositioning equivalent to a buccal version of the maxillary incisors. This is what the studies Park H-M et al 2015 (11), Halvorsen et al 2014 (12) and Kim C-S 2014 found (13). Park H-M et al 2015(11) found that after bimaxillary surgery in 38 patients, recurrence was less than 3° on average in both the group with first-line surgery and the group with the conventional protocol after 6 months of follow-up. It should be noted that the maxilla underwent a posterior impaction without advance, while the mandible was moved back by 5 mm on average. Halvorsen et al 2014 (12) and Kim and 2014 (13) obtained a recurrence of the maxillary incisor of less than 1° when they respectively performed a single surgery of vertical intraoral osteotomy of the Ramus for the former and sagittal osteotomy of the rising branches for the latter. These results are in contrast to those of Zhou et al 2016 (10) who found stability by incisive palatoversion after one year of follow-up in 40 patients who underwent bimaxillary surgery with genioplasty. However, recurrence by mandibular advancement between surgery and debagging in cases of mandibular surgery is most discussed by the authors because it easily leads to recurrence towards the front of the maxillary incisor. The study by Kim et al (13) comparing two protocols showed a significant horizontal mandibular recurrence for the group with first-line surgery between three days after surgery and the time of debagging (recurrence of 2.4 mm in the sagittal direction compared with 1.6 mm for the group with the conventional protocol). In the study by Zhou et al (10) a difference was also noted in the post-surgical vertical mandibular stability of the B-point, with a higher recurrence in the group with minimal orthodontic preparation, with the majority of recurrence

Tableau 2 characteristics of the studies included in this systematic review

Authors Year	Type of study	Sample size	Typeofsurgery	Measurements beforetreatment: T0	Measurements after surgery : T1, T2	Horizontalrelapse	Follow up time
Zhou Y et al 2016 [10]	Retrospective Cohort	Total :40 patients Gp1:20patients SFA Gp2:20 patients CA	LF1 + BSSO Gpe1 Genioplasty (19P/20) A-point ▶3,05 mm B-point ◀5,25 mm Gpe2 Genioplasty (16P/20) A-point3▶4 mm B-point6◀7 mm	Gp1 : T0=3,3 months ANB= -3,90° SNA=81,11° SNB=85,02° UI/PP=59 ,99° IMPA=77,55° Overjet= -2,17 mm GP2 : T0=18,10 months ANB=-5,3° SNA=80,15° SNB=85,44° UI/PP=63,02° IMPA=75,08° Overjet= -1,58 mm	Gp 1: T1=one week, T2=one year ANB: 2;75°(T1)/0,95°(T2) SNA:85,13°(T1)/83,55°(T2) SNB :82,39°(T1) /82,32°(T2) UI/PP :62,5°(T1) /60,03°(T2) IMPA :77,75°(T1) /81,79°(T2) Overjet :4,49 mm(T1) /3,26mm(T2) Gp2: T1=one week, T2=one year ANB : 1,41°(T1) /0,74°(T2) SNA :83,28°(T1) /82,92°(T2) SNB :81,86°(T1) /82,17°(T2) UI/PP :66,13°(T1) /62,15°(T2) IMPA :83,88°(T1) /80,93°(T2) Overjet:3,89mm(T1)/3,80mm(T2)	Gp1 : UI/PP ◀2,47° Overjet ◀1,13mm Gp2: UI/PP ◀3,98° Overjet ◀0,09mm	12 months
Park H-M et al2015 [11]	Retrospective Cohort	Total :38 patients Gp1 :19patients CA Gp2 :19 patients SFA	LF1+PI+BSSO Gpe1: A-point ▶1,8 mm B-point ◀8,3 mm IP ▲4,53 mm Gpe 2 A-point ▶0,12 mm B-point◀ 7,8 mm IP▲3,82 mm	Gp1: T0=11,47 months ANB= -3,08° SNA=81,25° SNB=84,32° UI/SN= 112,40° UI/NA=30,21° IMPA=77,76° Overjet= -2,79 mm GP2: T0=1,09 month ANB=-2,8° SNA=80,31° SNB=83,11° UI/SN=112,18° UI/NA=32,23° IMPA=81,14° Overjet= -1,92 mm	Gp 1: T1=one week, T2= six months ANB : 2,44°(T1) /1,56°(T2) SNA :82,37°(T1) /82,15°(T2) SNB :79,93°(T1) /80,59°(T2) UI/SN :106,75°(T1) /109,34°(T2) UI/NA :23,11°(T1) /25,92°(T2) IMPA :82,88°(T1) /80,28°(T2) Overjet :3,68 mm (T1) /3,29mm(T2) Gp2: T1=one week, T2= six months ANB : 1,65°(T1) /1,15°(T2) SNA :80,36°(T1) /80,89°(T2) SNB :78,71°(T1) /79,74°(T2) UI/SN :106,91°(T1) /108,62°(T2) UI/NA :27,09°(T1) /28,34°(T2) IMPA :82,58°(T1) /80,31°(T2) Overjet :3,68 mm(T1) /2,53mm(T2)	Gp1: UI/SN ▶ 2,59° UI/NA ▶ 2,81° Overjet ◀0,39mm Gp2: UI/SN ▶ 1,71° UI/NA ▶ 1,25° Overjet ◀1,15mm	6 months
Halvorsen ET 2014 [12]	Retrospective	Total :28 patients CA	IVRO	T0=6-18 months ANB= -2,3° SNA=84° SNB=86,3° UI/NA=25,8° UI/NA=5,3mm Overjet= -1,1 mm	T1=8 weeks, T2=one year ANB : 1,8°(T1) /1,3°(T2) SNA :83,6°(T1) /83,6°(T2) SNB :81,8°(T1) /82,3°(T2) UI/NA :24,4°(T1) /24,8°(T2) UI/NA :5,1mm(T1) /4,9mm(T2) Overjet :2,8 mm(T1) /2,4mm(T2)	UI/NA▶ 0,4° UI/NA ◀ 0,2mm Overjet ◀0,4mm	12 months
Kim C-S 2014 [13]	Retrospective cohorte	Total :61 patients Gp1 (38patients) : CA Gp2 (23 patients) : SFA	BSSO Gpe1: B-point◀ 4,7 mm Gpe2: B-point◀ 4,4 mm	Gp1 : T0=12,9 months ANB= -2,5° SNA=81° SNB=83,5° UI/FH= 121,8° IMPA=92,6° Overjet=-6,2mm GP2: T0=1 month ANB=-3° SNA=80,5° SNB=83,5° UI/FH=123,1° IMPA=82,3° Overjet=-4,4mm	Gp 1 : T1=3 days ; T2=6-22 months SNB :78,8°(T1) /79,7°(T2) UI/FH :121,8°(T1) /122,7°(T2) IMPA :92,6°(T1) /83,7°(T2) Overjet :3,9mm(T1) /3,1mm(T2) Gp2 : T1=3 days ; T2=6-22 months SNB :79,1°(T1) /80,2°(T2) UI/FH :123,1°(T1) /123,5°(T2) IMPA :93°(T1) /93,6°(T2) Overjet :4,9mm(T1) /2,6mm(T2)	Gp1: Overjet ◀0,8mm Gp2: Overjet ◀2,3mm	6-22 months

BSSO, bilateralsagittalsplitosteotomy; CA, conventional approach; SFA, surgery first approach; IVRO, intraoralverticalramusosteotomy;LFI,LeFortI; PI, posterior impaction of maxilla; T0: beforetreatment time;T1: postop.immediatelyaftersurgery; T2: postop later aftersurgery;

Tableau 3. Methodological quality of the studies included—Newcastle–Ottawa scale.

Studies	Selection 0-4				Comparability 0-2	Outcome 0-3			Score total
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis controlled for confounders	Assessment of outcome	Was follow-up long enough for outcomes to occur?	Adequacy of follow-up of cohorts	
Zhou Y et al 2016[10]	-	*	*	-	*	*	*	-	5
Park H-M et al 2015 [11]	-	*	*	-	*	*	*	-	5
Halvorsen et 2014 [12]	-	-	*	-	*	*	*	-	4
Kim C-S 2014 [13]	*	*	*	-	*	*	*	*	7
Maximum score = 9; range for low quality = 0–3; range for medium quality = 4–6; range for high quality = 7–9..									

occurring in the first 3 months after surgery. The authors recommend preoperative alignment and leveling of the two arches to avoid this phenomenon, as well as the maintenance of mini-screws up to six months after surgery, particularly for the placement of post-operative intermaxillary elastics.

For Choi et al; (18) who studied the difference between the two protocols in the context of orthognathic mandibular recoil surgery using the IVRO (Intraoral Vertical Ramus Osteotomy) technique, the distal mandibular segment is less stable in the protocol with first-line surgery compared with the conventional protocol, with a tendency for counterclockwise rotation. The importance of recidivism is correlated with the importance of mandibular recoil. The potential factors of instability in Class III cases with ortho-surgical treatment by primary surgery would be the important interference between the two arches before surgery, a very marked Spee curve, the importance of an anterior gap, and the importance of mandibular recoil. Horizontal stability is reduced when the mandibular recoil is greater than 15 mm (19) even in cases of bimaxillary surgery. Indeed, the leveling of the Spee curve after surgery leads to ingression of the anterior teeth and an eruption of the molars and premolars inducing an hourly downward and backward rotation of the mandible leading to recurrence. To avoid these factors, some authors such as Liou, Hernandez-Alfaro, and Huang (20-22) recommend that in cases with severe interference, a deep Spee curve, and anterior gap, most dysmorphoses should be corrected before surgery.
Alternatively, overcorrection of mandibular recoil or hourly rotation of the maxillo-mandibular complex could prevent recurrence in unfavorable cases. On the other hand, in cases with a very steep Spee curve, segmental osteotomy of the anterior mandibular block can be performed at the same time as bimaxillary surgery to insert the incisive-canine block and surgically level the Spee curve to reduce the risk of recurrence. (19)

Conclusion

The results of our study showed a difference between mono- and bimaxillary surgery regarding the stability of the maxillary incisor after orthosurgical therapy. However, these differences are statistically insignificant with better stability for bimaxillary surgery. Similarly, stability with conventional pre-surgical preparation is better compared to minimal pre-surgical preparation without this difference is significant. No studies in our work have performed extraction before or after orthognathic surgery. Additional studies should be conducted to evaluate long-term results as the maximum follow-up time in our study did not exceed two years.

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