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## Molar intrusion vs maxillary surgical impaction in skeletal open bite patients: Systematic review

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### Abstract

**Objective:** Skeletal openbite's control, is an effective challenge in orthodontics. In adults, treatment of severe skeletal open bite consists mainly of surgically repositioning the maxilla or the mandible. Recently, molar intrusion by using skeletal anchorage has been developed as a new strategy for open-bite treatment. The aim of this research is to compare the effectiveness of 2 approaches: Molar intrusion Vs surgical impaction in skeletal open bite's control through a systematic review.

**Material and Methods:** A search of the literature was performed in the following data bases: PubMed, Science Direct, Cochrane library. The search was limited to publications written in english and french from 2010 to 2021

**Results:** Out of 83 references initially identified, 12 corresponded to our inclusion criteria. These studies have looked at molar intrusion using skeletal anchorage or surgical impaction of the maxillary with or without mandibular osteotomy in the treatment of skeletal open bite. These studies have reported an increased incisal coverage, decreased lower facial height, counterclockwise rotation of the mandible, and a satisfactory stability of results.

**Conclusion:** The intrusion of molars using implant anchorage seems to be the most rational therapeutic procedure for skeletal open bite patients offering satisfactory skeletal and dento-alveolar results.

**Keywords:** Maxillary surgical impaction, molar intrusion, skeletal open bite, skeletal anchorage, hyperdivergent

### Introduction

Skeletal open-bite malocclusions are characterized by an increase in anterior facial height known as the long face syndrome. It can easily be detected by a clinical observation <sup>[1]</sup>.

In grown patients, the reposition of the maxilla by an orthognathic surgery can create a significant rotation of the mandible, accordingly decreasing anterior facial height and correcting the open bite <sup>[2]</sup>.

However, the patients don't accept the surgical procedures because of the possible risks and complications, the higher medical costs, the long hospitalization. They prefer, in fact, an easier solution to their masticatory and aesthetic problem which is orthodontics. But orthodontic intrusion of molars was impossible in the past. Recently, temporary anchorage devices, as the miniplates and miniscrews, have been used to intrude the maxillary molars to allow autorotation of the mandible to close an anterior open bite <sup>[3,4]</sup>.

However, it is unknown which method is better for treating skeletal anterior open bite. The aim of this research is to compare the effectiveness of the two approaches: Molar intrusion and surgical impaction of the maxilla in skeletal open bite's control through a systematic review.

### Material and methods

#### Research strategy

A systematic search was performed in several databases (Pub Med, Science direct, Cochrane Library) covering publications from 2010 to 2021. The search was made with reference to the acronym PICOS, using the following keywords in English and French: Maxillary surgical impaction, molar intrusion, skeletal open bite (table 1)

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**Table 1:** Question PICO

<b>Population</b>	Adults patients with skeletal open bite
<b>Intervention</b>	Maxillary surgical impaction / Molar intrusion
<b>Comparison</b>	Skeletal open bite adult patients treated by molar intrusion / maxillary surgical impaction
<b>Out come</b>	Efficacy and stability of the results obtained by maxillary surgical impaction or molar intrusion
<b>Studies</b>	Comparative studies: clinical trials, retrospective studies, cohort studies...

**Selection criteria**

**Inclusion criteria**

- Articles published from 2010 to 2021
- Full text accessible
- Articles published in English or French
- Original article, prospective, retrospective, longitudinal or cross-sectional studies, cohort study, case-control study, randomized control trials
- Adults patients with skeletal open bite
- Conventional orthodontic treatment with or without extractions
- Molar intrusion by conventional orthodontic treatment with or without skeletal anchorage
- Surgical maxillary impaction with or without mandibular surgery

**Exclusion criteria**

- A Case report
- Literature revues
- Studies including growing patients
- Orthodontic treatment with clear aligners
- Surgical treatment with mandibular osteotomy only

**Quality assessment**

The selected articles were scored based on the proposed criteria by “National Institutes of Health, USA” [5]. Risk of bias in studies was assessed by the authors, independently. Concerning the risk of bias, the studies which total number of points is between 9 and 13 were rated as low risk of bias, those for which the number of points is between 6 and 8 were rated as medium risk, a high risk is assigned to studies that meet or less than 5 criteria.

The risk of bias was considered medium in five studies, and low in seven studies observation. (table2)

**Tableau 2:** Assessment of risk of biases

Quality assesment	Teittinen. M et coll (2012) [6]	Ibitayo A.O et coll (2011) [9]	Maia F.A et coll (2010) [12]	Romero D.G et coll (2012) [15]	Deguchi. T et coll (2011) [7]	Marzouk. E.S et coll (2016) [8]	Turkar-rahman. H et coll (2019) [10]	Akan S et coll (2011)	De Oliveira M.T.F et coll (2014) [14]	Beak MS et coll (2010) [16]	Hart T.R et coll (2015) [17]	Scheffler. NR et coll (2014) [11]
Research question	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Study population	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Groups recruited from the same population and uniform eligibility criteria	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Justification of sample size	No	No	No	No	No	No	No	No	No	No	No	No
Exposure assessed before measurement of results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sufficient time to see an effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Different exposure levels of interest	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Exposure measurements and assessment	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Repeated exposure assessment	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No	No
Outcome measures	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blinding of exposure assessors	No	No	No	No	No	No	No	No	No	No	No	No
Follow-up rate	No	No	No	No	NA	No	NA	NA	NA	No	NA	No
Statistical analysis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Results	9	9	9	9	8	9	8	8	8	9	8	7

**Results**

On the basis of the key words, 83 bibliographical references were initially identified. After eliminating the duplicates, 79 were retained. The study of the titles allowed to select 46 articles. Then, after the reading of the full text, 12 articles were included in this systematic review.

Three studies have evaluated the effect of surgical maxillary impaction with or without mandibular osteotomy, eight studies have evaluated the effect of molar intrusion by a skeletal anchorage and only one study has compared the two procedures.

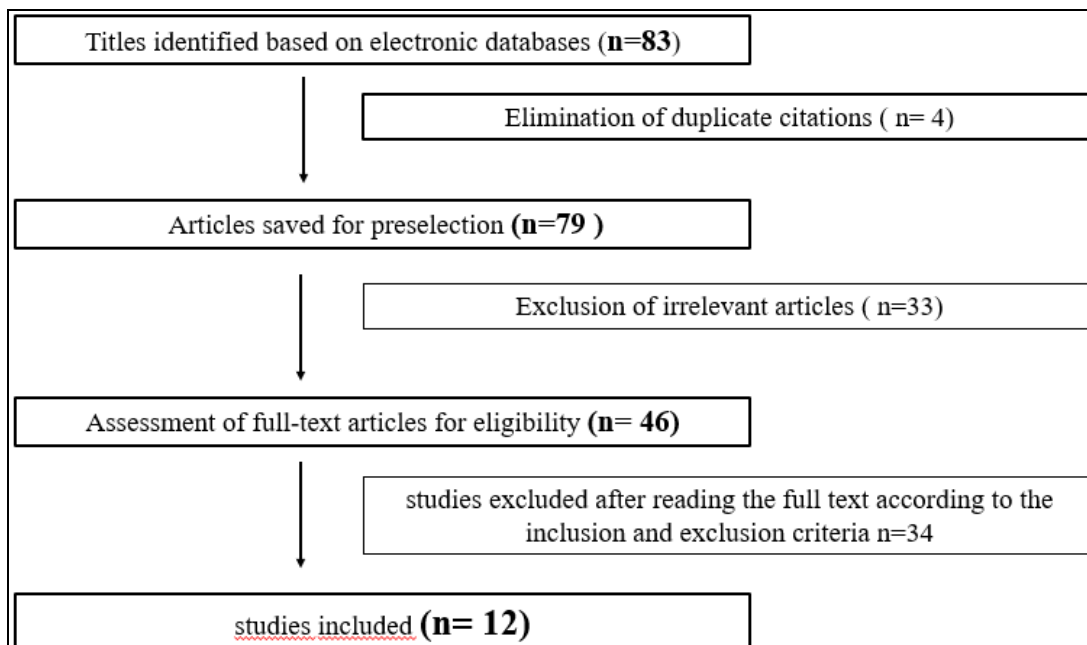


Fig 1: Flow diagram

Fig 2: Analysis of the studies selected

Study	Type of study	Aim of study	Intervention	Participants	Comparison	Results
Teittinen. M et coll (2012) <sup>[6]</sup>	Retrospective study	To assess the long-term stability of the correction of an anterior open bite by orthognathic surgery	Maxillary surgery (Le Fort I) Bi-maxillary surgery (Le Fort I + bilateral sagittal osteotomy)	24 participants Group Le Fort 1: -12 participants - average age: 29.3 years -Over bite = - 2.55mm +/- 1.41 -SN -mandibular plane = 38.1 ° +/- 6.33 -ANB: 1.52 ° +/- 3.37  Bimaxillary surgery group: -12 participants -30.8 years -over bite: -2.19mm +/- 1.44 -SN-mandibular plane: 42.08 ° +/- 9.27 -ANB: 4.65 ° +/- 5.82	Before / after maxillary surgical impaction -before / after bi maxillary surgery - Cephalometric analysis performed on lateral teloradiographs: T1: before surgery T2: Immediately after surgery T3: 3.5 years for the Le Fort 1 group 2 years for the bi maxillary surgery group.	→ Maxillary surgical impaction group (Le Fort I) -Over bite: T2: 1.23mm +/- 1.05 T3: 1.85mm +/- 0.93 -SN-mandibular plane: T2: 34.17 ° +/- 7.3 T3: 35, 84 ° +/- 5, 95 →Bimaxillary surgery group: -over bite: T2: 0.98mm +/- 1.53 T3: 0.73mm +/- 0.93 -SN-Mandibular plane: T2: 37.48 + / 8.47 T3: 41.25 ± 10.37 -The overbite is more stable in the group having undergone maxillary surgery (Lefort I) only. -Egression of the upper and lower incisors (0.6mm on average) observed in the 2 groups
Deguchi.T et coll (2011) <sup>[7]</sup>	Retrospective study	To compare the stability of the results of molar intrusion performed by the Edge Wise technique without skeletal anchorage and the technique using skeletal anchorage (mini implants)	-Molar intrusion via skeletal anchorage (Mini screw) -Orthodontic treatment by the Edge Wise Technique without skeletal anchorage	30 adults: 2 groups (15 treated by Edge Wise technique and 15 by mini implant)  -15 patients for treatment using the Edge Wise technique without mini screws : 22.9 +/- 4.9 years ANB: 5.4 ° +/- 2.4 SN-mandibular plane: 43 ° +/- 4.3 Anterior open bite: - 4.6mm +/- 1.5 15 patients for molar intrusion: ANB: 5.4 ° +/- 2.4 SN-mandibular plane: 45.8 ° +/- 6 Anterior open bite: - 4.4mm +/- 1.2	-before / after molar intrusion by skeletal anchorage -before after treatment with the Edge Wise technique without skeletal anchorage  - Cephalometric analysis On lateral teloradiographs performed before and after treatment	-Significant reduction in hyperdivergence in the 2 groups but the best results are those obtained with mini-implants (better stability). The group without implant (conventional Edge Wise treatment) had an extrusion of the incisors and molars leading to clockwise rotation of the mandibular plane SN-mandibular plane: 2.7 ° +/- 3.2, and OB: 1.9mm +/- 1.1 whereas in the group with implant, the patients had a counterclockwise rotation of the mandibular plane SN-mandibular plane: - 3.6 ° +/- 2.1 following the intrusion of the molars (2mm on average) and the incisor extrusion was kept to its minimum (0.8 mm and 0.7 mm extrusion of the maxillary and mandibular incisors respectively) OB: 1.8mm +/- 1.1 -reduction of ANB: -1.6 ° +/- 1
Marzouk. E.S et coll (2016) <sup>[8]</sup>	prospective study	Assessment of the long-term stability of molar ingression and the correction of anterior open bite	Molar intrusion via zygomatic anchorage (Mini plates)	-26 patients -Average age 22.5 +/- 2.4 -CI I or II malocclusion -ANB: 6.86 ° +/- 1.13 -AFH: 78.05mm +/- 5.83	-Dentoskeletal results obtained by molar intrusion via skeletal anchorage - Cephalometric analysis: lateral cephalograms before	T1-T2: -Statistically significant increase in incisal overlap 6.93mm +/- 1.99 -Statistically significant decrease in mandibular SN-plane: -2.13 ° +/- 0.31 - Counterclockwise rotation of the mandible

				-SN-mandibular plane: 49.05 ° +/- 3.90 -over bite: -4.75 mm +/- 2.27	treatment (T1), Immediately after (T2), 1 year after (T3), 4 years after (T4)	T1-T2: -decrease in AFH: -3.75mm +/- 1.17 - statistically significant extrusion of the maxillary incisors + 2.5mm +/- 0.11 T2-T4: Statistically significant increase in ANB + 0.61 ° +/- 0.10 -not statistically significant increase in mandibular SN-plane and AFH of 0.51 ° +/- 3.5 and 1.07mm +/- 5.02 respectively -not statistically significant decrease in over bite: -0.77mm +/- 0.43
Ibitayo A.O et coll (2011) <sup>[9]</sup>	Retrospective study	To compare the results obtained by bimaxillary surgery (Le Fort I + bilateral sagittal osteotomy of the mandible) in hyperdivergent patients with skeletal CLII with an untreated control group	Bi-maxillary orthognathic surgery: Le Fort I + bilateral sagittal osteotomy of the mandible	-- 15 patients: - average age 23 years and 6 months -Bimaxillary surgery ANB: 5.06 ° Over bite: 0.5mm GoGnSN: 39.2 ° AFH: 126.48mm PFH: 73.91mm FMA: 31.73 ° 17 non-growing patients: control group ANB> 4.5mm; FMA> 28 °; SN-GoGn> 35 °	- Before / after bimaxillary surgery -surgically treated group / untreated group -using lateral cephalograms : T1: before surgery T2: 2 weeks after surgery T3: 1 year later	-ANB : T2: -1,37 mm T3 : -2,25mm -Over bite : T2 : -0,37mm T3 : +0,65mm -GoGnSN : T2 : -3° T3 : -2,99° -FMA : T2 : -3,58° T3 :-3,33° -AFH : T2 :-0,88mm T3 : -1,63mm -PFH : T2 :-2,24mm T3 : 0,71 →Counterclockwise rotation of the mandible and clockwise rotation of the occlusion plane statistically significant
Turkarrahman. H et coll (2019) <sup>[10]</sup>	Retrospective study	To evaluate the effect of skeletal anchorage in the correction of skeletal open bite	Molar intrusion by skeletal anchorage	40 patients classified into 2 groups: -G1: 20 patients with an average age of 16.68 +/- 2.8 years -Skeletal anchorage -GoGnSN: 43.95 ° ± 6.68 -over bite: 4.34mm ± 1.71 -SN-occlusion plane: 19.69 ± 4.67 -AFH: 79.35mm ± 6.16 -G2: 20 patients with an average age of 16.63 +/- 2.8 years -Without any treatment -Over bite: -4.63mm ± 1.42 -SN-occlusion plane: 17.95 ° ± 3.72 -AFH: 81.01mm ± 7.91 -GoGnSN: 40.59 ° ± 4.7	Comparison of dentoskeletal effects after molar intrusion via skeletal anchorage: between (G1, G2) and G1 (before / after) -lateral cephalograms done: T1: before molar ingression T2: directly after treatment	Statistically significant results -Statistically significant molar intrusion of 3.59mm +/- 1.34 -no incisor extrusion noted - Posterior rotation of the occlusion plane of 3.42 ° +/- 2.17 -Anterior rotation of the mandible: -2.25 ° +/- 1.21 -Increase of the overbite 4.82mm +/- 1.53 -AFH: -3.3mm +/- 1.68
Scheffler. NR et coll (2014) <sup>[11]</sup>	Non-randomized retrospective study	-To assess the effect of molar intrusion by skeletal anchorage in the control of skeletal open bite and the closure of anterior open bite -To comparison of the results with a group of patients having undergone maxillary impaction (Lefort I osteotomy)	Molar intrusion by skeletal anchorage (mini plate) Maxillary surgical impaction (Lefort I osteotomy)	-molare intrusion group : 33 patients, Average age: 24.1 +/- 10.7 years, Overbite: 1.2mm +/- 1.7, Hyperdivergent -Maxillary surgical impaction: 37 patients, hyperdivergent, severe anterior open bite> 5mm, non-growing patients	-Before / after molar intrusion -skeletal and dentoalveolar changes (group having undergone molar intrusion by skeletal anchorage / group having undergone surgical maxillary impaction) -lateral cephalograms : before, in progress, directly after treatment, 1 year after and 2 years later	-Intrusion of maxillary molars (-2.3 mm +/- 1) -reduction in AFH of -1.6mm +/- 2.2 -Light incisor extrusion of 0.3mm +/- 1.8 - counterclockwise rotation of the GoGnSN mandible: -1.2 ° +/- 1.0 →Lefort I shows promising results in reduction of AFH compared to molar ingression
Maia F.A et coll (2010) <sup>[12]</sup>	Retrospective study	To assess the long-term stability of the orthognathic surgery in anterior open bite patients	-surgical maxillary impaction (Lefort I osteotomy) - bilateral sagittal mandibular	39 participants Average age: 20.83 years CI = 3 CII = 20 CIII = 16 9 Patients underwent bilateral sagittal	-Before / after orthognathic surgery - long-term stability of results - Cephalometric analysis on lateral cephalograms taken: T1: Before surgery	ANB: T2: 2.87 ° +/- 4.04 T3: 3.89 ° +/- 4.79 FMA: T2: 31.37 ° +/- 5.47 T3: 32.32 ° +/- 6.64 GoGnSN: T2: 36.92 ° +/- 5.91

			osteotomy	mandibular osteotomy 20 underwent bi-maxillary surgery (Lefort I + bilateral sagittal osteotomy) 10 patients underwent maxillary impaction only (Lefort I) On average : ANB = 2.59 ° +/- 5.3 FMA = 33.52 ° +/- 5.7 GoGnSN = 38.63 ° +/- 5.65 Over bite = -4.25 mm +/- 2.03	T2: immediately after T3: 2 years later	T3: 36.76 ° +/- 7.02 Over bite: T2: 1.10mm +/- 0.82 T3: 0.04mm +/- 1.81 -Statistically significant relapse in 35.89% of subjects -Relapse is less in patients treated with Lefort I only -Long-term stability of open bite correction is in 87.82% of CIII patients compared to 47.82% of CI and CII patients
Akan S et coll (2011) [13]	Retrospective study	To assess the effect of molar intrusion using a zygomatic anchorage (mini plates) on the dentofacial system in hyperdivergent patients	Molar intrusion	19 patients Average age: 17.7 years 8 patients with C I Treatment with extraction 14-24 11 Patients with CII Without extraction -all patients with an anterior open bite of: -3.21 ± 1.37 mm -GoGnSN = 45.58 ° ± 7.33 -FMA: 36.32 ° ± 7.03 -AFH: 82.22 mm ± 3.33 -IFH: 57.05 ± 4.92 -ANB: 5.11 ± 2.81	- before / after molar intrusion by skeletal anchorage -lateral cephalograms done : -To: before treatment -T1: directly after the treatment	Statistically significant results: Over bite: + 4.79 mm +/- 1.36 GoGnSN: - 3.79 ± 1.87  FMA: - 3.26 ± 1.56 AFH: - 2.82 ± 0.07 -IFH: - 4.16 ± 1.71 -ANB: - 2.42 ± 1.30 - Counterclockwise rotation of the mandible of 4.16 ° on average and intrusion of molars of 3.37mm on average
De Oliveira M.T.F et coll (2014) [14]	prospective study	To assess the dental and skeletal changes induced by molar intrusion with zygomatic anchorage in hyperdivergent patients	Molar intrusion by skeletal anchorage	9 patients: 6 women and 3 men - an average age of 18.7 +/- 5.1 years -CL I or skeletal CLII - anterior open bite -SN-mandibular plane: 35.44 ° ± 3.42 -AFH: 128.41mm ± 11.00 -SN-occlusion plane: 7.31 ° ± 4.65	before / after molar intrusion via skeletal anchorage in hyper divergent lateral Cephalograms taken: -T1: before molar intrusion; - T2: after treatment	- closure of the anterior open bite in all patients -Statistically significant counterclockwise rotation of mandibular of 1.57 ° - Statistically significant clockwise rotation of the occlusion plane of 4.27 ° -Statistically significant reduction in anterior facial height of 1.79mm - molar intrusion of 2.03 mm
Romero D.G et coll (2012) [15]	Retrospective study	-assess the skeletal changes obtained by bi-maxillary surgery in skeletal patients, and severe hyperdivergence -assess the stability of long-term results (6 years)	Bi-maxillary orthognathic surgery: Lefort I + bilateral sagittal osteotomy of the mandible	19 patients Average age: 19 years old (18-21 years old) -ANB: -2.82 ° +/- 2.28 -GoGnSN: 84.76 ° +/- 1.61 - anterior open bite	- Before / after bi-maxillary surgery in skeletal cl III patients and severe hyperdivergence -long term stability - lateral cephalograms -M1: measurements before surgery -M2: measurements immediately after surgery -M3: measurements 6 years after treatment	Short term : - closure of the anterior open bite in all patients - Counterclockwise rotation of the mandible (GoGnSN: -1.63 ° +/- 0.74) -Advance of the maxilla (SNA: + 3.97 ° +/- 2.14, retraction of the mandible (point SNB: -1.63 ° +/- 1.09) -ANB: + 5.61 ° +/- 2.16 Long-term : Statistically significant relapse: GoGnSN: + 2.11 ° +/- 1.40
Beak MS et coll (2010) [16]	Retrospective study	Evaluate the long-term stability of molar intrusion in the correction of skeletal open bite	Molar intrusion by skeletal anchorage (mini-screw )	9 patients (3 patients with premolar extraction and 6 without extraction) Average age: 23.7 years Duration of treatment: 28, 8 months -SN-mandibular plane: 45.44 ° +/- 4.11 -ANB: 4.6 ° +/- 1.28 -over bite: -3.91mm +/- 1.65	Before / after molar ingression Long-term stability of the results obtained - lateral cephalograms T1: before treatment T2: directly after treatment Q3: 1 year later T4: 4 years later	SN-mandibular plane: -2.03 ° +/- 1.59 ANB: -0.66 ° +/- 0.79 Over bite: 5.56 mm +/- 1.94 - Counterclockwise rotation of the mandible Incisor extrusion 1.05mm +/- 1.4 The results are similar in the 2 groups of patients -More than 80% molar intrusion relapse was in the first year after treatment
Hart T.R et coll (2015) [17]	Retrospective study	To assess dental and skeletal changes after maxillary molars intrusion in subjects with an anterior open bite	Ingression molaire via des mini implants	31 patients: Average age 20.7 years Anterior open bite: -3mm +/- 1.9 ANB: 5.5 ° +/- 3.2 AFH: 73.3mm +/- 7.4 Mandibular plane / Frankfort plane: 32.4 ° +/- 6.3	Before / after molar intrusion via mini implants - lateral cephalograms before and after treatment	-Statistically significant increase (SS) in overbite + 3.8mm +/- 0.94 -Statistically significant decrease in ANB -1.2 +/- 1.22 - counterclockwise rotation (SS) of the mandible of -1.1 +/- 0.09 - clockwise rotation of the occlusion plane of 1.3 +/- 0.13 (SS) -decrease in AFH by 1.5mm +/- 0.03 (SS)

				SN- Occlusion plane: 22.9 +/- 5.3	- mean ingression of 2.3 mm and 1.6 mm of the 1st and 2nd molars respectively. -Dental and skeletal outcomes are more apparent in adolescents than adults.
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## Discussion

Correcting vertical excess has always been a compromising challenge for the orthodontist, especially in adults patients.

The aim of this systematic review is to compare the effectiveness of the two approaches: Molar intrusion and surgical impaction of the maxilla in skeletal open bite's patients. Following an appropriate research protocol, our work included 12 studies matching our selection criteria.

The surgical approach generally consists of an impaction of the maxilla (Le Fort I osteotomy) associated or not to a mandibular osteotomy allowing the increase of the overbite, the harmonization of the face and the profile and ensuring a functional and stable occlusion.

But nowadays, with the advent of skeletal anchorages, the management of the vertical direction by molar intrusion represents a less invasive approach offering promising aesthetic and functional results, especially, not involving the cooperation of the patient.

Kuroda *et al.* 2007<sup>[18]</sup> compared through their study the skeletal and dentoalveolar changes detected in two groups of patients [the first group (Over bite > 5mm) having undergone a surgical maxillary impaction associated or not with a mandibular osteotomy and the second (Over bite < 5mm), having undergone molar ingression by skeletal anchoring] in order to correct the excess of anterior facial height and reported that in the first group, a decrease in facial height of 3.8mm and the increase in overlap of 6.8mm but the extrusion of the upper and lower incisors by 2.6mm and 2mm respectively was inevitable.

These results are in agreement with the study conducted by Proffit *et al.* 2003<sup>[19]</sup>, Teittinen 2012<sup>[6]</sup> and Sheffler *et al.* 2014<sup>[11]</sup> who reported similar results.

In addition, Teittinen *et al.* 2012<sup>[6]</sup> and Maia *et al.* in 2016<sup>[12]</sup> reported a more stable recovery in the group having undergone surgical impaction of the maxilla only (rate of stability: 100%) compared to the group of bimaxillary surgery (the stability rate: 92%) corroborating the results of Proffit *et al.* 2014<sup>[20]</sup> who confirmed that after maxillary impaction surgery (Le Fort I osteotomy) the recovery stability rate obtained is (99%) while for bimaxillary surgery, it is (86%).

Other studies have looked at molar intrusion by skeletal anchorage in the treatment of hyperdivergence, and all have reported increased overbite, decreased lower facial height, and counterclockwise rotation of the mandible. These results are in agreement with all the previous studies, as Akan S *et al.* 2013<sup>[13]</sup> which evaluated the effect of the maxillary molars intrusion by zygomatic anchorage and reported a decrease in facial height of an average of 3.37mm as well as an anterior rotation of the mandible of an average of 4.16 ° in the patients included in their study.

Similarly, Alsafadi AS *et al.* 2016<sup>[21]</sup> then Kim K *et al.* in 2018<sup>[22]</sup> reported similar results.

Several authors, notably Kim *et al.* in 2009<sup>[22]</sup> and Paik *et al.* in 2003<sup>[23]</sup> do not find a significant difference in the results of increased recovery and reduction in facial height obtained by orthognathic surgery. However, the study by scheffler *et al.* in 2014<sup>[11]</sup> demonstrated that Lefort I gives promising results in the reduction of AFH compared to molar intrusion.

Turkahraman *et al.* 2019<sup>[10]</sup> reported that in patients who underwent molar intrusion via skeletal anchorage, they didn't notice any incisor eruption, the same for Kurodo *et al.* 2007

<sup>[18]</sup>. However, Baek *et al.* 2010<sup>[16]</sup> and Sheffler *et al.* 2014<sup>[11]</sup> noted minimal incisor extrusion.

However, the instability of the results is a cause of dissatisfaction for both practitioners and patients. The relapse is commonly described in different studies. Indeed, Deguchi *et al.* 2011<sup>[7]</sup> as well as Scheffer *et al.* 2014<sup>[11]</sup> reported a relapse rate of 16% and 12% respectively, 1 year after treatment. These results are in agreement with those of Lee *et al.* in 2008<sup>[24]</sup> who reported a relapse rate of 18%, 1 year post-treatment, while Marzouk *et al.* 2018<sup>[8]</sup> reported a relapse rate of 11%, 4 years after treatment. Indeed, according to the study by Baek *et al.* 2010<sup>[16]</sup>, most (80%) of relapse of first molars intruded and the overbite occurs during the first year of retention. So, they suggest that effective retention during the first post-treatment year would provide long-term stability, considering the initial skeletal pattern, muscle strength, lingual and soft tissue influence.

Regarding the correction of hyperdivergence by molar intrusion using the conventional orthodontic technique without skeletal anchorage, Zurroff Jp *et al.* 2010<sup>[25]</sup> reported a higher relapse rate of up to 30% after 10 years of treatment, corroborating the results of Deguchi *et al.* 2011<sup>[7]</sup> who found the same rate after 2 years.

Baek *et al.* 2010<sup>[16]</sup> were the first to report the long-term stability (+3 years) of skeletal anchorage in patients with vertical facial height excess. The retentions used, were in place for 36 to 51 months. They didn't note any significant change in any skeletal parameter between 1 and 3 years.

Then, the systematic review done by Bueno-médeiros *et al.* 2011<sup>[26]</sup>, which aims to study the long-term stability of the different management approaches for hyperdivergent patients with associated anterior open bite, and which reported a long-term stability rate of up to 89% following surgical impaction of the maxilla, a result rather similar to that of orthodontic treatment by molar intrusion via a skeletal anchorage representing 84%.

Therefore, the correction of the excess of anterior facial height by molar intrusion using a skeletal anchorage is a valid, simpler and less invasive alternative to orthognathic surgery. Indeed, the results of our work are in perfect agreement with the comparative study, carried out by kurodo *et al.* in 2007<sup>[18]</sup>, between orthodontic treatment by molar intrusion via skeletal anchorage and surgical impaction of the maxilla in the correction of excess of anterior facial height.

## Conclusion

Molar intrusion is the most rational therapeutic procedure for correcting the vertical excess in skeletal open bite patients. A significant number of studies have proposed orthodontics methods of treatment of posterior intrusion and their results show satisfactory results.

Molar intrusion via skeletal anchorage now offers a real alternative to orthognathic surgery to improve function, occlusion and facial aesthetics.

## Limits

Although the success of the treatment appears to be well established, questions about stability and reliability remain unclear. How far can the posterior teeth be safely intruded? and, what are the criteria for choosing between these two therapeutic approaches?

Despite the results, this systematic review had some limitations in relation to the number of comparative studies available, the type of studies, the size and method of sample selection.

In order to improve the power of this systematic review, future studies are needed.

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