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SYSTEMATIC REVIEW

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Assessment of relapse of skeletal open bite treatment in adult patients treated with molar intrusion using temporary anchorage devices and orthognathic surgery - a systematic review

Avaliação da recidiva do tratamento da mordida aberta esquelética em pacientes adultos tratados com intrusão molar utilizando dispositivos de ancoragem temporária e cirurgia ortognática - uma revisão sistemática

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ABSTRACT

Objective: The purpose of this study is to systematically assess the available evidence for relapse of skeletal open bite treatment using temporary anchorage devices and orthognathic surgery. **Materials and Methods:** Five electronic databases such as MEDLINE, COCHRANE, SCIELO, GOOGLE SCHOLAR, EMBASE were systematically searched up to June 2020. Methodological quality studies were graded by means of the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool. **Results:** In total, 1005 studies were identified for screening, and 6 studies were eligible. The quality assessment tool showed moderate quality for all the studies. The immediate post treatment correction of open bite was better in the surgical studies than in the studies treated with TADs. **Conclusion:** Stability of treatment results of anterior openbite was comparable in cases treated in both the treatment modalities. Relapse of anterior open bite was associated with cases in which the posttreatment overbite was minimal. Overbite seems to be more stable when only the maxilla has been operated on than with bi-maxillary surgeries. Counterclockwise rotation of the mandible with subsequent reduction of anterior facial height was better in surgical correction than through TADs.

KEYWORDS

Skeletal open bite; Temporary anchorage devices; LeFort 1 impaction; Bi-maxillary surgery.

RESUMO

Objetivo: O objetivo deste estudo é avaliar sistematicamente as evidências disponíveis para recidiva do tratamento da mordida aberta esquelética usando dispositivos de ancoragem temporária e cirurgia ortognática. **Material e Métodos:** Cinco bases de dados eletrônicas como MEDLINE, COCHRANE, SCIELO, GOOGLE SCHOLAR, EMBASE foram pesquisadas sistematicamente até junho de 2020. Os estudos de qualidade metodológica foram classificados por meio da Ferramenta de Avaliação de Qualidade do Projeto de Práticas de Saúde Pública Eficazes (EPHPP). **Resultados:** No total, 1.005 estudos foram identificados para triagem e 6 estudos foram elegíveis. O instrumento de avaliação da qualidade apresentou qualidade moderada para todos os estudos. A correção imediata pós-tratamento da mordida aberta foi melhor nos estudos cirúrgicos do que nos estudos tratados com TADs. **Conclusão:** A estabilidade dos resultados do tratamento da mordida aberta anterior foi comparável nos casos tratados em ambas as modalidades de tratamento. A recidiva da mordida aberta anterior foi associada a casos em que a sobremordida pós-tratamento foi mínima. A sobremordida parece ser mais estável quando apenas a maxila foi operada do que com cirurgias bimaxilares. A rotação anti-horária da mandíbula com subsequente redução da altura facial anterior foi melhor na correção cirúrgica do que através de TADs

PALAVRAS-CHAVE

Mordida esquelética aberta; Dispositivos de ancoragem temporários; Impactação LeFort 1; Cirurgia bimaxilar.

INTRODUCTION

Anterior open bite is one of the most difficult malocclusions to be treated by orthodontics alone. Anterior open bite poses significant challenges in restoring esthetics of an individual, as it has its contribution from both the dentoalveolar and skeletal components [1]. Though immediate treatment result shows good improvement in open bite correction, the long-term stability still remains questionable [2]. The most common treatment modality for anterior open bite has been extrusion of the maxillary anterior teeth, which has the disadvantage of compromising smile esthetics of the individual. Long term stability of results of extruding incisors to correct openbite in growing individuals are compromised by the post adolescent growth changes [3,4]. Skeletal open bite usually exhibits increased posterior dental height, associated with clockwise rotation of the mandible leading to long face syndrome which has its impact on facial aesthetics [3].

Advent of Temporary Anchorage Devices (TAD's) has expanded the envelope of orthodontic tooth movement and renders non-surgical treatment of border line cases [3]. Despite the short-term success rate of tooth movement achieved by inclusion of TADs in the treatment, they are invasive and their long-term success rate is yet to be thoroughly researched [5].

For non-growing patients option of camouflaging the openbite by maxillary anterior dental extrusion or surgical correction by maxillary impaction or bi-maxillary surgery are available and should be presented to the patient [6]. Several studies reporting the immediate and short-term stability of surgical correction of anterior open bite found it to be fairly stable, studies on long- term stability still report a tendency of relapse [1,2]. Literature also states that post-surgical changes are bound to occur 5 years after the initial surgery for open bite correction [2]. Various studies have shown that the factors influencing long term stability of surgically corrected anterior open bite can be the type of fixation used, number of jaws operated on and post treatment dentoalveolar stability [1]. Though surgical correction of skeletal openbite has been followed for decades, there is definitive promise in using TADs for correction of moderate amount of openbite by intrusion of maxillary posterior teeth. The purpose of the present study is to systematically evaluate the available evidence for the long-term stability of the treatment of anterior open bite by using Temporary Anchorage Devices (TADs) and that by orthognathic surgery in adult patients.

MATERIAL AND METHODS

Search strategy

The protocol for the present study was registered in PROSPERO with the registration number: CRD42020201573. This review was planned, conducted, and reported in adherence to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards of quality for reporting systematic reviews and Meta-Analyses [7]. Five electronic databases such as MEDLINE, COCHRANE, SCIELO, GOOGLE SCHOLAR, EMBASE were systematically searched up to June 2020. The search strategy included limitations concerning language (English only), and on publication year, or status.

The search strategies that were employed -

"(Anterior open bite or molar intrusion or posterior teeth intrusion or maxillary impaction) AND (Stability or outcome)"

Research question

The purpose of the study was to compare the stability of anterior open bite correction by posterior teeth intrusion using TADS and orthognathic surgery and the question was assigned accordingly to the PICOS format as:

Population: Orthodontic patients undergoing fixed appliance therapy with anterior open bite malocclusion;

Intervention: Non-surgical treatment with TAD orthodontic appliances using the extraction or non-extraction method;

Comparison: Surgical treatment with orthodontic appliances for open bite correction;

Outcomes: To check the relapse of open bite correction following orthognathic surgery or temporary anchorage devices (TADs);

Study design: case control studies, studies involving clinical trials (prospective and retrospective).

Eligibility criteria

The studies that satisfied the following eligibility criteria were included in the systematic review:

(i) **TYPE OF STUDIES:** Case control trials, prospective, retrospective studies, studies that identified treatment methods as TADS or orthognathic surgery for open bite correction, studies with overbite data at pre-treatment, post-treatment, and post-retention periods, studies that assessed the treatment results at a post-retention period of at least 1 year and studies which assessed the relapse of anterior open bite following surgical correction and by employing TADs;

(ii) **PARTICIPANTS:** Orthodontic patients undergoing fixed appliance therapy with permanent dentition who had anterior open bite malocclusion requiring treatment through TADs or surgical correction.

Exclusion criteria

Studies including subjects with Craniofacial pathologies, diseases, or syndromes that affected vertical skeletal pattern. Studies involving Case presentation, Case series, review articles, case reports with absence of statistical analysis, abstracts, interviews, unsupported opinion of experts, commentaries, letters to the editors, studies in languages other than English were excluded.

Study selection

Data was extracted independently by five authors using a data collection form. A standardized table was used to extract the data. Data was compared for accuracy, and any discrepancy was resolved through re-examination of the original study until a consensus was reached between all the authors. The total records assessed were 1005 from which 33 articles were assessed for full texts and 6 articles which fulfilled the inclusion criteria were included in this systematic review. The data extraction was done by the same reviewers (Table I). The data extracted from the selected articles involves sample size, initial open bite(mm), open bite reduction, first molar intrusion(mm), follow up duration, relapse(mm). Quality of the selected studies was assessed using the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool and presented in Table II [8].

RESULTS

Study selection

This systematic review was executed based on the PRISMA, 2009 statement [7]. The result of the search strategy is described in Figure 1. The search strategy employed generated 1005 articles among which 33 were narrowed down for full text review. The assessment revealed 6 articles to be analyzed for qualitative synthesis for this systematic review among which 5 were

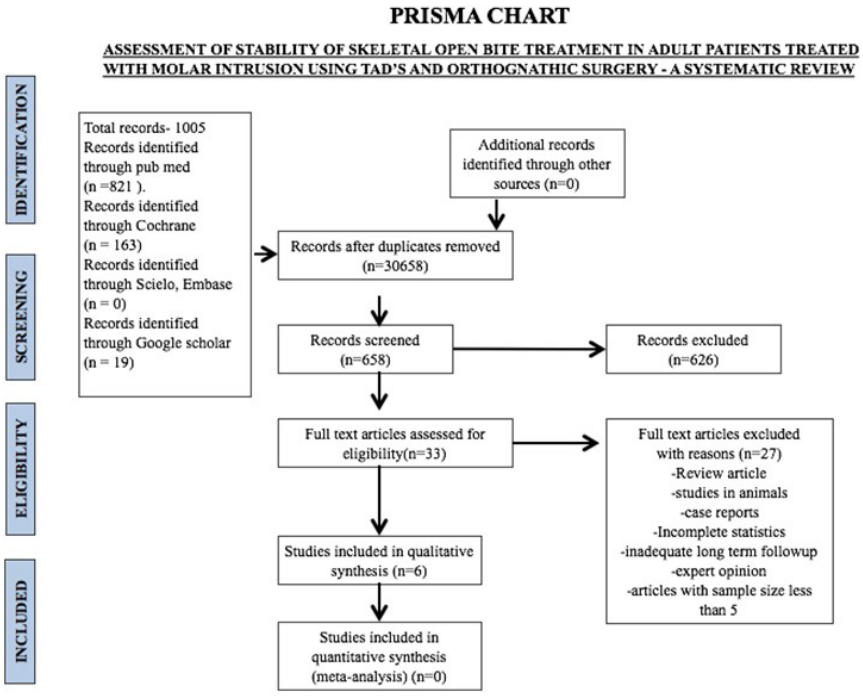

Figure 1 - PRISMA flowchart of article retrieval for the systematic review.

Table I - Summary of study characteristics of selected studies

sno	ARTICLE	DESIGN	METHOD OF INTRUSION	SAMPLE SIZE	INITIAL OPEN BITE (mm)	OPEN BITE RE-DUCTION	FIRST MOLAR INTRUSION(mm)	FOLLOW UP DURATION	OVERBITE AT THE END OF FOLLOW UP(mm)	OUTCOME
1.	**Deguchi et al. 2011** [5]	Retrospective study	Force of intrusion applied to buccal mini screws. Force element attached to sectional arch wire. Other group treated with anterior elastics	N=30 IA=15 Non -IA=15	-4.4 (1.2) -4.6 (1.6)	6.2 (1.7) (1.8) 6.5 (2.2) (1.9mm)	2.3 intrusion (1.3) 1.5 extrusion (1.3)	2years	OB:0.8mm (1.0mm) MI=0.5 OB=0.5 (1.4mm) MI=0.6	Relapse was reduced in miniscrews than conventional edgewise treatment.
2.	**Baek et al. 2010** [6]	Retrospective study	Mini screw placed buccally and palatally. Miniscrew buccally with TPA	N=9	-3.91 (1.65)	5.56 (1.94) (1.65mm)	2.39 (1.8)	1 year 3 year	OB: 0.99 (0.65mm) MI: 0.40 (0.59) OB:1.20 (0.45mm) MI: 0.45 (0.46)	Most relapse occurred during the 1st year of retention.
3.	**Scheffler et al. 2014** [3]	Retrospective study	Bonded maxillary splint attached to TAD	N=30 Miniscrew=16 patients Miniplate=14 patients	-1.2 (1.7)	2.2 (1.6) debond 0.9mm	2. 3 (1.4)	1 year 2 year	OB: -0.3 (0.8) MI:0.5 (1.1) OB: -0.4 (1.1) MI: 0.5 (1.2)	Most relapse occurred during the 1st year of retention.
4	**Teittinen et al. 2012** [1]	Case control	Lefort I max impaction / Lefort I max impaction+BSSO	N=24(12+ 12)	-2.55 (1.41) -2.19 (1.44)	1.23 0.98	Not available	3.5 Years 2 years	OB:0.59 (1.85mm) OB:-0.25 (0.73mm)	Overbite seems to be more stable when only the maxilla has been operated on when compared to bi-maxillary surgeries.
5	**McCance et al. 1992** [4]	Retrospective study	Class III-Lefort I downfracture and BSSO setback. Class II- BSSO advancement	N=21 Class III-11 Class II-10	-6.3 (3.8) -4.6 (4.9)	3.1 (1.9) -1.6 (1.9)	Not available	1 year	2.4 (1.2) -1.7 (1.9)	Relapse of class III openbite is less than class II open bite.
6.	**Swinnen et al. 2001** [2]	Retrospective Study	LeFort I intrusion (+mandibular surgery +FA) LeFort I extrusion (+Mandibular Surgery + FA)	N=38 N=11	-6.4 -6.6	1.1 (0.3mm) 2.3 (0.2mm)	Not available	1.2 years	1.8mm +0.8mm	Both exhibit relatively good clinical, dental and skeletal stability.

Table II - Effective Public Health Practice Project (EPHPP) Quality Assessment Tool [8]

CRITERIA	Deguchi et al. 2011 [5]	Baek et al. 2010 [6]	Scheffler et al. 2014 [3]	Teittinen et al. 2012 [1]	McCance et al. 1992 [4]	Swinnen et al. 2001 [2]
SELECTION BIAS	Moderate	Weak	Moderate	Moderate	Moderate	Moderate
STUDY DESIGN	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
CONFOUNDER	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
BLINDING	Weak	Weak	Moderate	Moderate	Weak	Moderate
DATA COLLECTION METHOD	Strong	Strong	Moderate	Moderate	Moderate	Moderate
WITHDRAWAL/ DROP OUT	Moderate	Moderate	Weak	Moderate	Moderate	Moderate
OVERALL GRADE	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

retrospective studies and 1 was case control study.

Study characteristics

The six studies included were all retrospective studies. Each study was described based on parameters like participant information, pre and post treatment record, sample size, age, sex, intervention, amount of openbite at the start of treatment and outcome assessed by parameters such as amount of openbite reduction immediately after treatment, quantitative value of molar intrusion achieved, duration of follow-up, overbite at the end of follow up duration. Summary of the selected studies are presented in Table I.

Risk of bias for individual studies

The risk of bias was assessed using Effective Public Health Practice Project (EPHPP) Quality Assessment Tool [8] and presented in Table II. The risk assessment revealed that all the studies have moderate risk of bias.Six parameters were assessed including study design, selection bias, confounding, blinding, data collection, dropout.

Results of individual studies

From the summary of information collected from selected studies, the following data were extracted. Of all the studies, McCance et al. [4] had the maximum initial pre-treatment open bite of -6.3(3.8)mm and evaluated the stability of anterior open bite following surgical correction. The overbite achieved at the end of treatment was 3.1mm but at the end of one year follow-up, it was 2.4mm amounting to about 0.6mm of relapse.

Swinnen et al compared the stability of openbite correction after Lefort 1 intrusion and downfracture [2]. They started with an initial openbite of 0.7mm in intrusion patients and achieved overbite of 1.3mm post surgery and 1.8mm at 1.2 years of followup. Teittinen et al compared the post-surgical stability of openbite correction after a prolonged follow-up of 3.5 years and found that immediate post-treatment overbite of 1.23mm was achieved, at followup the overbite was 1.85mm [1]. Scheffler et al evaluated the stability of anterior open bite following the treatment of bonded maxillary splint attached to either miniplates or miniscrews. Their patients had the least initial pretreatment open bite of -1.2(1.7) mm [3]. The post-treatment openbite was 2.2mm with 2.3mm of molar intrusion achieved. At the end of follow-up period, there was openbite of 0.3mm with the correction relapsed. Baek et al studied the amount of intrusion of posterior teeth during correction of openbite treated with mini-screw [6]. They observed that there was 1.65mm of overbite achieved at the end of treatment and amount of molar intrusion achieved was 2.39mm, after 1 year of follow-up overbite of 0.99mm was observed in buccal and palatal implant group and at the end of three years of follow-up the amount of overbite in buccal implant group was 1.20mm. Deguchi et al compared the open bite correction achieved by mini implant and elastics and found that about 2.3mm of molar intrusion was achieved in mini implant group with 0.8mm of overbite at the end of 2 year follow-up [5]. They achieved overbite of 1.8mm at the end of treatment. Of the six studies analyzed, clinical relapse of openbite was observed at follow-up in three of the studies, one that utilized mini-screws and mini-plates by

Scheffler et al. [3], two studies that evaluated open-bite correction by orthognathic surgeries: class II group of McCance [4] and combined LeFort 1 impaction and BSSO advancement by Teittinen et al. [1]. Relapse of openbite at follow-up is noticed in both the treatment modalities. Clinicians should follow the dictum of overcorrection in cases of open-bite correction to prevent relapse.

DISCUSSION

Development of open bite is associated with one of the two processes, excessive eruption of posterior teeth causing downward rotation of mandible or infra eruption of incisors which poses a challenge to orthodontists. Before the advent of temporary anchorage devices (TADs), open bite correction by intrusion of posterior teeth was a challenge [9-11]. This could be attributed to complex root morphology and the size of posterior teeth [10]. Several other techniques were utilized for open bite corrections such as extraoral anchorage devices, functional appliances, extraction procedures and other techniques [3]. Rigid Internal Fixation (RIF) through miniplates is an effective fixation technique after a surgical correction [10]. Before the introduction of RIF, intraosseous wires or piriform rim suspension wires were used, but the procedures had some limitations [1,2]. Kravitz et al reviewed the use of temporary anchorage devices to intrude maxillary molars and concluded that molars can be intruded upto 8mm in 7.5mm without the loss of tooth vitality [11]. Akan et al. [12] concluded that zygoma plates were effective in intruding posterior teeth whereas Xun et al. [13] and Lee and Park [14] recommended the use of mini screw anchorage to correct adult open bite as they were simpler and minimally invasive when compared to zygoma implants.

Surgical impaction of maxilla by Le-fort I osteotomy is a common technique to correct adult skeletal open bite. Profitt et al reviewed the hierarchy of orthognathic surgical procedures and concluded that superior repositioning of maxilla to correct skeletal open bite was the most stable of orthognathic surgeries in maxilla [15]. Proffit et al studied the long term stability of open bite correction using orthognathic surgeries-maxillary impaction alone and bi-maxillary surgery involving the mandible in three year follow-up and concluded that overbite reduction after three years was more in bi-maxillary surgery (12%) than in Lefort 1 impaction alone (7%) [16]. Similar results were observed by Teittinen et al, who concluded that relapse of openbite occurred in bi-maxillary surgery at the end of follow-up (Table I).

Studies have also confirmed that some amount of relapse occurs over a period of 1 year due to various factors [9,14]. Marjut Teittinen et al concluded that retention of positive overbite was more bi-maxillary surgeries than that of isolated maxillary surgeries [1]. The overbite achieved through maxillary surgery alone was 1.23 mm and both jaw surgery, about 0.98mm. When a one year follow up was conducted, the maxillary group's overbite recorded about 1.85mm and the bi-maxillary group had a reduction in openbite, with a reduced value of 0.73mm. The recurrence occurred mostly in the vertical direction for maxilla and mandible with an added sagittal component for the mandibular bone [1]. A one piece LeFort 1 osteotomy performed on maxilla can yield good results with reduced tendency for a relapse, rather than a mandibular ramus osteotomy alone [15-18]. Skeletal changes according to a study by Katlee Swinnen et al in two groups assessing open bite, were about 6.4mm and 6.6mm and overbite at the end of follow up was 1.8 mm and 0.8mm respectively, which occurred one year after the correction [2]. They postulated that skeletal landmarks for assessment might vary while in treatment, particularly during surgical correction. There is an increase in lower facial height prior to surgery attributed to an uprighting tendency of lower molar which subsequently increases the lower facial height. From the study conducted by Scheffler et al, it was evident that Le fort 1 maxillary impaction had more facial length reduction in comparison to a TAD assisted maxillary splint for intrusion [3].

McCance et al. [4] investigated the stability of a surgical orthodontic treatment and estimated the results. He concluded that in individuals with a skeletal class III condition, the mandibular plane angle was reduced by about 7° with a relapse of almost 1.7° over a period of one year. There was an increase of overbite from - 6 mm to +3.1 mm with a relapse of approx. 0.6 mm by the subsequent year. Toru Deguchi et al. [5] compared the effectiveness of a TAD anchorage and edgewise bracket system in correcting anterior open bite and concluded that treatment with

TADs yielded better results than in individuals treated with multibracket appliances.

For TAD intrusion of posteriors, a study by Man-Suk Baek et al. confirmed a counterclockwise rotation of mandibles with forward positioning of pogonion, resulting in the decrease in facial height [6]. The distance between the palatal plane and posterior teeth were also subsequently reduced. His study stated that a substantial relapse occurred in the first year after treatment, which pointed out the need to use a proper retention device. This could show better results even after one year of treatment [6]. From the synthesis (Table I) it is evident that orthognathic surgery and mini-screws/plates are equally effective in the treatment of openbite by either impaction of maxilla or intrusion of molars. Retention of the corrected malocclusion is dependent on various factors-

1. Clinical acumen in selection of technique for correction- patients with moderate openbite can be treated by mini-implants while increase in severity of openbite might warrant surgical correction;
2. Residual overbite at the end of treatment- increased amount of overbite achieved by overcorrection seems to prevent adverse relapse, hence its always better to overcorrect to a safety factor (class III group in the study of McCance et al. [4] – post treatment overbite is 3.1mm which is retained (2.4mm) with a minor relapse of 0.7 mm;
3. Method of surgical procedure followed- it was found that isolated maxillary surgeries fared better than bi-maxillary surgeries in terms of relapse of openbite.

LIMITATIONS

Owing to the heterogeneity of results observed from various studies, a quantitative meta- analysis could not be performed. Therefore, no forest plots or funnel plots were constructed and only simple descriptive and stratified comparisons were reported. Further research that has a larger sample size and increase in literary evidence in the form of randomized control trials in the topic are essential to provide a quantitative analysis.

CONCLUSION

Based on the results observed from the above study, the following can be concluded:

(i) Stability of openbite correction was comparable with both the treatment modalities -surgical and mini -implant assisted correction. Stability or prevention of relapse appears to be mainly associated with the amount of overbite achieved at the end of the treatment regardless of the method used. Relapse of anterior openbite was associated with cases in which the posttreatment overbite was minimal.

(ii) Overbite seems to be more stable in isolated maxillary surgeries than bi-maxillary surgeries.

Although the above conclusions were observations of this systematic research, they have to be tested through trials with greater sample size, extensive research and longer follow-up period to deem them definitive.

Authors' Contributions

PJ, DD, KR, KV, AS, AT, AH: study design, systematic search, quality analysis, summarizing the results of the studies, manuscript writing.

Conflict of Interest

Authors have no conflict of interest

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Regulatory Statement:

This study was conducted in accordance with all the provisions of the local human subjects

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