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Orthodontic canine substitution *vs.* implant-supported prosthetic replacement for maxillary permanent lateral incisor agenesis: A systematic review

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SUMMARY

Objective. The aim of this systematic review was to evaluate the results of two treatment methods: space opening for an implant and prosthetic replacement (PR) versus orthodontic space closure (SC) for maxillary lateral incisor agenesis (MLIA).

Material and methods. The protocol of the systematic review is in line with the PRISMA requirements. An electronic search was carried out on July 11, 2021 in Pubmed, ScienceDirect, Web of Science, and Plos One databases. The review included research articles published less than 10 years ago, written in English, involving both PR and SC methods in permanent dentition, and comparing and evaluating them.

Results. A total of 1,061 initially identified articles were found, full texts of 38 articles were read and assessed for eligibility, and 7 of them were included in this review. All of the articles evaluated the esthetics; in addition, 3 of them assessed periodontal health, 1 evaluated temporomandibular joint (TMJ) dysfunction, and 1 evaluated occlusion morphology disorders. One study of 7 found esthetics after SC to be statistically more pleasant, while the others found the results of both techniques to be equally esthetically satisfying. When comparing periodontal status between the groups, one study found gingival recession to be significantly more common in the SC group, while another article revealed that gingival recession and papillary defects were more common in the PR group. The remaining articles stated that there was no TMJ dysfunction, and differences in occlusion morphology disorders were not significant between the groups.

Conclusion. The results of MLIA treatment with SC were more favorable esthetically, but the difference was not statistically significant. There is no statistically significant data related to periodontal health, and neither of the treatment methods caused TMJ or occlusion morphology disorders. If both methods are available, space closure is preferable, although high-quality clinical trials are needed to find more evidence.

Keywords: incisor, anodontia, treatment.

INTRODUCTION

Tooth agenesis or hypodontia is the developmental absence of one or more teeth, excluding the wisdom teeth, in the primary or/and permanent dentition (1). It is one of the most common developmental anomalies in humans. Dental agenesis depends on the continent and sex: in Europe (males, 4.6%; females, 6.3%), its prevalence is higher than in North America (males, 3.2%; females, 4.6%). The prevalence of maxillary lateral incisor agenesis is approximately 1.5% - 2% (2). Besides, hypodontia of both maxillary lateral incisors is more frequent than agenesis of only one of them (3).

Tooth agenesis can reduce patients' chewing ability, may result in an inarticulate pronunciation, and may impair the balance and the symmetry of the smile leading to an unsatisfactory esthetic appearance that in most cases negatively affects patients' self-esteem. Especially, it can contribute to a significant social impediment for young people (4-6).

Hypodontia is a severe problem that constantly requires a challenging treatment. The phenomenon

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of tooth agenesis in the anterosuperior region has always concerned and engaged multidisciplinary teams of dental professionals and patients as it is an aesthetic dilemma.

For this reason, the demand for treatment of patients with hypodontia in the anterior segment is high, and highly satisfactory results can be achieved in these patients if procedures are carefully planned and performed with an interdisciplinary approach. Such treatment can restore the patient's esthetics and function, thus increasing the patient's self-confidence and improving interpersonal relationships (1). However, it requires a multidisciplinary team with the participation of an orthodontist, a prosthodontic surgeon, and an oral surgeon (7), the purpose being to restore the smile in terms of both function and esthetics. Some factors, including free space in the dental arch and alveolar bone, occlusion, profile, inclination of the incisors, and exposure of the gingiva, must be considered when planning the treatment. Maxillary lateral incisor agenesis has two of the main and well-established treatment options: 1) space opening for an implant and prosthetic replacement (PR) or 2) space closure (SC) with canine mesialization. There are some controversies in the literature regarding the assessment of the SC and PR methods.

Discussions continue on which approach allows for reaching better long-term results with regard to the patient's esthetics, periodontal health, and function (8). There are numerous articles on this subject. However, most of them are articles of opinion, case reports and case series, narrative reviews or studies with a single post-intervention evaluation and non-comparable control groups with a high risk of bias (9-11). In addition, the reviews are compiled of rather outdated studies. Consequently, there was a need for updating the search and reviewing the latest studies associated with this topic and for investigating if there are any new insights and significant evidence to prove which of the two treatment methods (space opening for implant and prosthetic replacement (PR) or space closure (SC) with canine mesialization) is better for maxillary lateral incisor agenesis (MLIA).

The aim of this systematic review was to assess two treatment alternatives: orthodontic space closure and implant-supported dental prostheses for patients with maxillary lateral incisor agenesis by comparing the esthetic, occlusal (functional), and periodontal results.

MATERIAL AND METHODS

The PRISMA selection criteria (Preferred Reporting Item for Systematic Review and Meta-Analyzes) were used for this systematic review (12) (Figure).

Protocol registration

The study protocol was not registered.

Eligibility criteria

1. Clinical studies that involve both PR and SC methods in permanent dentition, comparing and evaluating them.
2. Studies reporting the results — occlusal, periodontal, or esthetic aspects — of the different prosthetic treatments with orthodontic space opening for patients with maxillary lateral incisor agenesis, unilateral or bilateral, in the permanent dentition. In the space closure modality, only patients treated with fixed orthodontic appliances had to be included.
3. Articles with full text availability.
4. Research articles published less than 10 years ago.

PICOs

The clinical question was created using Population, Intervention, Comparison, and Outcomes (PICOs) format.

Population

Patients with unilateral or bilateral maxillary permanent lateral incisor hypodontia.

Intervention

Treatment of maxillary lateral incisor agenesis by orthodontic space closure and canine mesialization.

Comparison

Replacing missing lateral incisors using implants and implant-supported crowns.

Outcomes

Esthetic and periodontal assessment, and evaluation of TMJ and occlusion morphology disorders.

Exclusion criteria

1. Case series, case reports, systematic reviews, conference abstracts, and opinion articles.
2. Animal, in vitro studies.
3. Tooth loss because of a trauma or caries (these can cause bone resorption and confuse periodontal results).
4. Subjects with syndromes, cleft lip and palate, absence of other teeth in the maxilla, or having other dental anomalies.
5. Human trials with missing information or unclear data.

Information sources

An electronic search was carried out in Pubmed, ScienceDirect, Web of Science, and Plos One

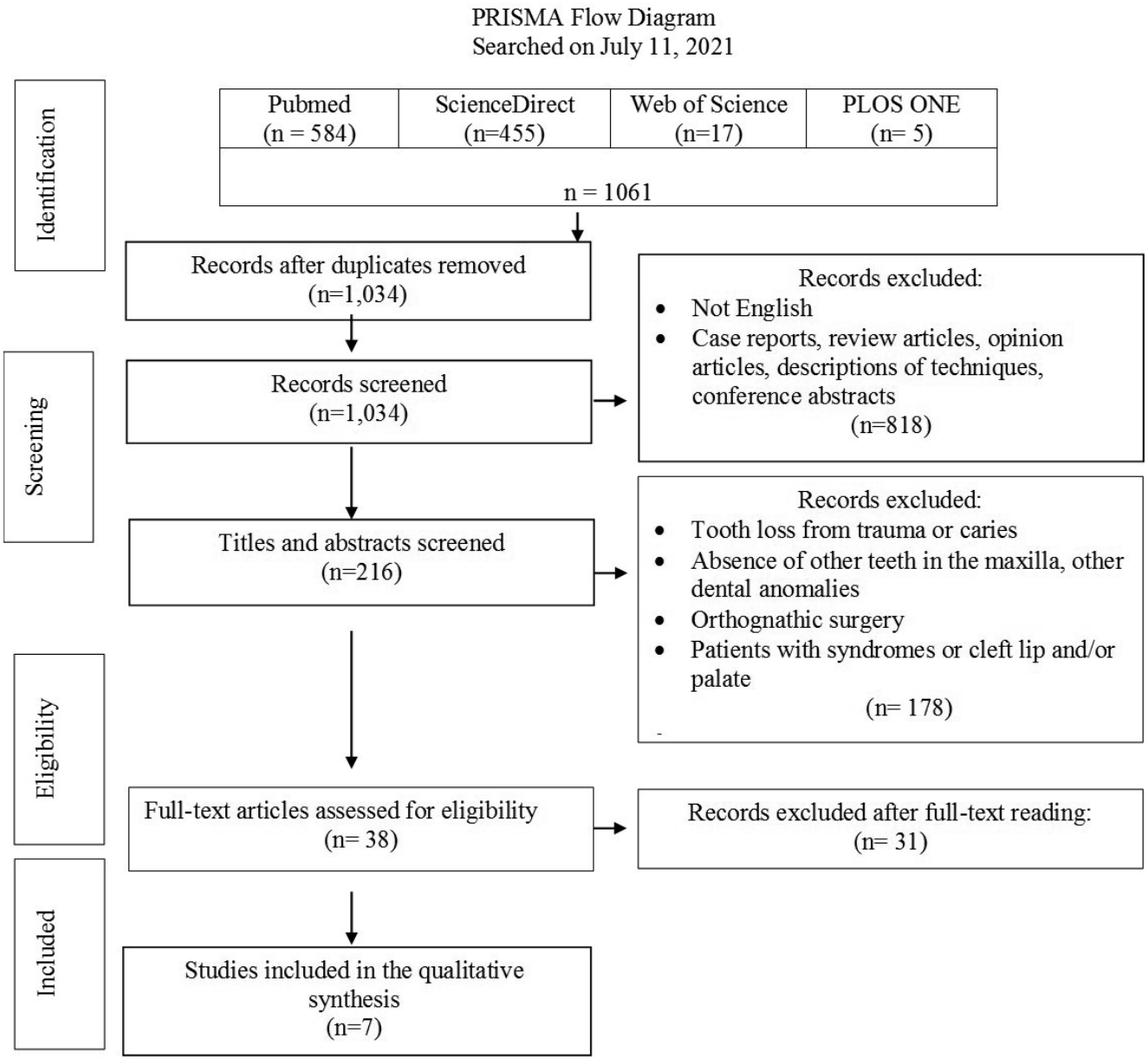

Fig. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart for the process of the selection of literature for systematic review (19).

databases to find articles published in English up to July 11, 2021.

Search strategy

The following combinations of search terms were used: "Incisor"[MeSH Terms] AND "anodontia"[MeSH Terms] AND "treatment". All references were managed by using reference manager software, and duplicates were removed (RefWorks-COS and Zotero).

Study selection

Study selection was completed in two phases. In the first phase, the suitability of the articles based on the selection criteria was determined by two independent researchers after screening the titles and abstracts of the studies identified in all the electronic databases. In the second phase, full-text articles were assessed by the reviewers to approve their final selection. Any disagreement was resolved through a discussion, and a third person was involved when necessary.

Data collection process and data items

Data collection was conducted by the two authors, and all the information was screened to verify the fullness of the retrieved data. Once again, disagreements between the researchers were resolved by re-examining the studies until the agreement was reached. The data extraction included the following items: general information (name of the authors, the year of publication, and type of the study), the size

of the studied groups, methods of measurement and treatment applied, the level of significance of the study, the obtained results, and follow-up (Table).

Risk of bias in individual studies

The case-control studies were evaluated by two independent reviewers in accordance with the Newcastle - Ottawa Scale. This was a "star" system in which a study was assessed according to three broad perspectives: the selection of the study groups, the comparability of the groups, and the ascertainment of the exposure. A star was marked in each domain if this was identified as satisfactory in the study.

The quality of cross-sectional studies was evaluated using the Joanna Briggs Institute's (JBI) critical appraisal checklist for analytical cross-sectional studies.

Disagreements were resolved through a discussion, and the third reviewer was included where necessary.

Summary measures

As a result of the heterogeneity among the studies included in this systematic review, particularly in their designs and the variables evaluated, it was not possible to perform a meta-analysis.

RESULTS

Study selection

The initial search identified 1,061 studies. Duplicates were removed, and after screening the titles/abstracts and according to the inclusion criteria, 38 potentially related studies were reviewed in depth. Finally, 7 studies were selected for this review (Figure).

Study characteristics

Out of the 7 included studies, 2 were case-control studies, and 5 were cross-sectional studies. All of the studies compared and evaluated the outcomes of prosthetic replacement (PR) and space closure (SC) treatment methods for maxillary lateral incisor agenesis (MLIA). All of the selected studies estimated esthetics; in addition, 3 of them assessed periodontal health, 1 – TMJ dysfunction, and 1 assessed occlusion morphology disorders.

In total, 218 subjects were involved in the studies: 99 patients with space closure, 94 – with prosthetic replacement, and 25 patients were in the control group.

Risk of bias assessment

The Newcastle-Ottawa Scale was adapted for the selected case-control studies, and the result of the risk of bias assessment showed gaps in compatibility (study controls for other factors than age) and outcome (follow-up durations) domains. In addition, blinding of allocation and blinding of measures had not been done and could have contributed to biases.

Each cross-sectional study was evaluated as a low risk of bias using the Joanna Briggs Institute's (JBI) critical appraisal checklist for analytical cross-sectional studies.

Esthetics

All of the selected articles (13-19) estimated esthetics using intraoral photographs, questionnaires, and clinical examinations (Table). For the evaluation of the esthetic principles, several different scales were used: the visual analog scale (VAS), the Pink Esthetic Score (PES), the White Esthetic Score (WES), and the Likert scale and a questionnaire with a fixed set of 7 bipolar adjective pairs.

The articles indicated that treatment outcomes comparing esthetics of the results of either SC or PR were equally satisfying (14, 18, 19), or SC was more acceptable than PR (13, 16, 17). However, there were no statistically significant differences between the groups. Only a study by Qadri *et al.* (15) found esthetics after SC to be statistically more pleasant. A web-based survey used 10 selected post-treatment intra-oral images of any patients who had been treated by either SC or PR to evaluate the attractiveness of the upper front teeth by the 5-point Likert scale. The esthetics was assessed by dentists and laypersons. As a result, the images of SC were selected as more attractive compared with the images of PR.

Periodontal status

Three of the selected studies (14, 17, 19) assessed periodontal health by measuring tooth mobility, plaque index, probing depth, and bleeding when probing as well as gingival recession and papillary defect.

When comparing periodontal status between the groups, a study by Jamilian *et al.* (14) found that SC patients had better periodontal health. There were no significant differences in tooth mobility or plaque index between the SC and PR groups. However, significant infraocclusion of more than 1 mm was noticed in all PR patients, and probing depth was also significantly greater in this group. Meanwhile more black triangles were seen in the SC patients.

According to the study by Schneider *et al.* (17), no statistically significant difference in clinical periodontal health was noticed between the SC and PR patients, except for the gingival recession, which was significantly more common in the SC group, though no recession was greater than 2 mm.

Table. Data extracted from studies in this systematic review

No.	Study	Type of the study	Participants: treatment modalities	Parameters evaluated	Method of measurement	Statisticalanalysis (level of significance)	Results	Follow-up: mean range
1.	De-Marchi *et al.* 2014 (1)	Case control	68 patients: 26 SC, 20 PR, 22 CG	Aesthetics	Intraoral photographs/ Questionnaire (VAS)	Fischer post hoc, Mann-Whitney, Shapiro-Wilk, t test, Cronbach's α, Kolmogorov-Smirnov, Multifactorial, ANOVA, 1-way ANOVA, Bonferroni correction (P=0.05)	SC group was more pleased with their smile than CG/ NS between the PR and CG and between SC and PR.	SC: 3.9 yrs PR: 3.5 yrs
2.	Jamilian *et al.* 2015 (2)	A retrospective cross-sectional study	20 patients: 10 SC, 10 PR	Aesthetics/ Periodontal status/ Signs and symptoms of TMDs	Questionnaire (VAS)/ Clinical examination (mobility, PD, infraocclusion, PI)/ Radiological exams	T-test P<0.05	The aesthetics satisfied both groups equally./ PR: 1 implant is mobile, 12 ↑PD, all PR elevated infraocclusion> 1 mm, PI higher in DI group. SC: 3 ↑PD./ No signs or symptoms of TMDs in either group.	SC and PR>5 yrs
3.	Qadri *et al.* 2016 (3)	Cross-sectional study	21 patients: 11 SC, 10 PR	Aesthetics	Intraoral frontal photographs (5-point Likert scale)	Two-sided paired t test P<0.05	Aesthetics after SC is statistically more pleasant.	Not reported
4.	Schneider *et al.* 2016 (4)	Case-control	9 patients: 3 SC, 3 PR, 3 CG	Aesthetics	Intraoral frontal photographs (7 adjectives pairs)	Tukey's post hoc tests, ANOVA, D'Agostino-Pearson's test, Levene's test P<0.05	Dentists rank PR and SC equally aesthetic, laypersons choose SC.	SC and PR: 6-12 months
5.	Schneider *et al.* 2018 (5)	A retrospective cross-sectional study	32 patients: 16 SC, 16 PR	Aesthetics/ Periodontal status	Intraoral photographs (PES, WES)/ Questionnaire (VAS)/ Clinical Examination (PI, BOP, PD, recession)/ Radiological exams	Mann-Whitney's U test, MANOVA, ANOVA, Wilcoxon test, One-tailed Spearman's test, Pearson's chi-square test p<0.05.	PES> SC and WES> PER (NS between the two groups), VAS both gr equally./ SC: 8 patients noticed discoloration, 2 patients – pulp necrosis, 13 ↑PI, 9 BOP, 3x > recessions in PER. PR: 14 ↑PI, 11 BOP, all patients PD 2-3 mm (PI, BOP, pockets – NS).	SC and PR>5 yrs
6.	Moradpoor *et al.* 2018 (6)	A retrospective cross-sectional study	24 patients: 11 SC, 13 PR	Aesthetics	Intraoral photographs (PES)	Mann-Whitney's U test, Fisher's Exact Test	Aesthetics NS between the SC and PR groups based on PES criterion. The only significant difference existed between the two treatments in terms of distal papilla, where the ranked mean and median in PR<SC.	Not reported
7.	Josefsson and Lindsten, 2019 (7)	Cross-sectional study	44 patients: 22 SC, 22 PR	Aesthetics/ Periodontal Status/ Occlusal morphology	Interviews/ Clinical examination (recession, BOP, papilla formation according to Jemt)	Pearson's chi-square test, Fisher's test, P<0.05.	NS aesthetic differences between the groups./ Gingival color was better in the SC group, crown color – in the PR group, gingival recession was more common in PR, BOP – in SC group, and papillary defect – in PR group./ The upper incisors were more proclined, and strained lip closure was more common in PR.	SC and PR>5 yrs

SC – orthodontic space closure, PR – prosthetic replacement, CG – control group, ANOVA – analysis of variance, MANOVA – multivariate analysis of variance, PD – probing depth, PI – plaque index, BOP – bleeding on probing, VAS – Visual Analog scales, PES – Pink Esthetic Score , WES – White Esthetic Score, NS – not significant.

Joseffson and colleagues (19) found gingival recession and papillary defect to be more common in the PR group, although bleeding when probing was more frequent in patients who had space closure. However, no significant differences were found for all these variables. Only discolored gingiva was significantly more recurrent in PR patients.

TMJ and occlusion morphology disorders

One of the studies (14) also investigated if there were any temporomandibular joint dysfunctions after treatment by giving the subjects an anamnestic questionnaire to fill. No TMJ dysfunctions were observed. Another study (19) looked for occlusion morphology disorders evaluating sagittal dental relationship, overjet and overbite, inclination of maxillary incisors, and midline in the upper jaw. The article stated that the prevalence of occlusion morphology disorders had no statistically significant differences between the SC and PR groups, except for significantly more proclined upper incisors and strained lip closure being significantly more frequent in the PR group than in the SC group (19).

DISCUSSION

There are some controversies in the literature regarding the two MLIA treatment methods: orthodontic space closure and prosthetic replacement. It has been found that while a large proportion of general dentists believe that the restorative method provides the best esthetic solution, many PR images are not classified as the most attractive results (20). Both treatment options are available to most patients (19). These methods do not differ significantly in terms of the prevalence of occlusion morphology disorders or temporomandibular dysfunction (TMD) (14). However, there are compromises between the function, esthetics, and periodontal health (3).

One of the benefits of SC is that the treatment can be completed at an early age, and no artificial material needs to be added to the jaw. In addition, the result is natural, and all of the changes will also be natural in the long term, unlike what may happen in the presence of a foreign body. SC procedures require moving the maxillary premolar into the canine's place and moving the canine next to the central incisor and camouflaging it as a lateral incisor (14). The formation of the maxillary canines, making them look more similar to the lateral incisors, has shown a great improvement in the esthetics of subjects who underwent the space closure, at least in the dentists' opinion (21).

Replacing missing lateral incisors using implants and implant-supported crowns is thought to be the optimal solution, considering the possibility of obtaining an ideal bite and an indisputable advantage – avoiding any damage to the adjacent teeth (14). Dental implants screwed into the anterior upper segment and restored prosthetically also showed satisfactory esthetic results and were positively evaluated by the patients (5). Eventually, implant-supported treatment might be appropriate for the group of patients with highly noticeable color differences between maxillary canines and central incisors, as well for the ones that have a steady Class I relationship between molars or congenitally missing teeth in the quadrant that also have to be replaced (22).

Our analysis of the esthetic outcomes after either orthodontic space closure or prosthetic rehabilitation treatment produced slightly different results to compare with the systematic review by Silveira *et al.* (8). Silveira and colleagues concluded that space closure was evaluated better esthetically than prosthetic replacements was, although the authors indicated numerous limitations of the studies they had analyzed (8). Our systematic review showed that the majority of the studies included in the review did not find any statistically significant differences in the esthetics between the SC and PR groups. Other articles (11, 23, 24) also made no final conclusions about the esthetic superiority of SC over prosthodontic intervention, which indicates that more studies with direct comparisons are required.

Considering the orthodontic space closure and canine substitution method, there is quite a challenge in achieving an acceptable esthetic outcome due to the inherent size, shape, and shade differences between maxillary canines and lateral incisors (25). On the other hand, implantation and prosthetic replacement may have much more esthetic-periodontal aspects, as most implant-supported crowns lack an interdental papillary fill (26), result in vestibular gingival retraction, darkening of the overlying labial gingiva, and infraocclusion of the implant. Besides, there are reports of bone loss around the implants, with high variability among the patients (27, 28). Different anatomical biotypes of the mouth with different structure (bone volume, papilla size, and arch form) determine the prognosis of the treatment (29). Probably the greatest disadvantage of the implantation and prosthetic replacement is that adolescents have to wait many years after orthodontic treatment until the completion of facial growth when the implant can be inserted. During this time, temporary restorations have to be used, which may create additional problems.

For a long time, clinical studies estimating treatments for maxillary lateral incisor agenesis have preferred the mesialization and re-contouring of the canine because of the periodontal issues found in subjects treated with prosthetic replacements (30, 31). These negative aspects include a higher prevalence of gingival inflammation, increased probing depth, and resorption of the labial cortical plate (32). Silveira *et al.*(8) reported that implant-supported restorations had lack of filling by the papilla in the interdental space between the central and lateral incisors. Other studies also found SC patients to have better periodontal health (3, 24), as the PR group frequently suffered from accumulation of plaque and gingivitis. The studies we analyzed only highlighted significant differences in infraocclusion, probing depth (14), and discolored gingiva (19) in the PR group as well as gingival recession (17) manifested in SC patients. Nevertheless, based on only three of the studies that investigated periodontal status and were included in our review, it is still difficult to state firmly which of the treatment methods is superior considering patients' periodontal health, and therefore, more clinical trials are needed.

TMJ dysfunction disorders either did not occur or were insignificant, and our findings corresponded to those of Silveira *et al.* (8), Robertsson *et al.* (3), Muhamad *et al.* (24), who also reported that neither of the treatments impaired temporomandibular joint function. Equally, no statistically significant difference was found between the two groups in occlusion morphology disorders, according to the study we analyzed (19). There was no difference in midline shift between PR and SC patients. This must be considered a good result, as some of the cases had a unilateral missing lateral incisor, which sometimes might result in asymmetry (3, 33).

Eventually, on the basis of the literature reviewed, the preferable treatment option for patients with maxillary lateral incisor agenesis, whenever possible, should be the orthodontic space closure, though more prospective controlled studies are needed to prove its superiority over the prosthetic rehabilitation. In addition, whatever treatment option may be chosen, a multidisciplinary team and an orthodontist as a part of it, is indispensable to restore the shape and proportionality of the smile and to contribute to both the functional and the esthetic re-establishment of the patient (25).

STUDY LIMITATIONS

Statistical analysis for this review was not performed, and there was a heterogeneity among the studies included in this systematic review, particularly in their designs and the variables evaluated. In addition, case-control studies were of a high risk of bias with small sample sizes, there was an incompatibility between the compared groups and a lack of blinding of the evaluation (when possible), and the selected studies either had relatively short follow-up time or it was not reported.

CONCLUSIONS

1. The treatment of maxillary lateral incisor agenesis by orthodontic space closure resulted in more favorable esthetics compared with the prosthetic replacement. However, there were no statistically significant differences between the groups.

2. The influence of these treatment methods on periodontal health remains debatable, as there is no common opinion considering the articles included in this review.

3. No signs or symptoms of TMJ dysfunction were noticed in any of the patients treated with either orthodontic space closure or prosthetic replacement, and no statistically significant differences in occlusion morphology disorders were found between the SC and PR groups.

4. If both treatment alternatives are available, space closure is preferable, although high-quality clinical trials are needed to find more evidence.

STATEMENT OF CONFLICTS OF INTEREST

The authors state no conflict of interest.

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