



REVIEW ARTICLE

The role of prosthetic, orthodontic and implant-supported rehabilitation in the management of secondary malocclusion to maxillofacial trauma- A systematic review



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Abstract Purpose: Different approaches have been proposed to treat malocclusion secondary to the treatment of maxillofacial trauma. This study aimed to investigate the efficacy of prosthodontic treatment, orthodontic treatment, and implant-supported rehabilitation for the management of secondary malocclusion after maxillofacial trauma.

Study selection: We searched five electronic databases and hand searched eight journals. The types of studies included were randomized controlled trials, cohorts, case-controls, and case series with at least eight patients with maxillofacial trauma and postoperative malocclusion. These studies used prosthetic treatment and implant-supported rehabilitation for secondary malocclusion after maxillofacial trauma. Risk of bias of eligible studies to be included in the final analysis was assessed independently by two authors using a tool for methodological quality assessment and synthesis of case series and case reports.

Results: After initial screening and identification of titles and abstracts, full text of 44 articles were found and evaluated against inclusion criteria. Of these 42 articles were excluded and remaining two were included in the review. Both the studies were case series with moderate to high risk of bias.

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Conclusions: Both prosthetic treatment and implant-supported rehabilitation have the potential to restore secondary malocclusion after maxillofacial trauma. However, because less number of well-designed studies with high risk of bias were included in this systematic review, the findings should be interpreted with caution. Well-designed high-quality studies are required to draw definitive conclusions.

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1. Introduction

Maxillofacial injury is considered an important health problem worldwide (Brasileiro and Passeri, 2006; Nesiamia and Sinn, 2010; Elbaih et al., 2018; AlHammad et al., 2019). Such injuries most often have significant financial consequences and result in deformity of facial aesthetics, loss of function, and increased incidence of other health problems (Brasileiro and Passeri, 2006; Nesiamia and Sinn, 2010; AlHammad et al., 2019; Assiri et al., 2019). Furthermore, another problem a patient experiences because of maxillofacial injuries is psychological effects (Elbaih et al., 2018; Al-Bokhamseen et al., 2019). Head injuries can present in several patterns. Mandibular fractures such as the fractures of the condyle, angle of the mandible, and parasymphysis are more prevalent than midfacial injuries (Bonavolonta et al., 2017; Abotaleb et al., 2018). Compared with adults, children are more prone to greenstick fractures than complete fractures (Nesiamia and Sinn, 2010; Qing-Bin et al., 2013; Zhou et al., 2013). Surgeons aim to prevent any situation that could worsen a patient's health when restoring aesthetics, function, and anatomy (Abotaleb et al., 2018). Victims of such injuries are usually exposed to other types of injuries such as orthopedic and neurological traumas. Moreover, maxillofacial traumas co-occur with other injuries, which might prevent immediate surgical correction. Such delay put the affected individuals at an extremely high risk of developing many problems such as infections, non-unions, and malocclusion. Patients returning for further correction of their sec-

ondary problems such as malocclusion after initial healing is common. The greatest problems with which patients return are asymmetrical teeth and occlusal dysfunction (Nesiamia and Sinn, 2010). Although secondary malocclusion occurring post-treatment is quite common, it has rarely been reported in the literature (Laine et al., 2004). This complication can be found either in the anterior or posterior part of the upper or lower jaw. Prosthodontic treatment, orthodontic treatment, surgical fracture reduction, surgical repair of soft tissues, and orthognathic surgery are among the many approaches available for correcting the resultant malocclusion. Dental casts, radiographic, and photographic images should be considered and acquired preoperatively. Commonly, three dimensional stereolithographic models are used in the management of such injuries to design an appropriate treatment plan and for accurate surgery (Sharma et al., 2017). Treatments of head and face injuries are categorized into surgical and non-surgical methods. Many common treatment approaches are extraction of teeth, occlusal adjustments, functional therapy, or a combination of these (Becking et al., 1998; Kim et al., 2018). An appropriate treatment plan should typically involve orthodontic treatment because it can prevent multi-segment upper jaw operations and stabilize the arches by coordinating and aligning them. In addition, prosthetic treatment after surgery is commonly required to restore missing teeth (Becking et al., 2007). However, studies summarizing the evidence regarding the role of prosthetic treatment, orthodontic treatment, and implant-supported rehabilitation for the management of sec-

ondary malocclusion after maxillofacial trauma are lacking. Therefore, a comprehensive and systematic review of the literature was conducted to summarize the available evidence regarding the role of different management approaches such as prosthetic treatment, orthodontic treatment, and implant-supported rehabilitation for the management of secondary malocclusion after maxillofacial trauma to inform healthcare providers.

2. Material and methods

2.1. Protocol and registration

This systematic review was conducted according to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009) and was registered *a priori* in the International Prospective Register of Systematic Reviews (registration number: CRD42020169627). Furthermore, the present systematic review was reported based on the PRISMA checklist.

2.2. Eligibility criteria

Inclusion criteria to select appropriate studies were as follows:

Population: children and adult patients with maxillofacial trauma.

Exposure: treated for maxillofacial fracture and with secondary malocclusion.

Comparison: different approaches to treat the secondary malocclusion associated with maxillofacial fracture.

Outcome: effect of prosthetic treatment, orthodontic treatment, and/or implant-supported rehabilitation to treat secondary malocclusion associated with maxillofacial fracture.

In this review, the concept of maxillofacial trauma involves both facial fractures and/or soft tissue injuries.

Type of studies: retrospective or prospective studies in patients with a diagnosis of maxillofacial fracture based on patients' complaints and clinical examinations that were confirmed by radiographic findings and findings during operation.

Exclusion criteria were as follows: articles not in English language, case reports, editorials, case series of less than eight patients, no evidence of maxillofacial trauma, no evidence of the use of prosthetic treatment, orthodontic treatment, and/or implant-supported rehabilitation for the management of secondary malocclusion after maxillofacial trauma.

2.3. Information sources

We systematically searched the following electronic databases until December 2019 to identify relevant studies: the Cochrane Central Register of Controlled Trials, PubMed, ScienceDirect, Scopus, and Clinical Key.

In addition, we hand searched the following journals to identify relevant studies: the World Journal of Orthodontics (2008–2010); Orthodontics and Craniofacial Research (1990–2020); American Journal of Orthodontics and Dentofacial Orthopedics (1996–2020); Journal of Prosthodontics (1992–2020); Journal of Prosthodontics on Dental Implants (2015–2020); Journal of Prosthodontics on Complex Restorations (2016–2020); Maxillofacial Plastic and Reconstructive Surgery

(2014–2020); and Oral Surgery, Oral Medicine, Oral Pathology, and Oral Radiology (2012–2020).

2.4. Search strategy

Simultaneously, two investigators searched and discussed their search outcome. In the case of disagreement between them, they consulted a third investigator to reach a final decision. We used the following Medical Subject Headings (MeSH) terms with Boolean operators for this search: “secondary malocclusion” AND “management” AND “maxillofacial trauma” AND “maxillofacial fracture” AND “face fracture” AND “face trauma” AND “malunion” AND “fixed prosthetic” OR “removable prosthetic” AND “fixed appliance” OR “removable appliance” OR “orthodontic” AND “supportive implant.” The search terms were adapted to each database before the search to avoid missing potentially relevant articles.

2.5. Data extraction

A data collection form was developed and piloted. Data collected from each study were as follows: study design, sample size, male-to-female ratio, age range of patients, main site of maxillofacial trauma (MFT), main cause of MFT, type of management of secondary malocclusion after MFT (prosthetic treatment/orthodontic treatment/implant-supported rehabilitation), and treatment outcome. A summary of this information is presented in Table 1. A meta-analysis was not performed because of the significant heterogeneity between the included studies and high risk of bias in the studies.

2.6. Risk of bias assessment of individual studies

A tool for methodological quality assessment and synthesis of case series and case reports was used to assess the risk of bias of the two case series included in this review (Murad et al., 2018). The quality of the included studies was assessed independently by two investigators. However, in the case of disagreement between the two investigators, a third reviewer was consulted to make a final decision.

2.7. Evaluation of quality of evidence

The included studies were assigned a quality grade related to the outcome measure based on the Grading of Recommendation, Assessment, Development, and Evaluation (GRADEpro Guideline Development Tool, gradepro.org). This tool consist of five domains to rate the quality of evidence as high, moderate, low, or very low (Schünemann et al., 2013).

3. Results

After initial screening and identification of titles and abstracts, 44 articles were deemed suitable for inclusion. The full text of these 44 articles was obtained and reviewed. After reviewing, 42 articles were excluded and remaining two articles that satisfied our inclusion criteria and were included in the systematic review (Fig. 1). The following section includes a summary of the findings of these two studies.

Table 1 Summary of data from studies included in this review.

Author/year	Study design	Sample size	Sample size with malocclusion	M: F	Age range	Main site of MFT	Main cause of MFT	Residual deformities in hard and soft tissues	Type of management (prosthetic/orthodontic/implant-supported)	Outcomes
Laine et al. 2004	Case series	8 patients	8 patients	4M-4F	19–50 years	Condylar Process, mandibular body, bilateral orbital floor, midfacial, symphyseal	Multiple (assault, vehicle accident, suicide)	Loss of alveolar bone and surrounding soft tissues	Mainly prosthodontic treatment, 2 surgeries, and 1 implant fixation	All approaches showed success because they were designed according to the case
Kim et al. 2018	Retrospective case series	9 patients	9 patients	5M-4F	18–56 years	6 had mandibular fractures, 1 had a maxillary fracture, 1 had a maxilla-mandibular complex fracture, and 1 had a panfacial fracture.	Multiple (traffic accidents, sports, trauma)	Resorption of the alveolar bone, deviation of the maxilla, abnormal shape and movement of the lower lip	Mainly prosthodontic treatment, 1 surgery, 1 implant fixation, and 1 TMD treatment	Mainly regaining of pre-injury occlusion, depending on complication, and reoperation advise.

Abbreviations: F, female patients; M, male patients; M:F, male-to-female ratio; MFT, maxillofacial trauma; TMD, temporomandibular disorder.

In the Laine et al. study, eight patients were reported to have experienced trauma such as McLennan type III bilateral condylar fractures, bilateral mandibular condylar fractures, multiple comminuted midfacial fractures, comminuted mandibular symphyseal fracture and bilateral intracapsular mandibular condylar fractures (Laine et al., 2004). The patients' age ranged from 19 to 50 years, and the male-to-female ratio was 1:1. Injuries were caused by incidents such as assault, motor vehicle accident, suicide, falling car, grenade explosion, and an unreported cause. The primary treatments included soft diet, mini-plate and screw fixation, maxilla-mandibular fixation, reconstruction of the orbital floor, and reduction in ramus height. However, the patients did experience postoperative complications such as anterior open bite, restricted mouth-opening, cross-bite, and occlusal discrepancy. The final treatments included slight occlusal adjustment, implant fixation, bone augmentations, mandibular body osteotomy, bilateral mandibular body osteotomy, bilateral sagittal split osteotomy, and bone grafting. The treatments resulted in stable occlusion.

The risk of bias was assessed as high because of the following reasons: sufficient details of all the reported cases were not provided, the follow-up intervals were unclear, and the outcome was not ascertained. Thus, three of four domains were inadequate (see Table 2).

Kim et al. study included 9 patients, of which 7 had mandibular fractures such as body, ramus, and condyle fractures (Kim et al., 2018). The patients' age ranged from 18 to 56 years, and the male-to-female ratio was 1.25:1. At the time of trauma, all patients had tooth fractures, displacements, dislocations, and alveolar bone fractures. These patients did not receive preoperative or postoperative dental treatment. The malocclusions were corrected with orthognathic surgery and iliac crest bone grafts. Common postoperative complications reported in this study were malocclusion, tooth loss, tooth pain, and temporomandibular disorders (TMDs). Six of the nine patients who complained of moderate occlusal abnormalities and TMDs such as limited mouth opening, underwent occlusal treatment with prosthodontic repair and temporomandibular joint treatment as an alternative to surgical treatment. The final treatment included tooth extraction, prosthodontic treatment, implant fixation, Le Fort I osteotomy, and TMD treatment. The treatment outcome was the resolution of complications.

The risk of bias was assessed as moderate because of the following reasons: sufficient details of all the reported cases were not provided and the follow-up intervals were unclear. Therefore, two of four domains were inadequate (See Table 2).

3.1. Assessment of the quality of evidence

The quality of evidence according to the GRADE was rated as very low because the included studies had a high risk of bias, small sample size, low-quality study design, and some important variables missing.

4. Discussion

This systematic review was conducted to determine the role of prosthetic treatment, orthodontic treatment, and implant-supported rehabilitation for the management of secondary

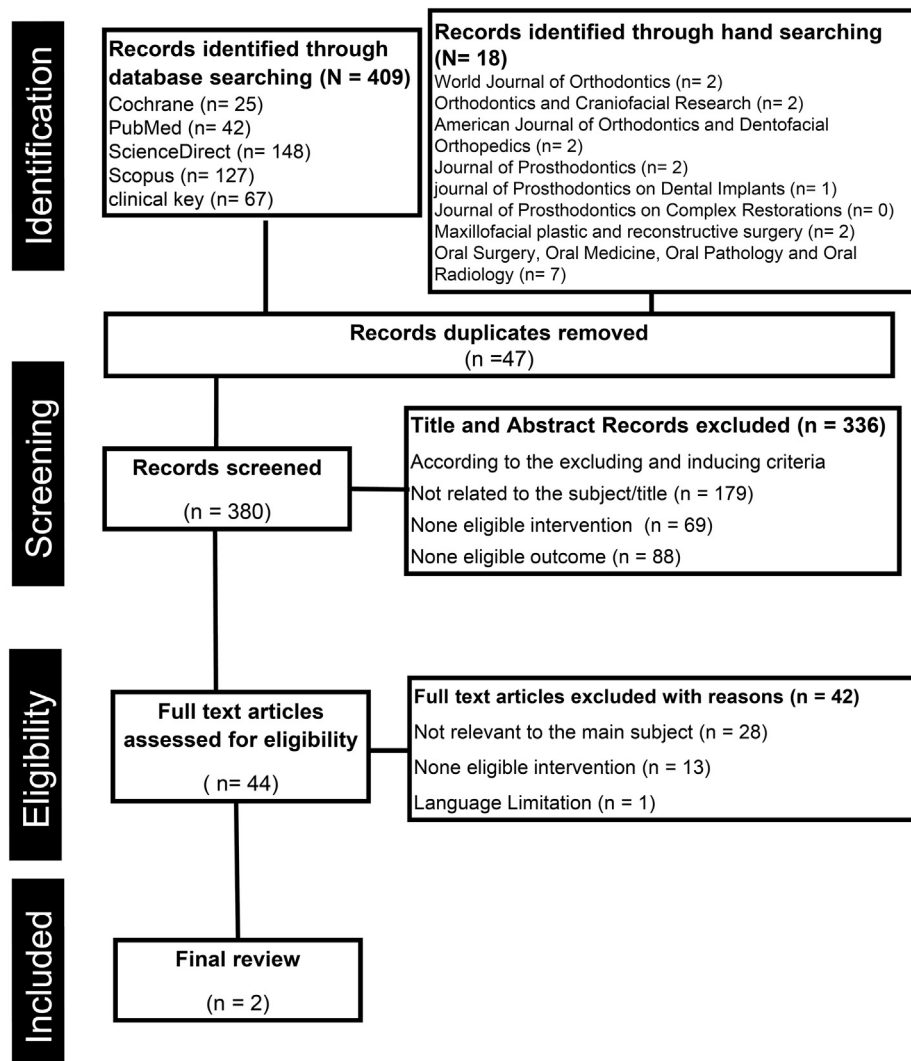


Fig. 1 Flow diagram of study identification and selection using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

malocclusion after maxillofacial trauma. This is the first systematic review to provide a comprehensive report regarding this problem. In this systematic review, we considered the most common approaches for the management of secondary malocclusion after maxillofacial trauma to achieve satisfactory aesthetic and functional results.

The results of this systematic review revealed that the reported management approaches provide good outcomes by achieving a stable occlusion (i.e., restoring the pre-injury occlusion). The total number of patients in these two studies was 17 (8 women and 9 men) with an average age of 38 years (Laine et al., 2004; Kim et al., 2018). The most commonly reported causes of trauma were assault and motor vehicle accidents (Laine et al., 2004).

Different management approaches were adopted for individual patients depending on the particulars of each patient and the requirement to achieve a satisfactory occlusion. Thus, interventions to correct post-trauma malocclusion involved prosthodontic treatment and implant fixation (Laine et al., 2004; Kim et al., 2018).

Maxillofacial injuries, especially midfacial fractures, often cause significant damage to the dentoalveolar region and subsequently loss of one or more teeth (Kloss et al., 2011). In such cases, to achieve a good outcome and to restore the occlusion to pre-injury status, fixation of dental implants and fixed prosthesis is often required, as presented in the two studies included in this systematic review.

Regarding the role of orthodontics, one study evaluated the treatment outcomes following the use of class III elastic mechanics to correct the postsurgical malocclusion after temporomandibular joint disc repositioning with the Mitek anchor technique and revealed that the secondary malocclusion resolved within 1 week to 1.5 months (Perez et al., 2019). However, maxillofacial trauma was not referred in this study.

The surgical approach to restore both anatomy and function is commonly incorporated in both primary and secondary care. For example, condylar fractures were mainly treated by a secondary surgical intervention to restore occlusion; however, the pre-injury occlusion was achieved after 1 year of the surgery (Becking et al., 1998).

Table 2 Risk of bias of studies included in this review.

Author/ year	Risk of bias tool	Category	Comments
Laine et al. 2004	Tool for evaluating the methodological quality of case reports and case series	High	Details of all the reported cases were insufficient, the follow-up intervals were unclear, and the outcome was not ascertained. Thus, three out of four domains were inadequate.
Kim et al. 2018	Tool for evaluating the methodological quality of case reports and case series	Moderate	Details of all the reported cases were insufficient and the follow-up intervals were unclear. Therefore, two out of four domains were inadequate.

Furthermore, some features of malocclusion that occur after the primary surgical care, such as anterior and lateral open bites, were managed using less invasive techniques such as occlusal adjustment to reduce premature contact (Laine et al., 2004).

In summary, the management of maxillofacial trauma often requires a multidisciplinary approach, making it challenging and difficult (Andreasen and Andreasen, 2010). This is because these injuries usually affect several oral and facial structures involving both hard and soft tissues, often causing a malocclusion. Thus, the clinical presentation and appropriate treatment strategy may greatly vary between individuals. Therefore, careful and thoughtful multidisciplinary evaluation of each patient is essential before a definitive treatment plan is designed.

The current systematic review has several limitations; thus, the aforementioned findings should be interpreted with caution. The number of studies that fulfilled inclusion criteria and were included in the final analysis was small. In addition, both the included studies were of low quality because of inferior design, moderate or high risk of bias, and high heterogeneity between them in terms of the type of management approach adopted and outcome measure/s reported.

5. Conclusions

Although postoperative complications are inevitable in the management of maxillofacial trauma, the findings of this systematic review reveal that both prosthetic treatment and implant-supported rehabilitation have the potential to restore secondary malocclusion after maxillofacial injury. However, because less number of well-designed studies with high risk of bias were included in this systematic review, the findings of our systematic review should be interpreted with caution. Well-designed high-quality studies are required to draw definitive conclusions.

Ethical Statement

The systematic review was registered on the PROSPERO database (Registration number: CRD42020169627).

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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