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Literature Review

Different Management Modalities for Skeletal Malocclusion Class II and Anterior Crossbite: A Comprehensive Review

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Abstract

Skeletal class II malocclusion with anterior crossbite presents a significant challenge in the field of orthodontics. Although anterior crossbite association with class II malocclusion is not common in literature, this condition not only impacts the patient's quality of life by affecting his facial appearance and resembling cosmetic concerns, but it can also affect masticatory and respiratory functions. The management of skeletal malocclusion class II with anterior crossbite requires a comprehensive approach that takes into account the severity of the condition, the patient's age, and their treatment preferences. A comprehensive search of prominent databases has revealed a range of management strategies used in clinical practice. This review categorizes these intervention methods into orthodontic, and surgical interventions to provide clinicians with an evidence-based decision-making foundation and help determine the best management plan that will provide optimal outcomes for patients with this complicated malocclusion. In conclusion, further high quality evidence is needed to accurately determine the incidence of class II malocclusion with anterior crossbite and the varying outcomes according to the management strategy.

Keywords: *Malocclusion; Anterior Crossbite; Orthodontic; Surgery*

Introduction

Background

Dental malocclusion is a common disorder characterized by atypical relationships during the process of tooth formation and includes irregularities in the alignment and position of teeth in the mandible and maxilla [1,2]. In 1899, Angle published the basic framework for the classification system, which initially consisted of three categories [3]. Later, in 1972, Andrews recognized the need for a more comprehensive classification system. He published the six keys to normal occlusion, which more accurately classified anteroposterior occlusal discrepancies [4]. Out of these three classes of dental malocclusions, Class II malocclusion is the second common malocclusion worldwide with a prevalence of approximately 19.56%. This prevalence may be influenced by genetic and environmental factors specific to the involved populations such as preterm birth, fetal alcohol syndrome, low socio-economic status, early loss of primary teeth, and prolonged feeding [5]. Caucasians have the highest prevalence of class II malocclusion [6]. Malocclusion class II is defined as a dental

relationship in which the mandibular first permanent molars are located more distal than the maxillary first permanent molars in class I and the maxilla and dentigerous molars protrude anteriorly into the mandible [7].

Geographical distribution of class II malocclusion worldwide

The prevalence of malocclusion class II varies worldwide, Africans showed the lowest prevalence of 6.76%, Caucasians 22.9%, and Mongoloids was of 14.14% [6]. Recently, in a study conducted by S. Sundareswaran in southern India, the prevalence was found to be 17.6% [8].

Akbari., *et al*. a meta-analysis conducted to estimate the prevalence of class II malocclusion in Iranian children, no gender difference was found in the prevalence of approximately 24.7% [9]. In a study conducted by E Aikins in Nigeria, the frequency of class II malocclusion was reported as 6.3% [10]. In Saudi Arabia, M. Amalky found that 25.23% of the population had class II malocclusion [11]. In a Chinese study, Chan., *et al*. reported the prevalence of class II malocclusion as 23.1% [12]. S El-Attar., *et al*. reported that 27.2% of the Egyptian population had class II malocclusion [13]. Bilgic., *et al*. reported that 44.7% of adolescents in Anatolia had class II malocclusion [14].

In another study, it was reported that the prevalence of class II malocclusion among adults in the USA is more than 60% and the rates vary according to age, gender, and socioeconomic status. However, the specific prevalence of class II malocclusion in the USA is not clearly stated in the search results [15].

Class II with anterior crossbite

Class II malocclusion is classified into division 1, characterized by protruding anterior teeth, and division 2, where soft tissue pressure is applied leading to incisor inclination [7]. If the misalignment specifically involves the incisors, it is an anterior crossbite (Figure 1). In clinical terms, an anterior crossbite appears as an inverted overjet, in which one or more maxillary teeth are positioned lingual to the mandibular incisors when the patient closes the mouth which is highly associated with division 2 malocclusion class II [7,16].

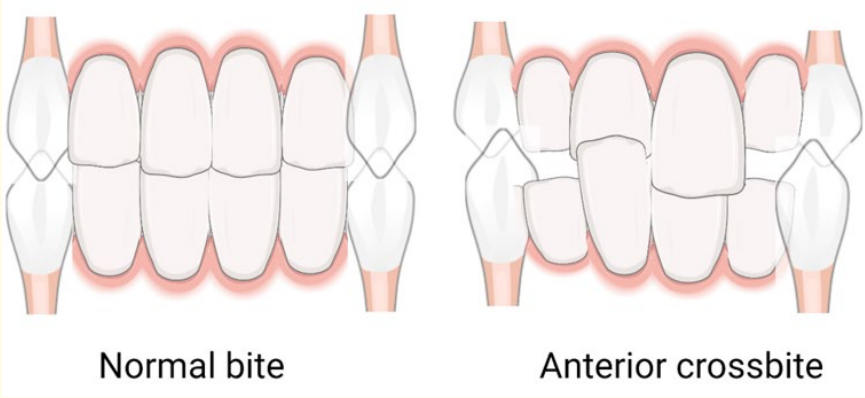

Figure 1: *Illustration of normal bite and anterior crossbite.*

The lingual eruption path of the maxillary incisor is caused by several factors, including trauma to the deciduous incisor causing lingual dislocation of the permanent tooth embryo, maxillary anterior teeth, over-retained necrotic or scale-free deciduous teeth or roots, odontomas, plexus in the incisor region, inadequate dental arch length and upper lip biting habits [17]. Vithanaarachchi., *et al*. reported that 62% out of 721 patients diagnosed with anterior crossbite were unilateral, and 38% were bilateral involvement. Furthermore, 51.8% had lesions on one incisor, and 33.2% had involvement of two incisors. Class II malocclusion was detected in 17.1% of these cases

[18]. Correction of anterior crossbite is very important for aesthetic and functional reasons, particularly during childhood development. Pediatric dentists and orthodontists have a significant role in guiding the normal growth of the teeth in line with oral-facial growth and development [19]. The challenges posed by anterior crossbite in skeletal class II malocclusion include potential negative effects on growth patterns, skeletal problems, and unfavourable occlusal conditions that can lead to a class III malocclusion growth pattern [7,19,20]. Early diagnosis and treatment of anterior crossbite cases is recommended to prevent tooth wear, fracture, gingival problems, and temporomandibular joint (TMJ) disorders, and to achieve a better functional bite and cosmetics [19,21].

Rationale

Skeletal class II malocclusion with anterior crossbite is a common dental problem with an average prevalence of 33.3% [22]. Anterior crossbite is a specific challenge for this malocclusion and can impact growth patterns and skeletal problems. The prevalence of various transverse and anterior crossbite malocclusion varies among different populations, with the highest prevalence of class II malocclusion reported in Europe and the highest prevalence of class III malocclusion in the mongoloid mixed dentition [22]. This review aims to provide a comprehensive overview of the different management options for skeletal class II malocclusion with anterior crossbite. The challenges posed by this malocclusion are highlighted and the need for a comprehensive review of different management methods is emphasized due to the wide range of prevalence in different populations and the potential adverse effects on growth patterns and skeletal problems associated with anterior crossbite. The review discusses traditional and contemporary orthodontic approaches, surgical interventions, functional appliances, interdisciplinary collaboration, patient-centred perspectives, new techniques, and current debates. The main findings of this review are aimed at understanding the potential impact of skeletal class II malocclusion with anterior crossbite extends to its potential impact on growth patterns, occlusal status, and overall oral health, the various treatment options and their effectiveness in optimizing the outcomes of patients with skeletal class II malocclusion with anterior crossbite, emphasizing the importance of individualized treatment planning, interdisciplinary collaboration and emerging technologies. Future research and advances in the management of skeletal class II malocclusion with anterior crossbite may focus on long-term outcomes, individualized treatment plans, innovative techniques, and interdisciplinary collaboration.

Diagnostic considerations

Skeletal class II malocclusion with anterior crossbite can be diagnosed based on precise clinical evaluation by history and examining the dental and facial features, diagnostic aids such as dental casts, photographs, and radiographs, and functional analysis such as the ability to chew and swallow properly, and any signs of temporomandibular joint (TMJ) dysfunction [21,23,24].

Class II malocclusion is characterized by an anteroposterior discrepancy between the maxillary and mandibular dentition, with or without skeletal discrepancy [7]. In general, class II cases with anteroposterior skeletal discrepancies are characterized by a larger ANB angle and Wit's assessment reflects the malocclusion relationship [7]. Additionally, early dentofacial features of class II malocclusion in the deciduous dentition likely reflect an underlying skeletal imbalance and typically result in class II malocclusion in the permanent dentition [7,23,25]. The success of treatment in growing individuals depends on the ability of the clinician to influence the relative growth changes in the maxilla and mandible [7,26].

Class II malocclusion can be further classified into several subtypes according to the severity and specific features of the malocclusion to division 1 which is characterized by a distal relationship between the mandibular and maxillary molars, with the maxillary anterior teeth protruding leading to a large overjet, division 2 which is characterized by a distal relationship between the mandibular and maxillary molars, with the maxillary central incisors retroclined resulting in a deep overbite, and skeletal malocclusion class II in which skeletal abnormalities, such as mandibular retrognathism resulting from a shortened mandible and maxillary protrusion are found [3,7,21]. The classification depends on the assessment of the maxillomandibular relationship, cephalometric variables, dentoalveolar characteristics,

and the presence or absence of skeletal abnormalities [7,27]. The degree of severity of the malocclusion and the specific characteristics play a crucial role in determining the appropriate treatment plan and approach [21,27].

The diagnosis of anterior crossbite requires an assessment of the lingual position of the maxillary anterior teeth in relation to the mandibular anterior teeth [16]. Diagnostic challenges specific to anterior crossbite include the divergent facial type where the facial bones grow in different directions, affecting the alignment of the teeth, abnormal growth patterns like asymmetrical growth and complete growth of the facial bones, severe skeletal disharmony, absence of anterior-posterior shift, genetic and environmental factors, unfavourable occlusal conditions, and poor cooperation from the patient [28].

Accurate diagnosis is very important in the treatment planning of skeletal Class II malocclusion and anterior crossbite. It allows for the identification of the specific characteristics and severity of the malocclusion, which in turn influences the selection of appropriate treatment options [7,21,29]. Additionally, accurate diagnosis facilitates timely and effective intervention by enabling the early identification of potential negative impacts on growth patterns and skeletal problems associated with anterior crossbite [19]. Early diagnosis and treatment of malocclusion are essential to prevent abnormal enamel abrasions, anterior teeth mobility and fracture, periodontal disease, and TMJ disturbance, and to achieve better functional occlusion and esthetics [29].

Different management modalities for malocclusion class II and anterior crossbite

The treatment options for anterior crossbite range from conservative measures such as tongue blades and composite inclined planes to more involved interventions like reversed stainless steel crowns, removable acrylic appliances with lingual springs, fixed appliances, and clear aligners [30]. The main goal of treatment is to tip the affected maxillary tooth or teeth labially to a point where a stable overbite relationship prevents relapse [30].

Orthodontic approaches for skeletal class II malocclusion and anterior crossbite

Traditional orthodontic strategies for managing class II malocclusion include growth modification and orthodontic camouflage therapy [21]. Growth modification aims to influence the relative growth changes in the maxilla and mandible during the growth phase to reduce the skeletal class II jaw-base relationship by enhancing mandibular and/or restraining maxillary forward positioning while at the same time controlling the lower face height [21]. Orthodontic camouflage therapy uses orthodontic appliances for rearranging the teeth and masking skeletal discrepancies [21,31]. Corrective camouflage has been successfully used to effectively treat mild skeletal class II malocclusion, but it has some limitations, including the inability to cope with underlying skeletal problems, the need for longer treatment times and higher cooperation, the possibility of unwanted sequelae, and limited effectiveness. in patients without residual growth [32].

Contemporary orthodontic innovations have introduced new approaches to the treatment of skeletal class II malocclusions and anterior crossbite. One of these approaches is the use of customized treatment plans based on 3D scanning, imaging, and modelling technologies [21,31].

These technologies enable more accurate and effective treatment, as well as better communication between the orthodontist and the patient. Another new trend is the use of mini-screw anchorage to correct skeletal class II malocclusion [33]. In the 20th century, skeletal anchoring was introduced as a method used in orthodontics to provide absolute anchorage for the correction of malocclusions and anterior crossbite [33,34]. It involves the use of temporary anchoring equipment (TADs) such as titanium anchor screws and plates to provide a stable and reliable anchoring unit [33]. The use of skeletal anchors has become increasingly popular in clinical orthodontic approaches, especially with the use of mini screw implants that provide temporary absolute anchorage, the benefits of skeletal anchors include the ability to provide absolute anchorage, reduce patient compliance dependence, and correct malocclusions without changing

the underlying skeletal relationships, while there is a possibility of complications such as implant failure, the need for careful evaluation, planning and monitoring to ensure effective correction of malocclusion [33,35]. Almaghlouth., *et al*. a systematic review found insufficient evidence to state that TADs can be used as orthodontic anchorage to effectively intrude on the incisors without the need for patient cooperation and suggested that future high-quality prospective randomized clinical trials are required [36]. Moreover, another systematic review and meta-analysis assessed the effectiveness of TADs in canine retraction during the two-step technique and found that TADs have been used for decades in orthodontic practice for many applications, including anchorage reinforcement during the space closure stage [37].

In addition, the invisalign mandibular advancement feature appliance (IMAF) has been used to manage skeletal class II malocclusion with mandibular retroversion. The IMAF is a clear aligner that enhances mandibular growth by moving the mandible forward. A 12-year-old male case with skeletal class II malocclusion had an IMAF instrument and there was a significant improvement in condition and facial expression [26]. Another case of an 8-year-old boy with a crossbite was also treated with IMAF, which led to better results and cosmology [38].

The treatment of skeletal class II malocclusion and anterior crossbite has evolved with modern orthodontic trends, offering more precise and efficient methods. The management of skeletal class II malocclusion varies with age, with treatment goals ranging from growth modification in growing patients to camouflage or surgery in adults [39].

Technological advancements, particularly 3D imaging, and computer-aided design (CAD), have had a significant impact on the diagnosis and treatment planning for malocclusions. The emergence of three-dimensional (3D) technology has transformed the field of orthodontics, particularly in the diagnosis and treatment planning for malocclusions [39,40]. The use of 3D technology requires a significant initial investment in equipment and training for orthodontic practices. Additionally, robust data security measures are necessary to protect patient information and comply with privacy regulations. Orthodontists and their teams may require training to effectively integrate and utilize these technologies in their practice [40].

Functional appliances are novel orthodontic devices that aim to correct skeletal class II malocclusion by influencing the growth of the maxilla and mandible. Functional appliances are two types, fixed functional appliances are bonded to the teeth by an orthodontist and can produce very accurate movement in the teeth, and removable functional appliances which are not bonded to the teeth and can be removed by the patient. Removable appliances are usually used by patients who have a high degree of compliance with their orthodontic treatment [41]. They work by applying forces to the teeth and jaws, which stimulate bone growth and remodelling [41,42]. They compel the patient to function with the lower jaw forward and could stimulate mandibular growth, thereby correcting a class II problem [42]. The effectiveness of functional appliances in correcting skeletal class II malocclusion has been evaluated in several studies [42]. The evidence supporting the effectiveness of functional appliances in correcting skeletal class II malocclusion is limited. While some studies have reported positive outcomes, others have reported no significant differences between functional appliances and other treatment modalities. A systematic review and meta-analysis found that functional appliances may be effective in correcting skeletal class II malocclusion in the long term, but the quality of the evidence is very low and the clinical significance is limited [43]. In another systematic review and meta-analysis, all variants of functional appliances successfully reduced the overjet to normal limits, but there were minor skeletal changes [44]. A novel technique using bimaxillary skeletal anchorage-supported fixed functional appliances was found to be highly effective in the treatment of class II malocclusion demonstrating a significant maxillary retrusion and increased mandibular length [44].

Surgical intervention for skeletal class II malocclusion and anterior crossbite

Surgical intervention is an effective treatment option for complex conditions such as skeletal class II malocclusion and anterior crossbite. The two main surgical options are orthognathic surgery and distraction osteogenesis. Orthognathic surgery corrects the

skeletal discrepancy by repositioning the maxilla or mandible. In distraction osteogenesis, the bones are gradually lengthened to correct the skeletal malalignment [32,45]. Risks associated with orthognathic surgery include nerve damage, bleeding, and infection, while risks associated with distraction osteogenesis include device malfunction and infection [45]. Patient selection criteria for surgical interventions include the severity of the malocclusion, the presence of skeletal abnormalities, and the age of the patient [46]. Additionally, the integration of patient and surgeon factors, such as psychological capacity, baseline expectations, the complexity of the case, and surgeon volume and experience, is crucial in determining the overall likelihood of successful outcomes, both technically and in terms of patient satisfaction [47]. A multidisciplinary approach is recommended, with agreed protocols, to ensure comprehensive patient assessment based on medical, surgical, and social criteria. With the migration of medically complex patients to the ambulatory setting, identifying suitability for ambulatory surgery is vital and depends on a complex interplay between the surgical procedure, patient characteristics, and the expected cosmetic technique [46,47].

Surgical interventions can be integrated with orthodontic interventions for comprehensive treatment of malocclusions. Orthodontic treatment aligns the teeth and prepares them for surgery, while surgical treatment can be used to correct the skeletal discrepancies [45,48]. Case studies have shown successful outcomes with the integration of surgical and orthodontic treatment. For example, in a case, a 22-year-old female presented with a severe skeletal class II malocclusion characterized by an increased overjet, proclined teeth, and moderate crowding. The treatment plan included extraction of the upper and lower first premolars was carried out. Subsequently, the first and second molars were banded, while the remaining teeth were bonded with metal braces. Over a period of three months, an ideal inclination was achieved through orthodontic treatment. After that preoperative orthodontic phase, orthognathic surgery was performed. To prevent postoperative relapse, a segmented maxillary archwire was bonded during the surgical procedure. Ten days postoperatively, intra-maxillary fixation was implemented, and it was left in place for six weeks. The final splint was then removed after eight weeks. The overall outcome was highly cosmetic, resulting in a favourable aesthetic improvement [45].

Interdisciplinary collaboration for class II malocclusion and anterior crossbite

Collaboration between orthodontists, maxillofacial surgeons, and other specialists is essential for the successful management of skeletal class II malocclusion and anterior crossbite. Interdisciplinary collaboration allows for a comprehensive approach to treatment based on the specific needs and characteristics of each patient. Such as collaboration between specialists can also help to identify and address potential risks and complications associated with treatment, resulting in better outcomes and increased patient satisfaction [49]. A case series described the combined orthodontic and surgical approach in the treatment of skeletal class II cases with different growth patterns, highlighting the need for a comprehensive treatment approach [49].

Patient-centered perspectives on dental care

Psychological, social, cultural, and economic factors, as well as physical findings, are all considered in patient-centered health services. Such services explain the consistency and responsiveness to the patient's wishes, needs, and preferences [50]. Fernandez., *et al.* studied the attitudes of children and parents before and after treatment to assess the quality of correctional services. When their children were between the ages of 11 and 16 [51]. Seventy-nine family units were polled to determine their satisfaction and treatment preferences. Throughout treatment, anxiety levels significantly decreased. Informed consent emphasises its role in the patient's autonomy and appears unaffected by the initial disagreement [51]. Patient dentistry has recently been transformed into a comprehensive dental unit focused on quality and safety as an integral part of medical facilities to improve the quality of life of an individual [52]. The patient's experience with malocclusions is critical. Factors such as treatment duration, discomfort, and aesthetic outcomes play a significant role in the quality of life of patients undergoing treatment. Patient-centered healthcare focuses on addressing the patient's wishes, needs and preferences and ensures that treatment is tailored to the patient's unique needs and circumstances [50-54].

Patients with severe malocclusion experience more problems later in life compared to patients with a normal bite [53]. Bradley., *et al*. the orthodontic patient treatment impact questionnaire (OPTIQ), pre-treatment experience, treatment influence and results obtained from treatment were included in the studies conducted on patient reporting experience and results obtained from orthodontic treatment. They found that some participants rated certain features of malocclusion as "much better". It has been specified that the appearance of teeth, uncomfortable when smiling, confidence in teeth and overall health have significantly improved. The percentage of participants who reported no changes in pain, diet or cleanliness was roughly equal to the percentage who reported improvement [54].

The duration of treatment for class II malocclusion and anterior cross-bite varies depending on the method used and the patient's response to treatment. Understanding the potential impact of the duration of treatment on the quality of life of patients to develop treatment plans that balance treatment benefits with the patient's daily life Weight [55]. Many case studies have demonstrated the significance of understanding the potential effects of malocclusions and anterior crossbite on the duration of treatment and patient QOL. Healthcare professionals can respond to each patient's unique needs and concerns while minimizing hospital stays by evaluating patient-specific considerations and incorporating a wide range of methods [55,56].

Another important aspect of patient-centered care is controlling discomfort throughout the treatment duration and after surgical interventions. Acknowledging their unique experiences, endorsing a professional approach, and perceiving people who've been generally seeking help are all important for pain control. Humanism and medicine must always be balanced, with a focus on effective communication and compassionate medical interviews. Pain management includes local anesthesia as well as painkillers and relaxation techniques [50,51].

The aesthetic outcomes of orthodontic treatment are a critical aspect of patient-centered care for individuals with malocclusion [50]. Improving facial aesthetics can have a profound impact on a patient's quality of life and psychological well-being. Therefore, it is essential to consider aesthetic outcomes when developing treatment plans and to ensure that the patient's unique needs and preferences are addressed throughout the treatment process. Several studies have highlighted the significance of aesthetic outcomes in orthodontic treatment [54].

Future perspective in orthodontic management

Future research and progress in the management of malocclusion should focus on the following areas: estimating the incidence of class II malocclusion with pre-cross-bite; investigating the long-term outcomes of various treatment modalities, including corrective approaches, surgical interventions and functional instruments; and better understanding of its effectiveness and potential risks. Furthermore, to make it easier for dentists to manage complex cases, artificial intelligence (AI) and machine learning are applied to dental care systems to manage dental malocclusion. Today, artificial intelligence has become a part of human daily life and improves the quality of human life. Artificial intelligence can not only benefit from time and easily help diagnose serious and complex cases but also help customize the management plan that best suits the situation. Several studies and articles have highlighted the potential of AI in dentistry. For example, the review discussed current and future applications of AI in dentistry, such as identifying normal and abnormal structures, diagnosing diseases, and predicting treatment outcomes. Agrawal., *et al*. they discussed the past, present and future of AI in dentistry and highlighted the potential benefits of healthcare, including reduced postoperative complications, improved quality of life, improved decision-making and far fewer unnecessary procedures [57].

Machine learning (ML) has been increasingly used in orthodontics to improve the diagnosis and treatment of several dental disorders. Several studies have explored the potential of ML in orthodontics, including the identification of normal and abnormal structures, diagnosis of diseases, and prediction of treatment outcomes [58]. Kılıç., *et al*. conducted a study where they developed a family-centered orthodontic screening approach using a mobile application employing machine learning to provide a preliminary diagnosis of skeletal

malocclusion [59]. Wang and his colleagues said that the application of the regression model improved the predictive ability of specialists to assess craniofacial morphological compliance after corrective therapy. The most significant factors affecting the final decision of physicians are the arrangement of the teeth, the posture of the jaw, and the state of soft tissue. This scientific method has also tended to increase the use of machine learning techniques to help fix complicated medical conditions without the need for large sample sizes [60].

Conclusion

The review highlights the prevalence of skeletal class II malocclusion with pre-cross bite, pre-cross bite, and malocclusion class II in different populations, as well as potential adverse effects on growth patterns and skeletal problems associated with pre-cross bite. The importance of addressing anterior crossbite and skeletal class II malocclusion as it can affect growth patterns, bite conditions, and overall oral health the need for a comprehensive review of various management modalities is justified.

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