

Czynnościowe leczenie ortodontyczne wspomagane zakotwieniem szkieletowym w wadach zgryzu klasy II: przegląd piśmiennictwa

Functional and Orthopedic Treatments Supported By Skeletal Anchorage in Class II Malocclusions: A Comprehensive Literature Review

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Streszczenie

Dzięki rozwojowi aparatów umożliwiających zakotwienie szkieletowe pojawiło się wiele różnych alternatyw terapeutycznych w leczeniu ortodontycznym za pomocą aparatów stałych i czynnościowych. Ta metoda jest często preferowana przez wielu klinicystów ze względu na minimalną inwazyjność zabiegu i łatwość zastosowania. **Cel.** Celem kompleksowego przeglądu literatury była ocena powszechnie stosowanej mechaniki zakotwienia szkieletowego z leczeniem czynnościowym wad zgryzu klasy II z retrognatyczną żuchwą. **Materiał i metody.** Aparaty czynnościowe są powszechnie stosowane w leczeniu pacjentów z II klasą szkieletową. Jednakże niekorzystne skutki uboczne, takie jak protruzja siekaczy dolnych, retruzja siekaczy górnych, ograniczają wpływ

Abstract

As a result of the development of temporary anchorage devices, many different treatment alternatives have emerged in fixed and functional orthodontic treatments. It is frequently preferred by many clinicians due to its minimally invasive procedure and ease of application. **Aim.** The aim of the comprehensive literature review was to evaluate the commonly used skeletal anchorage mechanics with the functional treatment of Class II malocclusion with mandibular retrognathia. **Material and methods.** Functional appliances are commonly used in the treatment of skeletal Class II patients. However, unfavorable side effects, such as protrusion of lower incisors, retrusion of upper incisors limit the skeletal effect of these appliances. To overcome

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szkieletowy tych aparatów. W celu przezwyciężenia tych wad stosowane są aparaty zapewniające zakotwienie szkieletowe. Zidentyfikowano ponad 20 istotnych artykułów, w których oceniano różne rodzaje podejścia do zakotwienia szkieletowego. Systemy te dawały różne wskaźniki powodzenia w odniesieniu do poprawy relacji szkieletowych i ograniczenia kompensacji zębowo-wyrostkowej podczas leczenia wad zgryzu klasy II. **Wyniki.** Zastosowanie aparatów zapewniających zakotwienie szkieletowe z aparatami czynnościowymi podczas leczenia wad zgryzu II klasy szkieletowej było skuteczne w minimalizowaniu protruzji siekaczy żuchwy, gdyż wyeliminowano niepożądany wpływ zębowo-wyrostkowy, biorąc pod uwagę inwazyjną interwencję chirurgiczną i wysokie koszty leczenia. **Wnioski.** Zastosowanie elastycznych wyciągów międzyszczękowych z aparatami zapewniającymi zakotwienie kostne, umocowanymi w obu szczękach lub jako alternatywy aparatu Forsus z płytkami w obrębie żuchwy, znacznie ograniczyło wzrost żuchwy i stymulowało następnie jej doprzedni wzrost. Ponadto stwierdzono korzystny wpływ na tkanki miękkie dzięki zmniejszeniu wypukłości profilu twarzy oraz uwzględniono wady stosowania inwazyjnych interwencji chirurgicznych i wysokie koszty leczenia. **(Alsalihi FS, Buyukcavus MH. Czynnościowe leczenie ortodontyczne wspomagane zakotwieniem szkieletowym w wadach zgryzu klasy II: przegląd piśmiennictwa. Forum Ortod 2020; 16 (4): 300-6).**

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Słowa kluczowe: aparaty czynnościowe, wady zgryzu klasy II, zakotwienie szkieletowe

Introduction

The ideal approach of skeletal malocclusions requires correction of the craniofacial pattern. Condylar adaptation and skeletal development of the mandible should be the main objective of functional treatments. Functional treatments refer to the use of various appliances designed for a certain time to produce a change in the functional activity of different muscle groups that affect the function and position of the mandible in order to transmit forces to the dentition and the skeletal bone (1). Researchers; supposed that the time required for the desired skeletal response was limited by the protrusion of mandibular incisors in almost six months with the use of functional appliances so they aimed to guide the force directly on to mandibular skeletal bone to prevent protrusion of the lower incisors (2). Thus, they observed that they could see the pure skeletal effect of functional treatment (2). As a consequence, skeletal anchorage practices have

these disadvantages, skeletal anchorage devices are incorporated. More than 20 relevant articles were identified which investigated various types of skeletal anchorage approach. These systems were associated with a wide variety of success rates in the skeletal effect improvement and limiting of dentoalveolar compensation during treatment of skeletal Class II malocclusion. **Results.** The corporation of skeletal anchorage devices with the functional appliance during treatment of skeletal Class II malocclusion was effective in minimizing protruded of mandibular incisors overcoming undesirable dentoalveolar effects, with considering the invasive surgical intervention and high cost of treatment. **Conclusions.** Using intermaxillary elastics with bone-anchored devices fixed in both jaws or as alternative conjunction of Forsus appliance with the symphysis plate were significantly limited the growth of the maxilla and forward stimulating the development of the mandible. In addition to positively affection of the soft tissue by reducing facial profile convexity with considering the disadvantages represented by invasive surgical intervention and high cost of treatment. **(Alsalihi FS, Buyukcavus MH. Functional and Orthopedic Treatments Supported By Skeletal Anchorage in Class II Malocclusions: A Comprehensive Literature Review. Orthod Forum 2020; 16 (4): 300-6).**

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been prominent in recent years both to increase the skeletal effect and to decrease the dentoalveolar effect and to increase the amount of mandibular advancement.

One of the most important issues to be considered in achieving a targeted result in orthodontic treatments is the anchorage control. Conventional anchorage methods are used to achieve it. The absolute anchorage is not always possible to be obtained by these methods, unwanted tooth movements and loss of anchorage also can be observed (3-5).

The protrusion of the lower incisors in all fixed functional appliances is an undesirable side effect that limits the skeletal effect of the appliances. Previous researches showed, lower incisor protrusion in amounts ranging from 2.4°-12.9° after the application of fixed functional appliances (6). Furthermore, studies have reported that the skeletal effects of fixed functional appliances are not showing skeletal effects as much as dental effects (6).

Although successful treatments are performed with functional appliances used in the treatment of skeletal Class II malocclusions during the growth period, it is seen that the dentoalveolar effect is higher as a result of cephalometric examination at the end of the treatment. This is one of the most important causes of post-treatment relapse. Their use together with the skeletal anchorage increases the skeletal effect of the appliance and decreases the dental side effects. Therefore, these methods are of great importance for both clinicians and researchers in terms of the success of treatment with function and minimal relapse.

Aim

In this review, orthopedic (functional) devices using skeletal anchorage will be shown and clinical consequences of different designs will be discussed. This literature review aims to demonstrate functional treatment outcomes and clinical outcomes of different designs using skeletal anchorage.

Material and Methods

In the selection of articles, databases such as PubMed, Scielo, LiLacs, Cochrane, and Google Scholar were searched (1995-2017). The search terms "Skeletal anchorage and Class II" or "functional treatment and skeletal anchorage" were used. Different applications were collected under four main headings in line with the search results. Articles using the same method and different publications of the same study were not included in the article.

Results

As a result of the literature review, the skeletal anchorage support systems in orthopedic and functional treatments applied in individuals with skeletal Class II malocclusion were collected under four main headings:

Jasper Jumper Appliance with skeletal anchorage

Gazivekili treated Class II individuals with mandibular retrognathism during the post-pubertal growth period by placing the Jasper Jumper appliance between the symphysis miniplates and the tube of the upper molar teeth. Immediately after the alignment of the upper incisors was achieved, specially designed mini-plates were surgically placed on the right and left sides of the symphysis area and Jasper Jumper was applied for an average of 9.0 ± 3.0 months. At the end of the study, both the mandible and the maxilla did not show significant improvement in the sagittal direction, the lower incisors were slightly retruded and the overjet changes were found to be as a response to dentoalveolar compensation. The researcher suggested that the skeletal effect was inadequate and the dentoalveolar effect was significantly high due to the insufficient physical structure of the Jasper Jumper

appliance so recommended the use of a more rigid functional appliance (7).

Gazivekili as a result of their study reported that the patient remained stable and comfortable for 9 months without complication (infection etc.). They did not observe any breakage or deformation in the Jasper Jumper. At the end of the study, a tooth-supported JJ appliance showed a clockwise rotation of 1.57 in the palatal plane and 5.71 in the occlusal plane, but no effective advancement in the sagittal direction was observed in the mandible. Dentoalveolar, on the other hand, showed a statistically insignificant 1.43 retrusion in the lower incisors (7).

Herbst appliance with skeletal anchorage

Herbst appliance is one of the rigid fixed functional appliances and we will review the results of various studies in which the Herbst appliance used with skeletal anchorage. Manni et al. Treat 50 patients who had Angle Class II division 1 with a mean age of 11.8 ± 1.7 years. Miniscrew anchorage supported resin splint Herbst appliance was applied on 25 of them and the mandibular acrylic resin splint Herbst appliance with no miniscrew support was applied on the other 25 (control group). The total treatment times of the two groups were similar. As a result of the study, it was reported that the lower incisor protrusion was significantly less in the miniscrew supported Herbst group (8).

Also, Manni et al. made a comparative study using the Herbst appliance with and without using miniscrew support. In this study, 28 patients had bilateral Class II division 1 malocclusion (more than half a cusp), permanent or late mixed dentition. In the test group, a titanium miniscrew was placed between the lower molar and the second premolar at the marginal gingival or in the mucogingival junction. The miniscrew and the canine tooth button are connected with ligation wire or with an elastic ligature (100 gr). In the control group, the mandibular acrylic splint appliance was used (9).

The results evidence that both treatments are effective in overcoming Class II malocclusion; in fact a bilateral molar Class I was achieved (9). In both groups, it was noticed a mild maxillary base retrusion, slight retrusion of maxillary incisors, and lower incisor teeth were found to be flared, which was determined to be significantly less in the test group. The retrusion of upper incisors slides the A point, while the mandibular incisors protruded. No significant changes were observed in the cranial base-mandibular angle, which consistent with previous Herbst studies. Proclination of the lower incisors was observed in both groups. But, Herbst with miniscrew combinations was found to be significantly better in proclination control. A slight anterior rotation of the mandible was also observed in the test group (9).

Luzi et al. investigating the use of Herbst appliance and TADs together, in comparison with traditional Herbst treatment in order to prevent undesired lower incisor proclination during Class II correction. 10 patients with Class II

division 1 malocclusion aged 11-15 years with increased overjet (5-12 mm) were included in the treatment groups. Five patients were treated with a mini implant supported Herbst appliance (test group). The other five cases were treated with conventional Herbst appliance (10). During the manufacture of the mini implant supported Herbst appliance, specially designed hooks are soldered to the casting structure and connection with TAD is provided. The inserted miniscrews are tightly connected to the specially designed Herbst hooks with 0.12 mm wire ligature. Thus, the appliance will directly be attached to the mandibular dentition and indirectly to the lower basal bone. During the treatment phase, the appliances were gradually activated until the incisors reached the edge-to-edge position. In both groups bilateral Class I relationship was achieved with a mean of 9 months of treatment time. Though, cephalometric analysis comparison of the examined group to the control group the following results were obtained (10). ANB angle was decreased when Class I relationship was achieved in all patients. There was a significant difference in proclination of incisors in the two groups, interincisal angle increase was 1° (test group) and 7° in (control group). Dentoalveolar compensation was decreased in the study group by decreasing the proclination of the incisors and a better skeletal effect was achieved during the treatment (10).

In addition to the previous study, Lopes et al. in order to apply orthopedic forces directly on TADs, for anchorage they developed a mini implant prototype designed Herbst appliance and examined in vitro flexural strength limits on brass blocks. After the tests, the maximum flexural strength was found to be 989 N, which is greater than the maximum bite force recorded for a human (mean of 756N). The maximum force gauge was the amount of force that able of plastic deformation of the mini implant or the telescopic tube. In another study, by using mini screws examined the flexural strength of mini implant prototypes designed for Herbst appliance to quantify if they are capable of withstanding orthopedic forces. According to researches, forces above 1.0 kg were considered orthopedic. A total of 13 mini implants (2 mm thick, 10 mm long) were attached to the telescopic tubes of the Herbst appliance and then placed in three mini screws. In response to the value calculated, the hypothesis that mini implants can not withstand orthopedic forces was rejected. Other forces that could affect the resistance of the mini implant prototypes such as forces that arrived from muscles and soft tissues of the face also should be considered. According to Panherz, the posterior teeth do not come into contact after applying the Herbst appliance. Contact is only observed in anterior teeth. This situation decreases the effects of the masseter and temporal muscles in the first three months of the treatment which reduces the effect of masticatory force. The authors stated that masticatory forces increased again within six months of treatment. However, the effect of the forces exerted by the muscles and soft

tissues on the resistance could not be examined. Therefore, the necessity of in-vivo studies has been emphasized (11,12).

Forsus appliance with skeletal anchorage

Aslan et al. in order to prevent the proclination of lower incisors during treatment of Class II relationship with a functional appliance and to investigate skeletal changes, 16 patients with a mean age of (13.68 ± 1.09 years of age) were treated with miniscrew supported FRD, whereas 17 patients with a mean age of (14.64 ± 1.56 years of age) were treated with conventional FRD. They compared the changes with each other and with the control group. In the mini screw supported Forsus group, the mandibular canines are bonded with a 0.018 X 0.018 inch vertical slotted bracket for connection with the miniscrew. The miniscrew (spiderscrew 1.5 mm X 8 mm) was applied at least 1 week before the Forsus was applied between the lower canine and the 1st premolar. 0.018 X 0.025 inch steel wire is placed between the vertical canine bracket and miniscrew slot to provide indirect anchorage (13). As a result obtained from this study, there was no significant skeletal effect has been noticed, similar to the maxilla, the sagittal position of the mandible showed no significant change in mandibular length with or without miniscrew supported Forsus appliance. The protrusion of lower incisors was effectively limited in the miniscrew supported group. The mesialization and tipping of the mandibular molars were not significant in the miniscrew supported group. The correction of the overjet and molar relationship was completely dentoalveolar in both groups and the distal movement of the maxillary molar teeth is more prominent in the miniscrew supported group suggested to be due to the fact that the mandibular dentition anchorage was increased with a miniscrew (13). By adding the mini screw support to the Forsus appliance, mandibular growth can be effectively stimulated by limiting the undesirable protrusion of the lower incisors, allowing the mandible to come forward more skeletally. However, in contrast to this study, no skeletal effect was observed on the mandible due to the resistance of the mandible to the Forsus appliance alone and its resistance to the forward force direction. However, this may be due to the fact that the 6-month period is not sufficient for mandibular growth (13).

Since the treatments performed with the removable and fixed functional appliances mentioned in the studies are mostly dentoalveolar and the skeletal improvements are limited. Therefore, Çelikoğlu et al. applied Forsus (FRD) appliance directly to the mini plates placed in the symphysis area of the mandible. Suggested that the application of the force directly to the mandible will increase the skeletal effect, undesirable side effects such as lower incisor protrusion to be reduced and more pronounced improvement in the profile is thought to occur (14). In this research, they aimed to treat skeletal Class II malocclusion due to mandibular retrognathism by use of Forsus fatigue-resistance device (FRD)

with miniplate anchorage. Mini plates were placed bilaterally in the mandibular symphysis area under local anesthesia. The mini plates are fixed with 3 titanium screws (7 mm long, 2 mm wide). Two weeks later, the selected Forsus FRD 35 mm rod was adjusted. After 9 months of skeletal anchorage Forsus application, Class I canine and molar relationship was achieved and overjet was significantly decreased. Lateral cephalometry examination was revealed restriction of maxillary growth, anterior positioning of the mandible and as a result of this, the maxillary and mandibular incisors retrusion was observed clinically (14). By using Forsus FRD with miniscrew anchorage, lower incisor protrusion, which is the most common finding of removable and fixed functional appliances, is eliminated. However, according to other authors, all changes were dentoalveolar and no improvement could be achieved for mandibular advancement. Whereas, in this case report cephalometric evaluations showed that maxillary growth was slightly restricted (mean SNS - 0.7 Co-A - 0.4 mm, A-PMV - 0.6 mm) and mandibular growth exceeded (mean SNB 1.6°, Co-Gn 3.1 mm, Pog-PMV 3 mm) when miniplate anchorage was used. The upper and lower incisors were retruded, the overbite increased and a significant reduction in IMPA (-7.8°) was noticed (14). The need of a minor surgical procedure to place the miniplate in this approach and a second surgery's necessity to remove it, were the disadvantages of this system (14).

Ünal et al. also studied the same procedure in 17 patients with skeletal Class II malocclusion with mandibular retrognathism. In order to reduce the edema after insertion of the symphysis plate, chin-cup with lite force was applied to the patients for 3 days following the surgical procedure (15, 16). At the end of the study, Forsus FRD with skeletal anchorage significantly limited the sagittal position of the maxilla which is similar to the occipital headgear effect and it is consistent with some previous studies. A significant increase in mandibular parameters was observed. These changes also lead to the development of maxillo-mandibular relations (ANB: $-3.32 \pm 0.70^\circ$; convexity: $-5.71 \pm 2.14^\circ$). Dentoalveolar changes after this study; retrusion of the upper and lower incisors, distalization of the upper molar teeth and marked improvement in the overjet (-5.11 ± 2.43 mm) with the contribution of skeletal effects these dentoalveolar changes when compared with previous studies. In this study, maxillary incisors retrusion were more frequently observed ($-10.86 \pm 4.57^\circ$). Its thought to be due to the skeletal anchorage force applied on the mandible was transmitted to the maxillary arch. The lower lip and soft tissue pogonion protruded prominently, while the upper lip is retruded. These changes leading to the improvement of the facial soft tissue (15, 16). Based on the results obtained, the Forsus FRD appliance supported by skeletal anchorage was found to be effective in the treatment of Class II malocclusion associated with mandibular retrognathia in light of the improvement was largely skeletal. However, it should be kept in mind that

this method increases the cost of treatment and necessitates surgical intervention during the placement and removal of miniplates, therefore should be considering the advantages and the disadvantages of this system during the evaluation of the treatment plan (15, 16).

In the study of Elkordy et al, Forsus FRD was applied conventionally to half of 32 female patients with class II malocclusion and the other half was supported by miniscrew. The miniscrew anchorage is provided by a wire fixed on to the mandibular canine and the miniscrew. At the end of the study, it was found that the two applications were similar in terms of acceptability and no significant skeletal change was observed in both appliances. (17). In the latest studies of the same researchers compared the effects of Forsus and Forsus appliance with miniscrew support in CBCT, it was founded that the Forsus appliance had mostly dentoalveolar effect in Class II correction and the skeletal effect was minimal. The use of the miniscrew anchorage significantly reduced the intrusion and proclination of mandibular incisors but did not contribute to this skeletal effect. Also, the use of FRD in combination with miniscrew reduced mandibular dentoalveolar effect and increased distalizing effect in the maxillary arch. (18). Finally, Elkordy et al. In a meta-analysis study of the skeletal changes of the use of fixed functional appliance with skeletal anchorage observed that the use of fixed functional appliances in combination with skeletal anchorage did not induce mandibular growth (No significant increase in SNB and mandibular length) in but can limit undesired mandibular incisor proclination (19).

Other functional treatments with skeletal anchorage

In addition to the fixed functional appliance applications with skeletal anchorage, a different application was done by Özel et al. In this study, 32 patients; miniscrews with a diameter of 2 mm and a length of 8 mm were placed between the mandibular 2nd premolar and the 1st molar. Class II elastics were applied between the miniscrew and the hooks adjusted in the distal region of the upper central incisors. Approximately 500 g of orthopedic force was applied and 89.06% success was observed. In addition, it has been presented as an alternative method which has positive dental, skeletal, and soft tissue effects in Class II cases shortens the orthodontic treatment time by 6-8 months, does not require the use of extraoral anchorage appliance, allows single-stage treatment and has no adverse effects to the surrounding tissues (20).

Ozbilek et al applied skeletal anchorage-supported Class II elastics and evaluated skeletal, dentoalveolar, and soft tissue effects in order to achieve pure skeletal effect in the functional treatment of Skeletal Class II patients with mandibular retrognathia. Twelve patients (6 girls, 6 boys) were included in the study and randomly divided into two groups. Six patients received bilateral Class II elastics from the miniplates placed on the ramus of the mandible, to the miniplates

placed in the Apertura piriformis region of the maxilla. Between the mini plates, 500 g of force was applied on both sides. The other six patients applied the monoblock appliance. Treatment was continued in all patients until a Class I canine and molar relationship was achieved. As a result of their work, the researchers observed that the mandible was moved forward and down. However, they noted a statistically significantly greater increase in the sagittal movement of point B and Co-Gn length in the Class II elastic group. Convexity angle, ANB angle, and Wits assessment decreased in both groups. In this study, an insignificant increase was observed in the elastic group in the SN-GoGn angle. In the elastic group, a marked retrusion of the mandibular incisors was noted. In both groups, soft tissue pogonion moved forward and the face profile improved (21).

Limitation

This review is a comprehensive literature review that provides information on studies on skeletal anchorage-supported functional and orthopedic treatments of individuals with skeletal Class II malocclusion. The limitations of this study are the lack of a systematic review of our study, the lack of quality evaluation of the studies mentioned in the article, and the failure to evaluate the precision of the evidence when the studies do not contain a statistical method by comparing them with each other.

Conclusions

- The incorporation of skeletal anchorage devices with the functional appliance during treatment of skeletal Class II malocclusion was effective in achievement Class I relationship and reduction of overjet.
- However, most, if not all, of the appliances were not effective in mandibular skeletal growth improvement. This is attributed to 2 reasons: Firstly, the rapid dental relationship correction of the maxillary dentition may limit the mandibular correction. Secondly, indirect application of the forces or contribution of the arch with the anchorage unite can lead to rapid dental relationship correction of the maxillary dentition and may limit the mandibular correction.
- Using intermaxillary elastics with bone-anchored devices fixed in both jaws or as alternative conjunction of Forsus appliance with the symphysis plate were significantly limited the growth of the maxilla and forward stimulating the development of the mandible.
- Although the use of skeletal anchorage positively affects the soft tissue by reducing the convexity of the facial profile, its disadvantages such as the need for invasive surgical intervention and high treatment cost should also be taken into account.

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