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Paper Accepted*

ISSN Online 2406-0895

Original Article / Оригинални рад

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Assessment of condylar position in asymptomatic individuals before and after neuromuscular deprogramming with a stabilization splint

Процена кондиларне позиције код асимптоматских особа пре и после депрограмирања неуромишићног система помоћу стабилизационог сплинта

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Received: February 27, 2022
Revised: January 26, 2023
Accepted: February 21, 2023
Online First: March 8, 2023
DOI: https://doi.org/10.2298/SARH220227028D

*__Accepted papers__ are articles in press that have gone through due peer review process and have been accepted for publication by the Editorial Board of the *Serbian Archives of Medicine*. They have not yet been copy-edited and/or formatted in the publication house style, and the text may be changed before the final publication.
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SUMMARY

Introduction/Objective Deprogramming of the neuromuscular system with the use of stabilization splint might provide more precise evaluation of the centric relation (CR) - maximum intercuspation (MI) discrepancy.

The study aimed to evaluate the differences between the bite registrations obtained in the CR before and after the application of the stabilization splint therapy.

Methods The sample included 48 non-deprogrammed individuals without any apparent signs and symptoms of temporomandibular disorders (TMDs). The neuromuscular system was deprogrammed by employing stabilization splint therapy. A condylar displacement evaluation was performed on vertical, horizontal and transverse planes of space, with the assistance of a condylar position indicator (CPI).

Results The mean values of condylar displacements, which were obtained after the deprogramming of the neuromuscular system, were significantly greater than those obtained before neuromuscular deprogramming for vertical condylar displacement ($p < .0001$). A greater degree of condylar distraction was observed on the left side of the vertical plane before ($p < .01$) and after neuromuscular deprogramming ($p < .05$). The highest level of condylar displacement occurred in the postero-inferior direction subsequent to the muscle deprogramming.

Conclusion It was observed that the level of average condylar displacements was significantly higher following the deprogramming of the neuromuscular system compared to that recorded before neuromuscular deprogramming using stabilization splint therapy. A more precise orthodontic diagnosis could have been obtained if the condyles were placed in a more exact CR position by muscle deprogramming.

Keywords: centric relation; maximum intercuspation; stabilization splint; condylar displacement

САЖЕТАК

Увод/Циљ Депрограмирање неуромишићног система помоћу стабилизационог сплинта даје могућност добијања прецизнијих резултата мерења приликом евалуације дискрепанци између центричне релације (ЦР) и максималне интеркуспидације (МИ). Циљ ове студије је био да евалуирају разлике између загриза који су регистровани у положају (ЦР) пре и после примене терапије са стабилизационим сплинтом.

Методе Ова студија је обухватала 48 пацијената (старости између 18 и 30 година) који нису били депрограмирани на неуромишићном нивоу и који нису имали очигледних знакова и симптома темпоромандибуларних поремећаја (ТМП). Депрограмирање неуромишићног система је извршено помоћу терапије са стабилизационим сплинтом. Евалуација степена кондиларних одступања је извршена у вертикалној, хоризонталној и трансверзалној равни, уз помоћ индикатора положаја кондила (ЦПИ).

Резултати Просечне вредности кондиларних одступања у вертикалној равни добијене након депрограмирања неуромишићног система, биле су сигнификантно веће у односу на просечне кондиларне вредности добијене пре неуромишићног депрограмирања ($p <.0001$). Већи степен кондиларне дистракције примећен је на левој страни у вертикалној равни пре ($p < .01$), као и после неуромишићног депрограмирања ($p < .05$). Након депрограмирања неуромишићног система највећи степен дистракције кодила је забележен у постеро-инфериорном правцу.

Закључак У студији је утврђено да је ниво просечних кондиларних одступања био сигнификантно већи после депрограмирања неуромишићног система у поређењу са нивоом кондиларних одступања забележених пре депрограмирања неуромишићног система. Постављањем кондила у правилнији положај центричне релације након депрограмирања неуромишићног система повећава се могућност за постављање прецизније ортодонтске дијагнозе.

Кључне речи: центрична релација; максимална интеркуспидација; стабилизациони сплинт; кондиларна одступања

INTRODUCTION

From the perspective of condylar health, the centric relation is widely accepted as the most stable position of the condyles in the glenoid fossa [1–4]. Earlier studies concluded that the mandible in the CR is positioned by the elevator muscles in case no dental influences are present [1, 3, 5, 6, 7]. However, the actual condylar position is determined by the contact between the upper and the lower teeth in the maximum intercuspation (MI) position. Positions of CR and MI are rarely coincident, and small discrepancies are usually present between them. Discrepancies between the CR and MI can be evaluated at dental and condylar levels. Slides increased at the dental level should be confirmed through condylar measurement using the CPI articulator. Significant slides might affect proper orthodontic diagnosis by changing the dentofacial features of dental malocclusions [2, 5, 7, 8]. Proffit recommends mounting the orthodontic models on an articulator in case anterior slides of 2 to 3 mm and lateral slides of any range exist between the MI and the CR positions at the dental level [9]. Values of dental CR–MI discrepancies do not usually correspond to discrepancy in values obtained at the condylar level for the asymptomatic population [2, 3, 4, 10]. Therefore, the mounting of diagnostic models is recommended by several clinicians before the start of orthodontic treatment. This enables the observation of the real difference between the CR and MI [2, 3, 7, 11, 12]. Furthhermore, if the positions of the CR and MI are close to each other, the possibility for the development of TMDs is lower [6]. The stability of condyles in the CR is most commonly worsened by the presence of occlusal interferences located in the area of the posterior teeth, which might increase the CR–MI discrepancy and cause development of TMD [2, 3, 9, 11, 13]. In order to reach the most stable intercuspal position, the mandible must avoid these prematurities that lead to mandibular shifts on all three spatial planes [11]. These deviated positions of the mandible coerce the related muscles to adapt to various neuromuscular patterns of activity, causing condylar instability [2, 3, 11]. In order to relieve the muscles of inadequate

activity, neuromuscular deprogramming is required. Several researchers recommend the application of stabilization splint therapy for deprogramming the neuromuscular system prior to the registration of the CR position [12, 14, 15]. Also, when compared to other methods, the most consistent and reproducible results of CR bite registration were obtained after deprogramming was performed with the occlusal stabilization splint [15, 16]. Ideal protocol calls for complete the neuromuscular deprogramming of all subjects, with increased CR–MI discrepancy at the occlusal level (horizontal or vertical discrepancy greater than 2.0 mm between the CR and MI position), using a stabilization splint therapy before the registration of the CR position. Roth suggested that even if asymptomatic individuals were deprogrammed with an occlusal splint, greater difference between CR and MI would be observed in comparison with non-deprogrammed asymptomatic individuals [11]. With regard to the impact of the neuromuscular system on CR bite registration, it was hypothesized that asymptomatic patients could show greater condylar distraction if the neuromuscular system was deprogrammed using the stabilization splint therapy, compared to the case of absence of such deprogramming. The purpose of this study was to compare the condylar displacements between the CR and the MI positions across three planes of space, when measured before and after the deprogramming of the neuromuscular system using a stabilization splint. Additionally, the condylar positions among males and females were compared both before and after the neuromuscular deprogramming.

METHODS

Forty-eight non-deprogrammed individuals in the age range of 18 to 30 years (24 females and 24 males), who did not show any obvious signs and symptoms of temporomandibular disorders, participated in the study. The study was carried out at the Private Practice for Orthodontics and Dentofacial Orthopedics “Demirovic” located in Sarajevo.

Exclusion criteria included history of trauma involving the temporomandibular joints (TMJ), history of orthodontic treatment or orthognathic surgery, history of TMJ treatment, presence of any past major prosthetic treatments and presence of rheumatoid arthritis or other rheumatic disorders. The study protocol was approved by the Ethics Committee, School of Dental Medicine, University of Sarajevo, Bosnia and Herzegovina.

All the subjects included in the study had increased CR–MI discrepancy (greater than 2 mm) in the horizontal or vertical plane, measured at the level of occlusion. Horizontal (overjet) and vertical (overbite) values were measured in the positions of MI and CR, obtained before and after the deprogramming of the neuromuscular system with stabilization splint. The measurement of these parameters was recorded to the nearest 0.1 mm with the help of a digital ruler.

Evaluation of condylar displacement between the centric relation and maximum intercuspation

Bite registration in the MI position was obtained using a single layer of extra-hard pink wax (Beauty Pink Wax, Moyco Inc, Philadelphia PA, USA), prior to the deprogramming of the neuromuscular system. In order to register the CR position, blue bite registration wax (Delar Corp., Lake Oswego, Ore) was used in accordance with Roth's power centric technique. Maxillary and mandibular diagnostic casts of all the participants were obtained before the neuromuscular deprogramming and mounted on an articulator (Panadent Corp, Grand Terrace, Calif) using an estimated face-bow and wax bite registered in the position of CR. The level of condylar displacement between the CR (Figure 1) and the MI (Figure 2) positions was evaluated before the neuromuscular deprogramming using initial CR and MI bite registration records. After the neuromuscular deprogramming with stabilization splint, newly obtained upper and lower diagnostic casts were mounted on an articulator using a new wax bite

registered in the position of CR. The amount of condylar displacement between the CR and MI positions after the neuromuscular deprogramming was evaluated using the initial MI bite registration record, and the CR bite registration record taken after the neuromuscular deprogramming with stabilization splint.

Neuromuscular deprogramming with stabilization splint therapy

In order to find a more reliable CR position in patients with a large CR–MI discrepancy, deprogramming of the neuromuscular system was performed using an acrylic stabilization splint [7, 17] (Figure 3). This stabilization splint was constructed according to the principles of the mutually protected occlusion (Figure 4). All participants were instructed to wear the stabilization splints round the clock, except while eating and maintaining their oral hygiene. At each visit, centric stops and the posterior eccentric disclusion were evaluated using .008 mm colored articulating paper (Arti-Fol, Bausch Articulating Papers, Koln, Germany), and the splints were adjusted to optimum occlusal conditions for mutually protected occlusion. In order to track the condyles to a stable condylar position, centric relation records were taken every 15 days during the first two months of stabilization splint therapy and at one-week intervals during the third and/or fourth month of therapy. Stable condylar position was considered to be achieved when identical CPI values were obtained for three consecutive weeks. Neuromuscular deprogramming and stable condylar position in the fossa were obtained during the third or fourth month of splint application in all subjects. All mountings were performed on the same articulator. All the steps in this study were performed by the same trained operator. For statistical analysis, results were presented as mean ± standard deviation and median, while the testing of differences was performed with the nonparametric Mann-Whitney U test. Analysis was performed using the statistical package IBM Statistics SPSS v 23.0.

The authors certify that they have obtained the necessary patient's written consent.

RESULTS

The mean values of condylar displacements obtained after the deprogramming of the neuromuscular system proved to be significantly greater than those attained before neuromuscular deprogramming in the case of CPI vertical right (Vert R) (p = .0001) and CPI vertical left (Vert L) (p = .0001) but not for the CPI horizontal right (Hor R) (p = .144), CPI horizontal left (Hor L) (p = .171) and CPI transversal (Transv) (p = .203) (Table 1).

Greater left-side inferior and posterior displacement of the condyles was observed after the neuromuscular deprogramming. These differences were statistically significant before (p = .010) and after (p = .021) in the vertical but not in the horizontal plane, neither before (p = .449) nor after (.596) (Table 2). No statistical differences were observed between the genders (all p > 0.05) (Figure 5). Before neuromuscular deprogramming was performed, 70.8% of the subjects in the study had postero-inferior displacement of the condyles, 22.9% antero-inferior and 6.2% straight inferior on the left side, while on the right side, condyles were displaced postero-inferiorly in 60.4%, antero-inferiorly in 25.0% and straight inferiorly in 14.5% of the subjects. Evaluation of the direction of condylar displacement, after the deprogramming of the neuromuscular system, showed that 81.2% of the condyles were displaced in the postero-inferior direction and 18.7% in the antero-inferior direction on the left side. On the right side, 77.1% of the condyles were displaced in the postero-inferior direction, 20.8% in the antero-inferior direction and 2.8% in the straight inferior direction.

DISCUSSION

It is considered that mandibular stability is realised when the position of CR coincide with the MI position [11]. This means that orthopedic stability is guaranteed if the musculoskeletal position of the condyles in the fossa is as much as possible harmonized with

the position of the teeth in MI [6]. In the studies that evaluated CR–MI discrepancy in asymptomatic individuals using just a CPI instrumentation, significant differences between the CR and MI were found [4, 17,18]. Previous studies indicate that asymptomatic individuals with a higher oclusal CR–MI discrepancy (greater than 2.0 mm in horizontal and vertical directions) also showed significant condylar CR and MI differences [2, 10]. Most commonly, the presence of occlusal interferences increases discrepancy between the CR and MI, thereby leading the mandible to deviated positions, indirectly causing neuromuscular reprogramming of the related muscles. Deprogramming of the neuromuscular system is needed before CR bite registration, in order to detect a true discrepancy between the CR and MI. Although Roth's power centric technique was recognized as the most reliable and reproducible technique of CR bite registration, Roth himself stated that clinical mandibular manipulation is not reliable in determining condylar position due to the effects of the neuromusculature [11]. In a very recent study, authors concluded that ¨Dentists and dental experts are dependent not so much on the head posture but on an acceptably reproducible horizontal jaw relation in order to be able to repeatedly check the occlusion in reconstructions of the mandibular posture [19]˝. In most of the earlier studies, CR bite registration was recorded without previous muscle deprogramming, although the impact of the neuromuscular system on CR registration had already been proved [3, 4, 12, 18]. In a study by Fantini et al. [7] vertical and horizontal condylar displacements in asymptomatic patients were found to be greater after neuromuscular deprogramming with the stabilization splint in comparison with the results of previous studies, where no neuromuscular deprogramming methods were employed [12, 18]. In this study, it was hypothesized that stabilization splint therapy for approximately three months could lead to better seating of the condyles in the fossa, resulting in different CPI measurement results compared to those obtained before the deprogramming of the neuromuscular system in asymptomatic individuals. Statistically significant differences between the CR and MI were observed on the vertical plane.

It was found that the mean vertical displacements on the right and left sides, obtained after the neuromuscular deprogramming, were significantly greater than those attained before the neuromuscular deprogramming (Table 1). These results are in close agreement with those derived in similar studies by Fantini et al. [7] and Yoon and Kim [17] who used identical methods. Vertical displacement of the condyles was more expressed on the left side before ($p<.01$) and after ($p<.05$) the neuromuscular deprogramming (Table 2). On the other hand, Fantini et al. found that after the neuromuscular deprogramming with the stabilization splint vertical condylar displacements were of greater magnitude on the right side [7]. After the neuromuscular deprogramming, greater mean condylar displacements were observed on the horizontal plane too, but without statistical significance (Table 1). The condyles were displaced in posteroinferior, anteroinferior and straight inferior direction, which was analogous with the findings of similar studies [2, 3, 11, 12, 18]. The results of this study are consistent with the findings of previous studies, confirming that the deprogramming with the stabilization splints significantly increases the amount of condylar distraction in vertical direction in asymptomatic patients [7, 17]. Also, before and after the neuromuscular deprogramming, patients showed higher mean values of condylar displacement than that it was found by other authors in non-deprogrammed asymptomatic groups [12, 18]. Statistically, no significant differences in condylar displacements were observed between males and females. In this study, it was shown that after the neuromuscular system was deprogrammed and the condyles were in a stable musculoskeletal position, the magnitude of discrepancy between the CR and MI at the level of occlusion might be significantly changed. The most common changes observed in inter-arch relations after the neuromuscular deprogramming included the following: the presence of localized occlusal interferences in premolar and molar areas, increased overjet, decreased overbite and coincidence of transverse midlines (Figure 6 A-D), which corresponded with findings by other authors [2, 9, 5, 11, 20, 21]. These significant changes at the level of occlusion

demonstrate the importance of neuromuscular deprogramming, especially from the aspect of making an accurate orthodontic diagnosis [2, 5, 7, 8, 21-25]. The use of occlusal splints for deprogramming of the neuromuscular system before orthodontic treatment is usually recommended for patients with signs and symptoms of TMDs. Earlier investigations have demonstrated the efficacy of neuromuscular deprogramming with occlusal stabilization splint in the reduction of signs and symptoms of TMD in patients with a large CR–MI discrepancy [3, 5, 15, 26]. Padala et al. [20] and Lim et al. [22] indicated that the signs and symptoms of TMDs are more significantly expressed in individuals with large CR–MI discrepancy. The latest studies confirmed that the most common type of occlusal splint used for treatment of the patients with TMDs is occlusal stabilization splint [26–29]. Crawford's study showed how anamnestic and clinical symptomatology drastically increase as the CPI values in vertical and horizontal direction rise from 1 to 2 mm [3]. Accordingly, this implies that orthodontic models of asymptomatic patients with increased slide between the CR and MI at the dental level (greater than 2.0 mm) need to be mounted on an articulator and measured at the condylar level. If condylar measurements detect vertical and horizontal displacements larger than 1.0 mm and transverse condylar displacements larger than 0.3 mm, these patients may be at potential risk of developing TMD during or after the orthodontic treatment [30]. In this context, the deprogramming of the neuromuscular system with a stabilization splint and the consequent placement of temporomandibular condyles in a more correct and reliable CR position within the fossa could prevent a possible TMD in asymptomatic patients who showed greater CR–MI discrepancy between maxillary and mandibular dentition. The results of this investigation demonstrated that the mounting of orthodontic models in the CR on a semi-adjustable articulator and muscle deprogramming with a stabilization splint is recommended in asymptomatic patients who show increased discrepancy between the CR and MI. Moreover, it was assumed that a more accurate orthodontic diagnosis could be obtained if these

asymptomatic patients were neuromuscularly deprogrammed and analyzed in the CR position in comparison with patients diagnosed on the basis of hand-held casts articulated in maximum intercuspation.

CONCLUSION

Measured on the same group of patients, greater mean condylar displacements on the vertical plane were observed after the neuromuscular system was deprogrammed in comparison with condylar displacements recorded before muscle deprogramming. The more significant vertical displacement of the condyles was present on the left side before and after the neuromuscular deprogramming. It is recommended that patients without any existing signs and symptoms of TMDs but with condyles in unstable musculoskeletal position should be neuromuscularly deprogrammed prior to the commencement of orthodontic treatment. The use of stabilization splint therapy in asymptomatic patients with increased CR–MI discrepancy could prevent orthodontic misdiagnosis and possible development of TMD during or after the orthodontic treatment.

Conflicts of interest: None declared.

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Table 1. Comparison of mean values, standard deviations and median, in mm, of vertical condylar displacement on the right (CPI Vert R) and left (CPI Vert L) side, horizontal condylar displacement on the right (CPI Hor R) and left (CPI Hor L) side, and transversal condylar displacement (CPI Transv) before (B) and after (A) neuromuscular deprogramming with stabilization splint

Parameters	N	Mean ± SD	Median	Z	p
B - CPI Vert R (mm)	48	1.54 ± 0.47	1.60	-3.532	0.0001
A - CPI Vert R (mm)	48	1.97 ± 0.69	1.80		
B - CPI Vert L (mm)	48	1.82 ± 0.54	1.80	-3.912	0.0001
A - CPI Vert L (mm)	48	2.20 ± 0.63	2.20		
B - CPI Hor R (mm)	48	-0.32 ± 0.69	-0.50	-1.460	0.144
A - CPI Hor R (mm)	48	-0.49 ± 0.92	-0.8		
B - CPI Hor L (mm)	48	-0.41 ± 0.62	-0.50	-1.368	0.171
A - CPI Hor L (mm)	48	-0.56 ± 0.85	-0.65		
B – Transv (mm)	48	0.20 ± 0.25	0.20	-1.274	0.203
A – Transv (mm)	48	0.27 ± 0.30	0.20		

CPI – condylar position indicator; Z – standard score

Table 2. Comparison of mean values, standard deviations and median, in mm, of vertical condylar displacement according to right (CPI Vert R) and left (CPI Vert L) side, and horizontal condylar displacement according to right (CPI Hor R) and left (CPI Hor L) side before (B) and after (A) neuromuscular deprogramming

Parameters	N	Mean ± SD	Median	Z	p
B - CPI Vert R (mm)	48	1.54 ± 0.47	1.60	-2.577	0.010
B - CPI Vert L (mm)	48	1.82 ± 0.54	1.80		
B - CPI Hor R (mm)	48	-0.32 ± 0.69	-0.50	-0.757	0.449
B - CPI Hor L (mm)	48	-0.41 ± 0.62	-0.50		
A - CPI Vert R (mm)	48	1.97 ± 0.69	1.80	-2.313	0.021
A - CPI Vert L (mm)	48	2.20 ± 0.63	2.20		
A - CPI Hor R (mm)	48	-0.49 ± 0.92	-0.80	-0.530	0.596
A - CPI Hor L (mm)	48	-0.56 ± 0.85	-0.65		

CPI – condylar position indicator; Z – standard score

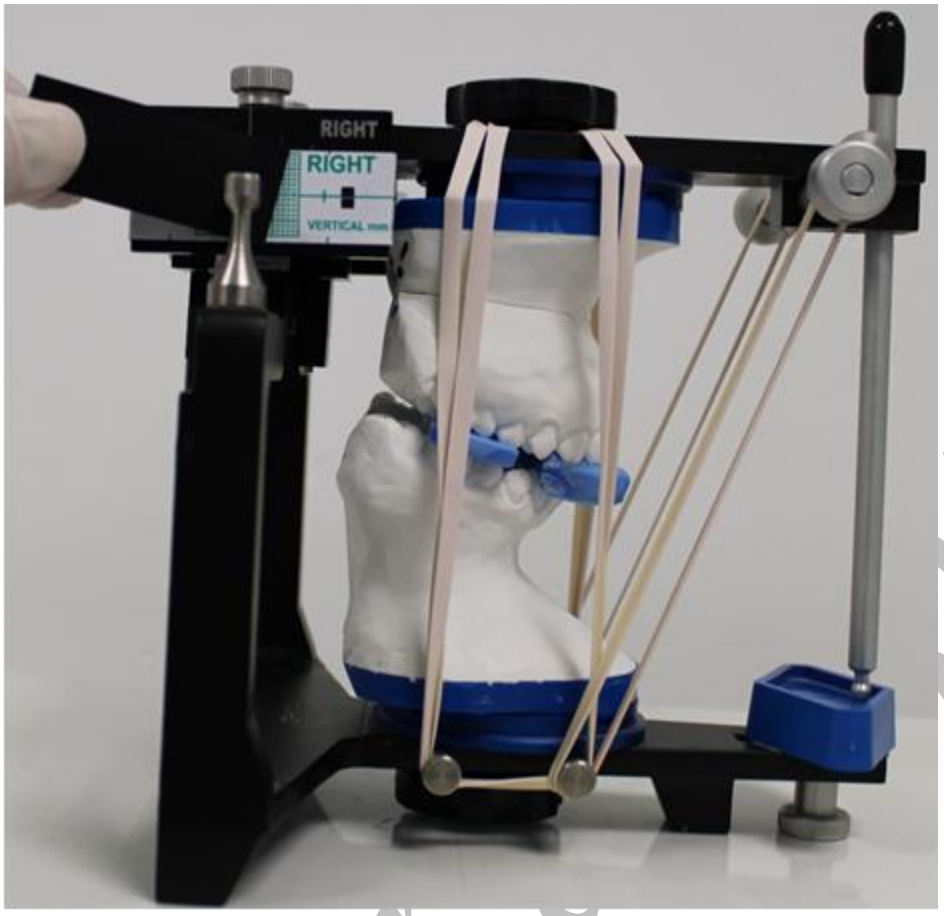

Figure 1. Centric relation position in condylar position indicator instrumentation determined by bite registered in centric relation position

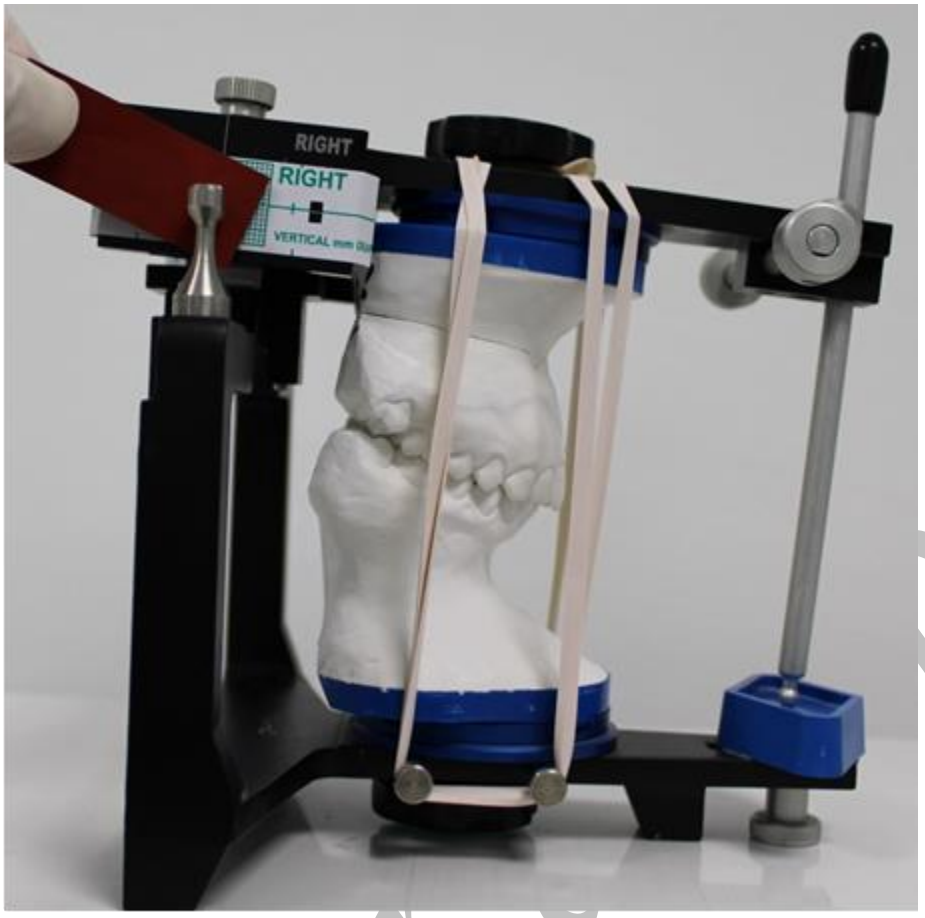

Figure 2. Maximum intercuspation position in condylar position indicator instrumentation determined by bite registered in the position of maximum intercuspation

Figure 3. Acrylic stabilization splint constructed in a semi-adjustable articulator

Figure 4. Occlusal scheme of the stabilization splint based on principles of mutually protected occlusion

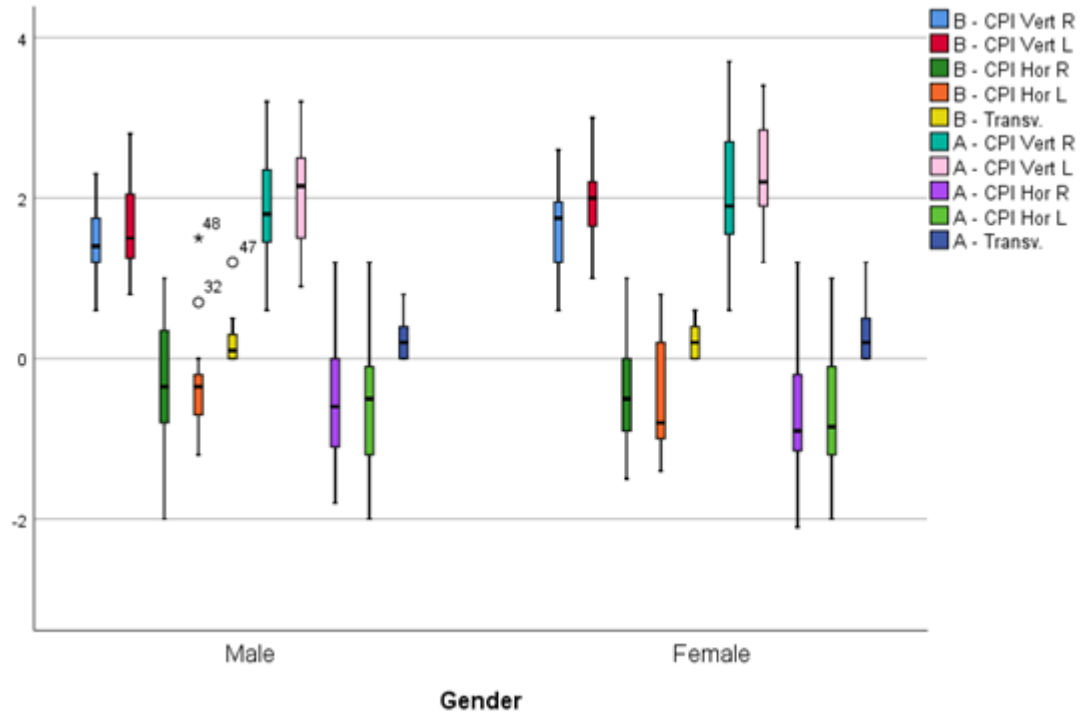

Figure 5. CPI – condylar position indicator; comparison of mean values, standard deviations and median, in mm, of vertical right (CPI Vert R) and left (CPI Vert L), horizontal right (CPI Hor R) and left (CPI Hor L) and transverse (Transv) condylar displacement between genders, before (B) and after (A) neuromuscular deprogramming with stabilization splint

Figure 6. (A) right lateral intraoral view of occlusion in maximum intercuspation before the stabilization splint therapy; (B) right lateral intraoral view of occlusion after neuromuscular deprogramming with a stabilization splint; discrepancies between the upper and lower dental arch had increased in horizontal (overjet) and decreased in vertical (overbite) direction affecting the orthodontic diagnosis and plan of treatment; (C) left lateral intraoral view of occlusion in maximum intercuspation before the stabilization splint therapy; (D) left lateral intraoral view of occlusion after neuromuscular deprogramming with a stabilization splint; discrepancies between the upper and lower dental arch has increased in horizontal and vertical plane affecting the orthodontic diagnosis and plan of treatment

