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ЕФЕКТ НА КВАЛИТЕТОТ НА ВЕШТАЧКАТА ОКЛУЗИЈА ВО РАЗВОЈОТ НА ВИЛИЧНОЗГЛОБНА НЕПРАВИЛНОСТ СО УПОТРЕБА НА Т-СКЕН

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THE EFFECT OF THE QUALITY OF ARTIFICIAL OCCLUSION ON THE DEVELOPMENT OF TEMPOROMANDIBULAR DISORDERS USING THE T-SCAN ANALYSIS

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ABBREVIATIONS

CG: Control Group
CR: Centric Relation
COF: Center of the occlusal force
DT: Disclusion Time
DC/TMD: Diagnostic Criteria for Temporomandibular Disorders
EMG: Electomiography
MIC: Maximal Intercuspation
MHI: Maximal Habitual Intercuspation
OHRQoL: Oral health-related quality of life
OT: Occlusion Time
RDC/TMD: Research diagnostic criteria for temporomandibular disorders
SD: Standard deviation
SG: Study Group
TMD: Temporomandibular disorders
TMJ: Temporomandibular Joint

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Abstract

THE EFFECT OF THE QUALITY OF ARTIFICIAL OCCLUSION ON THE DEVELOPMENT OF TEMPOROMANDIBULAR DISORDER USING THE T-SCAN ANALYSIS

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INTRODUCTION

Since the role of occlusal interference on the etiology of temporomandibular disorder (TMD) is evaluated in many studies, these interferences can be formed by uneven tooth wear, but also by restorative procedures performed incorrectly, which can leads to a disharmonic relation between the arches. Therefore, after conducting direct or indirect restorations, a careful analysis of occlusal contacts should be performed, in order to avoid the creation of iatrogenic interferences that can produce the signs and symptoms of TMD and postural disorders.

TMD and facial pain is a collective term for a number of clinical problems that involve the masticatory muscles, temporomandibular joints (TMJ), and associated structures.

Carefully balanced occlusal contacts should be performed not only at committed time of restoration, but also at later stages of clinical supervision.

For many years to balance the occlusion in the arsenal of a dentist, there was only one way, and are believed to be reliable enough - articulating paper. However, in several studies it was discussed the perception about its accuracy in the circles of professional dentists opinion. The fact is that articulating paper often it's not enough to carry out adequate diagnosis and functional occlusal balance correction.

Articulating paper shows no contact force, the sequence of appearance of contacts over time, and shows only the contact area of antagonists in the occlusal surfaces of the teeth. Also as qualitative method its disadvantages is lack of objectivity and reproducibility, as well as the difficulty of describing the various states of occlusion.

The present level of high-tech industries and their rapid implementation in various spheres of human activity, especially in medicine and dentistry covers entirely. The urgency of monitoring occlusion constantly stirs interest to create new methods and devices.

On the world market of dental equipment is represented occlusal device "T-Scan" (USA), by which we have the opportunity to receive information about the strength of the contacts and the sequence of their appearance. However, data on working with the device "T-scan» are often contradictory, in this study we decided to determine usefulness and consistency of T-scan in assessing occlusion of subjects with dental prosthetics ceramic restorations.

OBJECTIVE:

Quality of artificial occlusion and its impact on the TMJ is objective of this study, comparing classical method of analyzing with articulating paper and measurements reported with electronic system T-scan III.

RESEARCH OBJECTIVES:

1. Investigating if any direct relationship exists between the quality of artificial occlusion on the development of TMD comparing classical traditional method of analyzing with articulating paper and measurements reported with electronic system T-scan III.

2. Registering frequency of nonbalanced occlusion and frequency of TMD in subjects with prosthetic ceramic restorations.

MATERIALS AND METHODS:

This study has been realized in:

• Faculty of Medicine, School of Dentistry, Pristina, Kosovo and in

• Faculty of Dentistry, Skopje, Macedonia.

STUDY SAMPLE:

The study population consisted of total 105 subjects of mean age 20-65 year-old.

The study population was divided in three groups of 35 subjects:

• In the first study group (SG I) were 35 subjects with fixed dentures with prosthetic ceramic restorations

• In the SG II were 35 symptomatic subjects with TMD. Subjects also underwent clinical and dental examination for signs and symptoms commonly associated with TMD. In

this group were excluded subjects with orthodontic problems or pretreated with orthodontic device.

• In the third SG III-Control Group were 35 healthy subjects with Class I Angle's classification with normal occlusal relations. Subjects were with full arch dentition where the presence or absence of third molar was not a criteria considered in the study. The study has been initiated after research program had been approved by the Ethical Committee, all procedures were fully explained to all subjects and they had signed written informed consent forms. All the subjects are examined clinically by the same trained dentist and answered the questionnaire for TMD-the anamnesis index proposed by the Fonsseca.

For the measurements was used The T-Scan III - Computerized Occlusal Analysis System 7.0 , (Tekscan Inc., South Boston, MA, USA). In the end all the subjects were analyzed in habitual occlusion also with the two color articulation paper and they were captured the picture do to compare the findings.

RESULTS:

In this study after measuring occlusion in both central and habitual position during operation with T-scan was analyzed deviation of the jaw in all three groups and from this measurements we can consider that incidence of unbalanced occlusion is high. Differences between these two positions were evident even so there was no significance. When the deviation of the Centre of Force (COF) was present, differences were distinguished and even more pronounced.

According to this study there is high frequency of TMD in subjects with prosthetic ceramic restorations, also it can be considered that subjects with prosthetic ceramic restorations influence the occurrence of TMD as iatrogenic factor of unbalanced occlusion. The deviation of the COF is present in group with TMD but also in control group so it can be concluded that the unbalanced occlusion may cause the appearance of changes in the TMJ and as the result of this occurrence of TMD even in a non-patient population in future.

Scientific uniqueness of the clinical computer controlled occlusion at prosthetic ceramic restorations shows the frequency of unbalanced occlusion and convincingly proved the inadequacy when using the traditional method of control and correction of occlusion using articulating paper alone.

DISCUSSION:

From the information gathered, it seems to be evident that occlusal interferences can lead to the development or to an increase in the severity of TMD.

The T-Scan III system is a quantitative and reliable method for occlusal evaluation, and represents a potential substitute for occlusal indexes.

Anderson et al. reported on the reliability of dentists' ability to evaluate occlusal contacts in the intercuspal position. In this research we have found that sensitivity of the T-scan III always recorded percentage of force for particular occlusal contacts which were actually present and that in many cases it differs from the size of the trace that is caused by occlusal contacts with articulation paper. In some cases tooth that is visually identified with articulation paper in supra contact, it even differs from the tooth that have higher percentage of force checked with T-san III.

Certain occlusal factors (occlusal interferences and tooth contact) have been suggested to have a role in the development of facial pain.

The theories of TMD etiology that have made the largest impact are related to various types of occlusal imperfection. Dahlström and Carlsson (2010) concluded that subjective TMD symptoms had a greater impact on Oral Health Related to Quality of Life (OHRQoL) than did clinical findings of TMD, and that the more painful and severe the TMDs were, the greater the impact was.

In contrary according to the study of Pullinger and Seligman (2000), occlusal characteristics are co-factors in the development of TMD in only a small proportion of patients, and the majority of the associated factors seem to be non-occlusal.

In particular, it must be pointed out that the role of dental occlusion cannot be considered negligible because it may determine the patterns of load distribution on the TMJ, thus acting as a factor that could influence the overall resistance of the musculoskeletal system. The possibility that occlusal interference results in TMD has been investigated and it was found that subjects without a history of TMD show fairly good adaptation to interferences. In contrast, subjects with a history of TMD develop a significant increase in clinical signs and self-report stronger symptoms (occlusal discomfort and chewing difficulties) in response to interferences.

In this study as refered Kerstain and al. in their research was found that subjective data are not exact when compared with measurements reported with

electronic device T-scan III, also after distributing attributive data of occlusal balance subjectively reported and compared with measurements analyzed with electronic system T-scan III were found many differences in all three groups. Discclusion time (DT) in this study was not significant in large group of subjects but Occlusion time (OT) was outside the range at all three groups and was related with frequency of premature contacts and asymmetry in the occlusal force . TMD subjects had a significantly higher frequency of premature contacts and greater bilateral asymmetry in the occlusal force. As was found that interpretation of the paper marks varied widely when using the principles of mark size and color in this study we have registered high degree of false positive markings. But more important than consistency of marked tooth with articulation paper and with T-san III is the percentage of force that this software displays. In this we can rely on during occlusion analyzes.

CONCLUSION

In this study it can be concluded high frequency of nonbalanced occlusion in subjects with prosthetic ceramic restorations that can influence the occurrence of TMD as iatrogenic factor of nonbalanced occlusion.

This study convincingly proved the inadequacy of the control and correction of occlusion in prosthetic ceramic restorations only using articulating paper and subjective feelings of the subjects, as it concluded that subjective data are not exact with measurements reported with electronic device T-scan III.

After comparing results using articulating paper as traditional method of control and using computer unit T - Scan III in detecting occlusal interferences we can evaluate its reliability and we can give special importance to the necessity of using this device.

From this we consider that T-Scan III it certifies its role and usefulness as an adjuvant therapeutic device in detecting occlusal interferences as latest technology which can help improve clinical results and minimize destructive occlusal forces that are not seen with traditional occlusal indicators alone. During the delivery of the ceramic restorations in future we have to consider better and balanced occlusion in order not to progress severity of TMD or even be the cause as iatrogenic factor on its occurrency, especially in patients receiving full arch ceramic restorations.

“Not all of us can do great things.

But we can do small things with great love.”

— **Mother Teresa**

REVIEW OF THE ACHIEVEMENTS OF THE SCIENTIFIC DISCIPLINE RELATED TO THE SUBJECT OF RESEARCH

Occlusion is not just about teeth, it involves the entire stomatognathic system. It requires developing an understanding of the interrelationship between teeth, periodontal tissues, bones, joints, muscles, nervous system during the full range of mandibular movements.[1]

The subject of occlusion is such that it forms a medium to bring all the branches of dentistry together.[1,2]

There exists a protective relationship between the anterior and posterior teeth which should be respected and not violated while performing restorative procedures. Placement of restorations should not lead to the generation of any abnormal forces or creation of lateral stresses. In fact, they should be so well integrated in the system that a feeling of artificial replacement does not occur.[2]

Occlusal interferences are quite common in natural dentition and can be associated from cranio-mandibular disturbances.[3]

Several studies have evaluated the role of occlusal interference on the etiology of temporo-mandibular dysfunction (TMD).[4-9] These interferences can be formed by uneven tooth wear, but also by restorative procedures performed incorrectly, which can leads to a disharmonic relation between the arches.[10]

The confirmative approach is defined as the provision of restorations 'in harmony with the existing jaw relationships'.[11] In practice this means that the occlusion of the new restoration is provided in such a way that the occlusal contacts of the other teeth remain unaltered.[12]

Therefore, after conducting direct or indirect restorations, a careful analysis of occlusal contacts should be performed, in order to avoid the creation of iatrogenic

interferences that can produce the signs and symptoms of TMD and postural disorders.[10]

In the work published by Magnusson et al.[13], it was concluded that occlusal factors are weakly associated to TMD, though forced laterality between centric relation and maximum inter-cuspidation, and unilateral cross-bite deserve consideration as possible local risk factors in the appearance of TMD.

In view of the information provided by the literature, the precise role of occlusion in TMJ pathology does not seem to be clearly defined. [14]

In the mid-1950s one of the central references of the theories interpreting TMJ pathology came under questioning: its relationship to occlusion. In effect, it was postulated that emotional tension constitutes a primary etiological factor - an idea that constituted a radical change from an “ideal structure” concept to a more physiological concept based on joint biomechanics and muscle physiology. [14-16]

Alterations in occlusion such as Angle malocclusions, cross-bite, open bite, occlusal interferences, prominent over-jet and overbite, crowding, midline discrepancies and missing teeth have been identified in different studies as predisposing, triggering or perpetuating factors. The authors concluded that occlusal alterations may act as cofactors in the identification of patients with TMD, and that some occlusal variables may be a consequence rather than a cause of TMD. [17-26]

Studies have tried to establish the relationship between occlusal interferences and TMD.

Kopp [27] analyzed the effect of professional advisement during occlusal therapy. In spite of its interesting findings, this study presented some limitations; for example, the occlusal interventions consisted of several modalities of treatment, such as occlusal adjustment, installation of occlusal splints, and even complete dentures. Because of these factors, it might be reasonable to assume that such results cannot be directly connected to the clinical management of patients with TMD.

Forssell [28] evaluated the efficiency of occlusal adjustments in reducing or eliminating TMJ dysfunctions.

Studies repeatedly show that the clinician can be very difficult to predict the occlusal contact with a higher power than other nearby terminal when used only articulation paper. By using articulating paper as a force measurement device, we, as clinicians, will miss seeing properly the occlusal force problems that affect our patients on a daily basis in our practices. [29]

Several additional devices have been proposed to detect the suspected abnormal occlusal contact facets. To obtain information on tooth contact during physiological and artificial occlusion are used occlusal indicators. [29]

There is a wide range of indicators ranging from articulating paper to the T-Scan system - **The *T-Scan* III Computerized Occlusal Analysis System (Tekscan Inc. South Boston, MA USA)**. With T-scan we have the opportunity to receive information about the strength of the contacts and the sequence of their appearance.

However, few data on working with the device T-Scan are often ontradictory. [30,31]

Hsu et al. [30] reported on the sensitivity and reliability of the T-Scan system for occlusal analysis. They concluded that the sensors did not have the same sensitivity in the entire occlusal surface and the T-Scan is always recording less occlusal contact points than they actually were and present after checking with occlusal films.

While only two years after Mizu [31] - as measured the time and force of occlusal contacts using the T-Scan system they reported in patients with TMD asymmetric center of effort which has not always been in the region of the first molar and this was determined with the T-Scan system.

Kerstein [32-38], Krasteva [39,40], Makofsky [41] consider the facts that articulating paper, often not enough to carry out adequate diagnosis and functional occlusal balance correction. Articulating paper shows no contact force, the sequence of appearance of

contacts over time, and shows only the contact area of antagonist with occlusal surfaces of the teeth.

The authors have concluded that the different answers from patients with and without a history of TMD may suggest dissimilar vulnerability to occlusal interferences, indicating the need for a reassessment of the etiology of TMD. The TMD is a multidisciplinary and multi-factorial dysfunction, since factors like occlusal balance, vertical dimension, muscle function, and psychological aspects are involved. [10]

CHAPTER I

1. INTRODUCTION

"Peace begins with a smile..."
— Mother Teresa –

Smile is considered a window to the individual's personality. That's why it's important to have inner balance and harmony in all aspects, good health in general and wellbeing. Every discomfort interferes by damaging quality of life of individuals accompanied by psycho-emotional discomfort also.

TMJ and its associated structures during everyday tasks such as chewing, swallowing, and speaking play an essential role in guiding mandibular motion and distributing stresses. [42]

One of biggest discomfort in life is pain. All that inner balance is ruined when we feel pain. It's important to identify structures that are stressful during everyday tasks and may generate pain. TMD is a blanket term for a group of conditions that generate pain and involve the muscles and/or anatomic components of the TMJ. [43]

1.1 Temporo-mandibular joint (TMJ)

The temporo-mandibular articulation is composed of bilateral, diarthrodial, TMJ. Each joint is formed by a mandibular condyle and its corresponding temporal cavity (glenoid fossa and articular eminence), (Figure 1).[42]

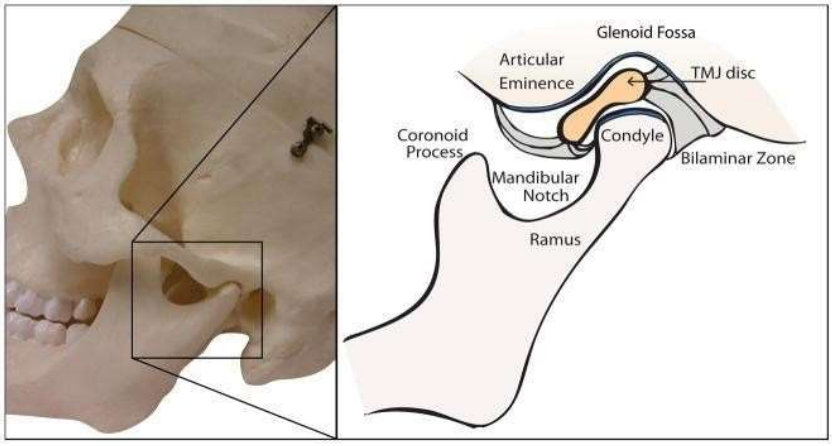


Figure 1. Temporomandibular joint and its structure

1.2 Temporomandibular disorder (TMD)

Pathologies of the TMJ and its associated muscles of mastication are jointly termed TMD.[44] TMD as a collective term defines a subgroup of painful orofacial disorders, involving the complaints of pain in the TMJ region and fatigue of the craniocervicofacial muscles, especially masticatory muscles, limitation of the mandibule movement and presence of the articular clicking. [45] Accordingly, the symptoms of patients with TMD are musculoskeletal in essence, and mostly derive from long-lasting muscle hyperactivity.[46]

TMJ function has been the subject of considerable study for over a century, and despite voluminous literature, the multifactorial etiology of TMD even today is an unsolved issue.[47]

Most clinicians have difficulty in diagnosing TMD because of the wide range of symptoms associated with it. [48]

The most important signs and symptoms of TMD include TMJ sounds, limited jaw opening capacity, limited lateral movements and protrusion of the mandible, deviations in mandibular movements, pain in masticatory muscles and TMJ and facial pain. [49-51]

The literature also suggests that occlusal abnormalities may be causes of headache, TMD and facial pain.[52,53] Ringing in the ears, the sensation of ear fullness, earache, sensation of hypoacusis (diminished hearing) and dizziness may also be present.[54]

A multifactor etiology involving structural and psychological factors has been attributed to TMD.[5,7,55] The etiology of TMD is considered to be complex and multifactorial, with structures, occlusion, craniofacial morphology, function, joint hypermobility, trauma, stress and psychological factors as possible risk or contributing factors.[56-59]

Due to the high prevalence and variability of the complaints, TMD is diagnosed by associating signs and symptoms, as some characteristics may be frequent even in a non-patient population.[60] Previous studies involving a non-patient population showed that 75% of sample had one TMD sign and 33% had one TMD symptom. TMD signs are present in 50-75% of the population at some moment in life, whereas an estimated 20 - 25% rate exhibit mild symptoms.[47,48,60] While up to 33% of the population may experience symptoms of TMD, only a small percentage of afflicted individuals seek treatment.[42]

The prevalence of TMD in the general population is high [61,62], it's between 40% to 60%. [63,64] Individuals with low self esteem are more likely to suffer from TMD psychological and emotional factors are clearly involved in the development of the disorder. [45,48,55,62-64]

Furthermore, epidemiological data showed that TMD symptoms occur disproportionately between the sexes.[42,61] It is mainly reported by middle aged females who tend to recognize the symptoms more readily than males and therefore more commonly seek professional help.[65-68] The higher prevalence of orofacial pain, headache and pain tenderness on palpation of masticatory muscles among women has been found in clinical studies as well.[68-70] Epidemiological studies disclose that TMD symptoms are most frequent in age groups between 20 and 40 years and twice as common among women as among men.[67,70] Female to male ration range between 2:1 - 8:1.[42,61] This disorder affects approximately 34,7% of adolescents.[64]

Several etiological factors have been acknowledged including local trauma, bruxism, malocclusion, stress and psychiatric illnesses. The Research Diagnostic Criteria of the Temporomandibular Disorders (RDC/TMD) is advanced to other criteria as it takes into consideration the socio-psychological status of the patient.[65] RDC/TMD has further been developed into the Diagnostic Criteria for TMD (DC/TMD), which has been developed for both clinical and research purposes.[71] Mild TMD signs and symptoms (e.g. TMJ sounds) are common in normal population. Several treatment modalities have been recommended including homecare practices, splint therapy, occlusal adjustment, analgesics and the use of psychotropic medication; as well as surgery, supplementary therapy and cognitive behavioral therapy. Although splint therapy and occlusal adjustment have been extensively used, there is no evidence to suggest that they can be curative; a number of evidence-based trials have concluded that these appliances should not be suggested as part of the routine care. Surgery, except in very rare cases, is discouraged since it is the most invasive alternative; recent studies have shown healthier outcome with cognitive behavioural therapy.[65]

1.3 Occlusion, occlusal interferences, artificial occlusion as possible cause for development of TMD

Some studies have evaluated and reported the important role of occlusal alteration and strong correlation between occlusal interferences and TMD [66,72-77], but mostly one of the studies elaborated very well this alteration and its consequences on stomatognatic system in long term. It explains that inadequate occlusal contacts turn to shift mandible in order to reach maximal inter-cuspal position and all this reflects on condylar displacements, overload of muscle function with adaptive responses on many stomatognatic structures. Temporo-mandibular joint presents tissue modification, disc alteration and cracking noise, periodontium show increased periodontal membrane, bone height loss and gingival recession. Teeth manifest increased wear facets, abfraction and non-accidental fractures. The periodontal and teeth adaptive processes are usually identified as occlusal trauma.

Even so significance of occlusion in TMD is still in debate and it has been suggested that occlusal condition may relate to TMD by two mechanisms: acute changes in occlusion can create a protective muscle contraction response, or occlusion can affect stability of the mandible as it loads against the cranium.[64] This is the reason that occlusion has an important place within the multi-factorial concept of the TMD etiopathogenesis as well as in every form of dental treatment.

Schematic description presents interconnection of the masticatory system and temporo mandibular joints with occlusal relations and TMD (Figure 2).[78]

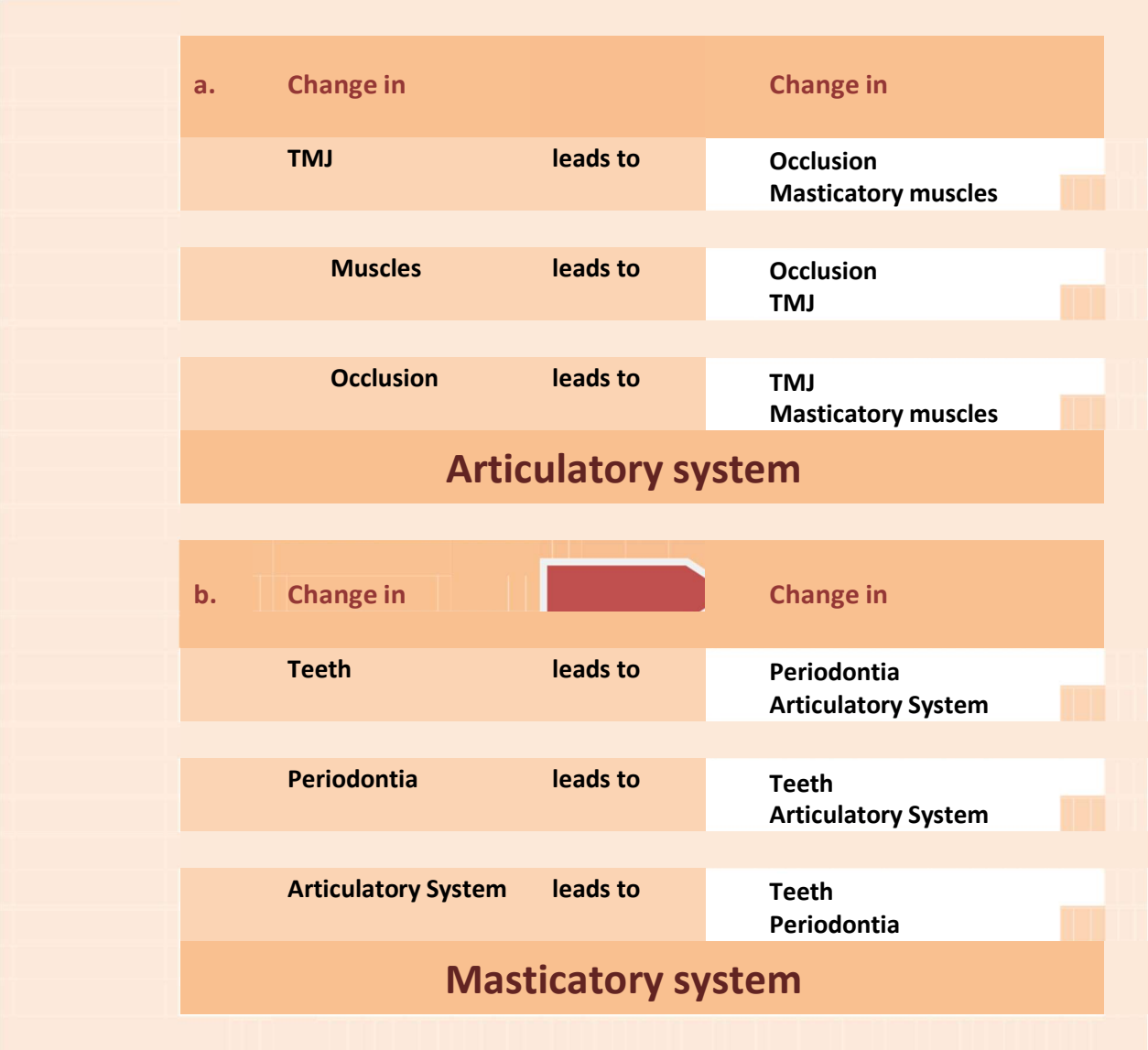


Figure 2. Interconnection of the masticatory system

In natural dentition there is a perfect harmony between form and function of tooth, a harmony which we should aim to attain, respect and reproduce with dental restorations.[79-81]

Anatomic examination of the teeth reveals an irregular occlusal surface, but it does not seem that provokes pathological phenomenon at the muscle, teeth or TMJ. The anatomical shape of each dental crown surface contributes to certain measure of health and consequently in the normal function of all its constituent elements of stomatognatic system: teeth, periodontal tissues, temporo mandibular joint and neuro-muscular system.[80,81]

1.4 Static and dynamic occlusion

1.4.1 Static occlusion

Static occlusion is the study of the tooth contact between each other, when the mandible is not moving. Another aspect of the static occlusion is the presence or absence of 'freedom in centric', this is also known as 'long centric'. Upon reaching the first contact, mandible slips a bit forward (while still the teeth are in contact) and so we have a movement called "freedom in Centric Occlusion", another word for Maximal Intercuspal Position (MIC).[82]

This freedom occurs in centric occlusion when the mandible is able to move anteriorly for a short distance in the same horizontal and sagittal plane while maintaining tooth contact (Figure 3b). Alternatively there will be no freedom in centric occlusion if either the front teeth or the posterior occlusion do not allow this horizontal movement (Figure 3a).[82]

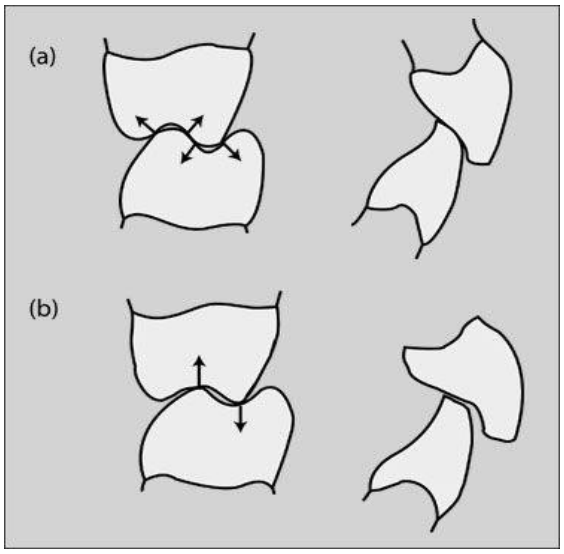


Figure 3: (a) No freedom in centric occlusion
(b) Freedom in centric occlusion

Other aspects of the static occlusion that can be described are the area of the posterior support, the Angle's classification of the incisor relationship together with measurement of the overbite and overjet, and the existence of any cross bites. [83]

The first essential question when considering a patient's static occlusion is: *'Does centric occlusion occur in centric relation?'*

Another source of confusion has been the change of the meaning of some long-established terms, such as centric relation and centric occlusion, for which different authors and clinicians have used various, sometimes contradictory definitions. These inconsistencies have not helped to clarify the study of occlusion.[84]

Definition of Centric Relation (CR) has evolved over the years. There are over 26 definitions for CR since the term was first developed as a starting point for making dentures.[85,86]

1.4.2 Centric Relation (CR)

This position is a jaw relationship: it describes a conceptual relationship between the maxilla and mandible. CR has nothing to do with teeth because it is position that it's reproducible with or without teeth present.

Definition of CR needs to be clinically oriented, explaining the maxillo-mandibular relationship without creating any confusion and controversies, by eliminating clinically invisible parts from the definition. The acceptance of one definition is necessary to improve communication at all levels of dentistry. [85] There is no one ideal position of the condyle in the glenoid fossa, but there is a range of normal positions. [84-89]

There is hardly any aspect of clinical dentistry that is not adversely affected by a disharmony between the articulation of the teeth and the centric relation position of the temporo-mandibular joints. [90]

CR it has also been described as the most stable and comfortable position of the mandible in which the joints can be loaded without discomfort. [91]

Although the previous and present glossary of prosthodontic terms definitions are diametrically opposite to each other, methods to record CR remained the same. [92,93]

1.4.3 Habitual occlusion

The position of **Maximal Inter-cuspation MIC / Centric Occlusion (CO) / Habitual occlusion** is defined as the position of the occlusal relationship in which the teeth of both arches are mostly interposed independent of condylar position. [94-98] MIC also known as Centric Occlusion: this position is dictated by the teeth themselves, determined when the patient habitually self-closes into complete tooth inter-cuspation. [93,94,98-101]

1.4.4 Dynamic occlusion

The functions of chewing, swallowing, and speaking are largely dependent on the manner in which the upper and lower teeth come together. As clinician, we are presented daily with the opportunity to affect this relationships.[102]

In a broader context, however, the definition of the term 'occlusion' is not limited to morphological tooth contact relationships. Rather, it embraces the dynamic morphological and functional relationships between all components of the masticatory system – not just teeth and their supporting tissues but also the neuromuscular system, the TMJ and the craniofacial skeleton. [87-89]

Dynamic occlusion represents tooth contacts when the mandible moves forward, backward and sideways or at an angle.

Although the jaw is moved by muscles, the contact lines depend on both the teeth positions and shapes (obviously), and the shape of the TMJ. [91,97,98]

The first contact in the CR can be localized by different methods that are realized by the mandibular guidance by the therapist. The first contact resulting from this manipulation is known as premature contact of CR.[50]

Dental professionals must consider the importance of occlusal contacts for the success of dental treatment, maintaining occlusal stability and orofacial harmony, as occlusal interferences may implicate potential damages to the whole stomatognathic system, which includes teeth, supporting structures, neuromuscular system and TMJ. [103-108]

Pullinger [108] carried out a study to assess which factors could be associated to TMD. He found that discrepancies between MIC and CR position are factors to show individual TMD symptoms.

Controversy continues about what is considered an ideal condyle-fossa relationship when the teeth establish MIC.[94,110]

If any premature occlusal contact changes the jaw closing arch, the condyles might be displaced to achieve a maxillo-mandibular relationship in MIC, thus avoiding premature contact.[94]

It is not clear how occlusal changes (natural dentition development, occlusal treatments, or restoration procedures) affect the function of the TMJ.[95,111]

Differences between the CR and MIC should not be ignored because depending on the mandibular position also previous studies[81,100,101,111,112] have shown that CR and MIC discrepancies are frequently present in the general population and it could be presumed that these were in relative balance or were not yet capable of generating alterations condyle/fossa relation.

The presence and localization of tooth contact can be done in different ways. As a clinician, you must determine if CR is a functioning position and how the patient gets from CR to MIC. Only then can you determine if the slide is pathological or physiological. Occlusal interferences in the mandibular CR however rare and unstable are an obstacle to achieving maximum intercourse. [113]

If a patient has not been equilibrated so that maximum inter-cuspation is coincident with CR, then that patient will continue to bite into maximum inter-cuspation during function. [99,114]

In cases where CR and MIC are not the same, during normal functions, the mandible rarely occupies the central position.

On the other hand the displacement of the mandible creates opportunities for the emergence of occlusal interferences. New dental, which will constrain other changes related to (adaption) dental contact with the positioning of the mandible until placed in position of MIC. [99]

The discrepancy between the mandibular position in which the largest number of contacts and the position in which the condyles are located in the optimum physiological position in the articular fossa represents the potential source of chronic

microtrauma for joint tissues and an additional load for certain groups of masticator muscles. Discrepancy between CR and MIC greater than 2 mm could be considered occlusal risk factors for TMD.[64, 114-116]

Bilateral balanced occlusion is a concept that is not used as frequently today as it has been in the past. It is largely a prosthodontic concept which dictates that maximum number of teeth should contact in all excursive positions of the mandible. This is particularly useful in full-mouth reconstruction.[113]

1.5 Occlusal contact observation

The concept of CR emerged due to the search for a reproducible mandibular position that would enable prosthodontic rehabilitation, especially in patients needing dentures.[117]

It evolved into orthodontics, restorative dentistry, full-mouth reconstruction, and orthognathic surgery as a diagnostic and treatment position for natural teeth as a part of the gnathological concept of McCollum and Stallard and others.[117-120]

Althougt, occlusion is not the dominant cause of TMD problems, the important biological and psychosocial role of the dental occlusion becomes most obvious when teeth are missing, therefore the situation certainly does not remain stable after presence of dental deficiencies. [121]

Studies show an increase in the prevalence of occlusal interferences in cases where dental deficiencies were un-substituted in time accompanied by a series of adaptive changes to all elements of the chewing system. Over 50% of teeth that do not have contact with the antagonist are involved in occlusal interferences .[10]

In the other hand, several studies have shown that in most cases the neuromusculature places the mandible in such a position that the highest number of occlusal contacts is established without taking into account the final condylar position.[75,77,82]

However, the role of condylar displacement in the context of morphologic and functional occlusion could be the risk factor in TMD development.[66,75,82,122-124]

Becker and Kaiser [124] recommended avoiding occlusal therapy for individuals who appear to be functioning in health, even if their occlusal scheme does not fit a concept of optimum occlusion'.

All dental practitioners such as prosthetics, paradontology, orthodontics, etc., are today in the foundation of occlusion and observance of occlusal harmony.

Lack of a standardized mandibular position could lead to inconsistent results in assessing occlusal contacts. The conflicting findings regarding the role of occlusal contacts in temporo-mandibular disorders, bruxism and periodontal disease could have been caused, in part, by inconsistencies in the examination method.[125,126]

The collective arrangement of the teeth in function is quite important and has been subjected to a great deal of analysis and discussion over the years. There are three recognized concepts that describe the manner in which teeth should and should not contact in the various functional and excursive positions of the mandible. They are bilateral balanced occlusion, unilateral balanced occlusion, and mutually protected occlusion.[127]

Although dental profession mainly recognizes the importance of occlusal treatment of TMD problems, their relationship is controversial because it is not strictly demonstrated in numerous scientific studies.[78]

Therapeutic occlusion may include some structural modifications that are not necessarily found in nature, and such concepts should not be applied to functioning patients who do not need extensive dental work.[121]

In order of possibility of interferences not to be formed by uneven tooth wear, or by restorative procedures performed incorrectly, which can lead to a disharmonic relation between the arches.[4-9] Traditional concepts of traumatic occlusal interferences involve a single anterior or posterior tooth, which is in "supra-contact" during maximal

inter-cuspidation or on excursive jaw movement. Detection of “occlusal interferences” and identification of other physical signs of occlusal trauma such as a wear facets, tooth pain, tooth mobility, or widened periodontal ligament spaces, are most commonly performed through a clinical and sometimes radiographic examination.[58]

Since then, several balanced and non-balanced articulation concepts were proposed in the literature. A balanced articulation appears to be most appropriate because of tooth contacts observed during nonfunctional activities of patients.[128]

Balanced Occlusion is defined as the bilateral, simultaneous, anterior, and posterior occlusal contact of teeth in centric and eccentric positions.[128]

Therefore, careful analysis of occlusal contacts should be performed in every fixed restorations in order to avoid the creation of iatrogenic interferences that can produce the signs and symptoms of TMD [11,70] and postural disorders,[10,99] also to increase durability of the ceramic restorations with respect to tooth enamel requires carefully balanced occlusal contacts not only at commit time of restoration, but also at later stages of clinical supervision.

Without doubt, for restorative purposes, some scientifically based recommendations are desirable for reaching an acceptable occlusion.[121]

1.6 Occlusal recorders

Dentists as clinicians are constantly involved in the management of their patients' occlusion during routine restorative dental procedures. [29] This is because the occlusal surfaces of the teeth are usually involved in the provision of restorations. Successful occlusal management leads to: predictable fitting of restorations and dentures, longevity and absence of iatrogenic problems, patient comfort and occlusal stability.[129]

It is essential to have a good record of the patient's occlusion if any treatment is to be provided that may have the potential for changing the occlusion. Just as there are protocols of recording baseline measurements in periodontal and dental disease,

there is a need to establish easy and universally reproducible ways of recording the patient's occlusion.[29,129]

Furthermore, because of local environmental factors and intra-individual biological processes (adaptations), the dental occlusion is changing constantly throughout life.[121]

When we deliver and apply prosthetic work that not only does not have to cause disorders in any receptive system of all its constituent elements the chewing system, but when it is necessary to adjust and modulate the complex receptive system aligned to the standards of "biological harmonization". All dentistry treatment should be built in order to restore the normal state of harmony and occlusal balance. [130]

In this context, it is necessary to evaluate the tooth for the presence of a supra - contacts. This evaluation typically involves a clinical occlusal examination of the teeth for wear facets, mobility and fremitus. [77]

For many years identifying them and to balance the occlusion there was only one way based on subjective interpretation by using conventional methods with articulation paper, impression waxes and shim-stock foil. [131]

1.7 Recording of occlusal contacts

1.7.1 Traditional methods of analysis - articulation paper

Articulation paper is the most commonly used method to determine excessive force in differing occlusal contacts.[131] Patients occlude upon strips of articulation paper that leave behind various ink markings on the tooth surface with excessive force. It may be double or single sided, but it must be thin and dry. Adjustments are made by selectively gridding the marks that have left articulating papers to achieve occlusal stability, multiple, uniform contacts throughout gridding, and to reduce stress in occlusal contacts and periodontal contact.[132]

This method was believed to be reliable enough but is an ineffective clinical method for determining the relative occlusal forces of tooth contacts, and thus a poor guideline for performing occlusal balance. [132,133]

Various researchers were critical for confidence and lack of reliability due to the effect of humidity also due to poor accuracy during procedures. Signs made with articulate paper, having approximately the same surface and color present approximately the same strength. Indeed, no study so far has shown that similar signs represent similar strength.[134]

Carey et al.[134] have not found a direct link between the fields marked with articulation paper and applied load, although there is a noticeable increase in the field marked with the increase in color.

According to Carey et al. [134] there are many myths about the articulation paper. Some of them are:

- The size of the sign marked with articulation paper, represents the force applied to it. Indeed, the size of the mark distinct with articulation paper is only its surface.

- The intensity of the sign color with articulation paper represents the force applied to it. Indeed, the intensity of color represents only the ability of the articulation paper to color the mark. Articulating paper shows no contact force and shows only the contact area of antagonist with occlusal surfaces of the teeth.

- When the patient states that everything is OK, the bite is balanced. Indeed, perceptions of the patient are poor indicators of balanced occlusion.

If occlusal contacts are recorded with the articulation paper, then there is no sign of the color depth and contact surface, its strength, or the time it is recorded. Also as qualitative method its disadvantages is lack of objectivity and reproducibility, as well as the difficulty of describing the various states of occlusion.[133]

1.7.2 The newest possibilities of computer occlusal device – The T-scan III device

Several electronic instruments and radiological techniques have been proposed over the years in the attempt to integrate clinical evaluation of TMD patients.[15,16,74,77] Additional devices have been proposed to detect assumed abnormal occlusal contact patterns.[76,77] The claim that these instruments can provide the dentist information above and beyond what a clinical examination provides about the location, timing, direction, and magnitude of the occlusal contacts. One of the devices for decoding the occlusion is the T-scan device (Figure 4). [73-76]

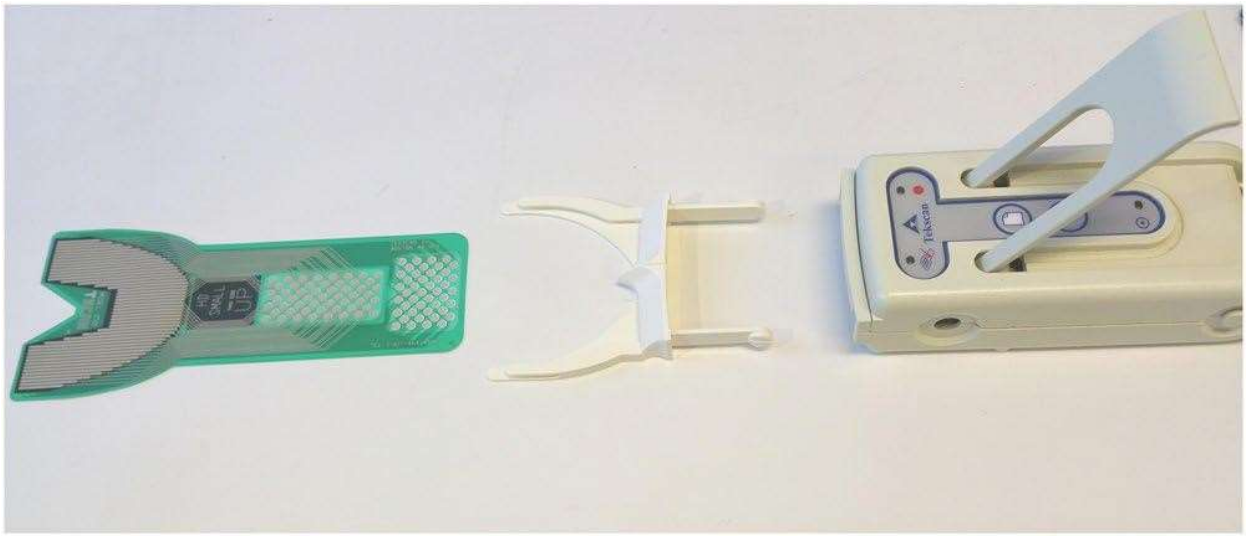


Figure 4. T-Scan device (T-Scan III, Software version 8.0.1, Tekscan, Inc., Boston, MA, USA)

This is a very valuable electronic device that helps in patient bite diagnostic procedures. The T-Scan system was designed to analyze and display occlusal contact information gathered by the pressure sensitive film. With this system, it was possible to detect the distribution of tooth contacts identifying the force and the relative timing on that traced arch mark. The T-scan uses computer software to analyze and graphically to present the strength and timing of occlusal contacts. [135,136]

Historically for over 30 years, T-Scan has evolved as a very important diagnostic tool for determination of correct occlusal pattern and resulted in high quality treatment

results which were not possible earlier. The entire system has undergone tremendous revisions of hardware, sensor and software to come up to the latest version of *T-Scan* III system (version 7.0). This new version is improved enormously over the earliest *T-Scan* I.[74, 137]

With the evolution of time, other methods like measuring occlusal features with a millimeter rulers, testing occlusal contacts with articulating ribbon/paper or occlusal wax, registering occlusion with silicones, mapping occlusion with occlusal sketch, photographs and the use of occlusal sonography have finally reached to a stage of computer aided determination of occlusal contact points and the use of T-scan pressure sensitive films**.**[138]

Thus, this device is applied in all disciplines of dentistry, such as: fixed prosthetics bite adaptation, orthodontics, periodontology, TMD, implantology.etc.[139,140]

Studies have shown that it is difficult for the clinician to identify which are occlusal contacts when they are registered with articulation paper. The T-scan system for occlusal analysis exceeds the already known limitations of the articulate paper (Figure 5). [134]

Figure 5. T-scan vs articulation paper

Studies repeatedly show that it can be very difficult for a clinician to predictably identify which occlusal contact has more force than the others nearby when using articulating paper alone. [32-34]

Signs obtained with articulation paper that appear to be simultaneous when analyzed with the computer system indicate that different strength is applied to each contact and cannot represent signs that have occurred at the same time. Thus the relative size of signs made with articulation paper may not indicate the characteristics of occlusal force.[134]

Force and time cannot be "read" from the signs recorded with articulation paper. And indeed it can only be done with T-scan, giving the dentist knowledgeable control over the adjustment process.[133]

During contacts between the teeth, T-Scan can record place and strength as the main occlusal factors. It can also record the first contact.[136,138]

Modern requirements for dental restorations involve reproduction of ideal esthetic parameters but also addition to restoring function.[140]

The T Scan system's ability to record the occlusal contact time quantitatively and dynamically along a continuous extension of the mandibular movement is also significant, as compared to numerous qualitative methods that are limited to a difficult, often controversial work of repeated static recording, in a fixed mandibular position.[138-140]

T-scan system is among one of the most frequently used computerized analyzing systems to objectively assess occlusal equilibration.[74,76,141-143]

The system records relative force values and objectively quantifies occlusal balance by displaying numerical values for occlusion and disclusion time.[138,144]

T-Scan is used to give dentists data that reveals the occlusal dynamics of the bite to ensure the longevity of prosthetic work. T-Scan will be used to ensure dental prostheses are loaded in harmony with the rest of the natural occlusal surfaces to minimize: fractured porcelain, broken prostheses, bruxing, interferences and uncomfortable high spots.[145-147]

CHAPTER II

2 SUBJECT OF THE RESEARCH

Reconstruction of harmonious occlusal relationship compared to the antagonist teeth during delivery of new prosthetic restoration is vital because otherwise the patient may have tooth pain after a period of time and changes in the TMJ. The aim of such an intervention is to obtain a stable occlusal relationship, with no premature contacts or mandibular excursion.

For many years to balance the occlusion was the arsenal of a dentist and as only way to do it and believed to be reliable enough was articulating paper.

The subject of our research is to:

- to consider the reliability, validity and usefulness of the instrument T - Scan III and to certify its role as an adjuvant therapeutic device in detecting occlusal interferences.

- to compare results after using traditional method of control using articulating paper and computer unit T - Scan III in detecting occlusal interferences.

- to evaluate the effect of the quality of artificial occlusion in patients with prosthetic ceramic restorations on the development of temporo-mandibular dysfunction using the T-scan analysis.

- to register the quality of the balanced occlusion in subjects with prosthetic ceramic restorations.

- to register frequency of non-balanced occlusion in subjects with prosthetic ceramic restorations.

- and to register the frequency of TMD in subjects with prosthetic ceramic restorations.

The aim of this study is to determine usefulness and consistency of t-scan in assessing occlusion after artificial occlusion also to investigate if any direct relationship exists between the quality of artificial occlusion on the development of temporo-mandibular dysfunction comparing classical method of analyzing with articulating paper and measurements reported with electronic system T-scan III.

CHAPTER III

3 HYPOTHESIS OF THE RESEARCH

Working Hypothesis 1: According to this study non-balanced occlusion in subjects with prosthetic ceramic restorations influence the occurrence of TMD and this will be determined during operation with T-scan analyses.

Hypothesis 2: This study has to determine whether non-balanced occlusion at natural dentition influence the occurrence of TMD with T-scan analyses.

Hypothesis 3: This study has to determine if balanced occlusion in subjects with prosthetic ceramic restorations influence the occurrence of TMD with T-scan analyses.

Hypothesis 4: This study has to determine if balanced occlusion at natural dentition influence the occurrence of TMD with T-scan analyses.

Hypothesis 5: This study has to determine whether there are differences and connections between non-balanced and balanced occlusion in subjects with prosthetic ceramic restorations in influence the occurrence of TMD with T-scan analyses.

Hypothesis 6: According to this study will determine is any changes in measurements with articulating paper and computer analyses with T-scan.

Zero Hypotheses: According to this study artificial occlusion in subjects with prosthetic ceramic restorations has no influence on the occurrence of TMD**.**

CHAPTER IV

4 MATERIALS AND METHODS

This research has been realized in:

• Faculty of Medicine, School of Dentistry, Pristina, Kosovo and in

• Faculty of Dentistry, Skopje, Macedonia.

4.1 Study sample

The study population consisted of total 105 subjects ranging age 20-65 year-old.

The study population was divided in three groups of 35 subjects:

• In the first study group (SG I) there were 35 subjects with fixed dentures with prosthetic ceramic restorations.

• In the SG II there were 35 symptomatic subjects with TMD. Subjects also underwent clinical and dental examination for signs and symptoms commonly associated with TMD. In this group there were excluded subjects with orthodontic problems or pretreated with orthodontic device.

• In the third SG III-Control Group there were 35 healthy subjects with Class I Angle's classification with normal occlusal relations. Subjects were with full arch dentition where the presence or absence of third molar was not a criteria considered in the study. Exclusion criteria were the presence of TMJ problems that limit mouth opening and malocclusion, such as open bite, increased over jet or reverse over jet, cross bite, and skeletal anomalies with occlusal disturbance. Subjects completed a subjective questionnaire to document the absence of jaw pain, joint noise or locking. (Figure 6 a-b)

Figure 6a. Control group frontal view

Figure 6b. Control group side view

With this questionnaire even non-patient population that was unaware can be identified that they had TMD. Using a simplified questionnaire, they were able to recognize unnoticed symptoms that could lead to a wear or a greater disorder of the stomatognathic system.[60]

4.2 Ethical approval

The study has been initiated after research program had been approved by the Ethical Committee, all procedures were fully explained to all subjects and they had signed written informed consent forms. All the subjects are examined clinically by the same trained dentist and answered the questionnaire for TMD-the anamnesis index proposed by the Fonsseca. [60,70,148,149]

4.3 Questionnaire

The Fonseca's questionnaire follows the characteristics of a multidimensional evaluation. It is composed of 10 questions, which include checking for presence of pain in temporo-mandibular joint, head, back, and while chewing, movement limitations, joint clicking, perception of malocclusion and sensation of emotional stress (Figure7). [70,148-150]

		NO	SOMETIMES	YES
1	Do you have difficulty opening your mouth wide?			
2	Is it hard for you to move your mandible from side to side?			
3	Do you feel fatigue or muscle pain when you chew?			
4	Do you have frequent headaches?			
5	Do you have neck pain or a stiff neck?			
6	Do you have ear aches or pain in that area (TMJ)?			
7	Have you ever noticed any noise in your TMJ while chewing or opening your mouth?			
8	Do you have any habits such as clenching or grinding your teeth?			
9	Do you feel that your teeth do not come together well?			
10	Do you consider yourself a tense (nervous) person?			

Figure 7. Questioner for Assessment of Prevalence and Severity of TMD (Fonsseca)

Also like in some other studies other questions on para-functional habits such as nail/check biting, bruxism, finger and thumb sucking were also included in the questionnaire [150].

4.4 Measurements obtained with unit T-Scan III to evaluate the occlusion

For the measurements was used The T-Scan III - Computerized Occlusal Analysis System 7.0 , (Tekscan Inc., South Boston, MA, USA). The T-scan III is a bite analysis system that measures the efficiency of how teeth come together and separate. Ultra-thin sensitive sensors are shaped to fit the dental arch and they are inserted into the sensor

handle and are used to senses and analyses occlusal contact forces by means of pressure.[137-140]

T-Scan sensors are available in two sizes: large and small. Large size sensor can accommodate arch up to 66 mm wide and 56 mm deep and contains 1370 sensels whereas small size sensor can accommodate arch up to 58mm wide and 51mm deep and contains 1122 sensels. The thickness of the sensor is 0.1mm3. *T-Scan* III analyzes the order of the occlusal contacts while simultaneously measures the changes in force percentages of the same contacts, from the moment the teeth begin contacting to maximum inter-cuspation. Therefore, it can assess the initial occlusal contact, the order that all the occlusal contacts occur in, and the amount of relative occlusal force loading at each contact.

It enables us to assess the force changes, all during the process of contact evolutions.

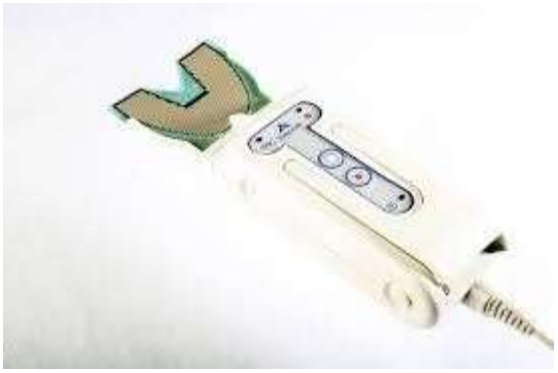


Figure 8. T – Scan handel with sensors

Evaluating occlusal forces is as simple as having a patient bite down on a thin sensor of the handle that is connected with computer (Figure 8) and the software displays the timing of contacts and levels of force in full-color 3-D or 2-D graphics or a dynamic movie. It shows the patient's bite from beginning to end and all that is happening in between. The instrument was directly interfaced with a computer which presented the data on a screen during the examination and recorded them for further analysis.

For all scanning procedures, subjects were asked to sit in a relaxed upright position in the dental chair. The sensor was held consistently at the same position with respect to the teeth and aligned parallel to the occlusal plane and centered on the midline between the central incisors.

The measurements and recordings were registered in the following order:

1) 1st Centric Occlusion Bite

2) 2nd Habitual Occlusion Bite

3) Right Lateral Excursive Bite

4) Left Lateral Excursive Bite

5) Protrusive Bite

The occlusal data obtained from T-Scan were displayed graphically for analysis in two or three dimensions (Figure 9-10) or as a dynamic movie that can be analyzed stepwise.

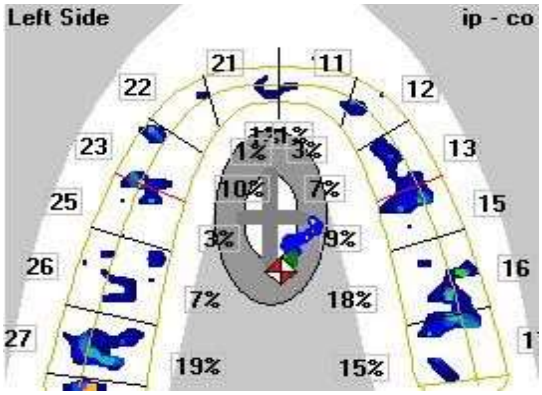


Figure 9. 2-D graphics automatically presented occlusal force percentage by the t-scan electronic system

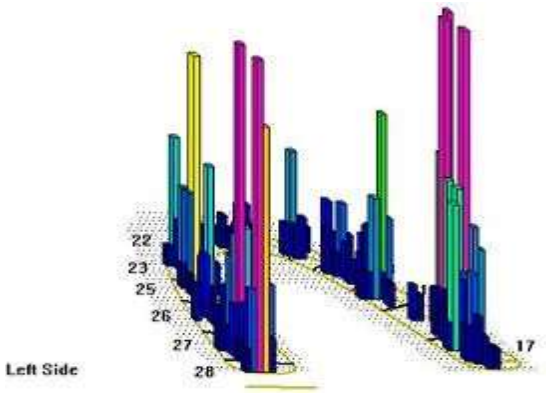


Figure 10. 3-D graphics presented occlusal force by the t-scan electronic system

For this research with T-Scan III were recorded these parameters: Occlusal force distribution, the centre of force (COF) trajectory (Figure 11), first contact, occlusal

interference, occlusion time (OT) and disclusion time (DT). The centre of force demonstrated the symmetry of the occlusal force and also occlusal force distribution between two halves of maxillar dental arche. Premature contacts and interferences can be identified in the dynamic occlusion instead of static.

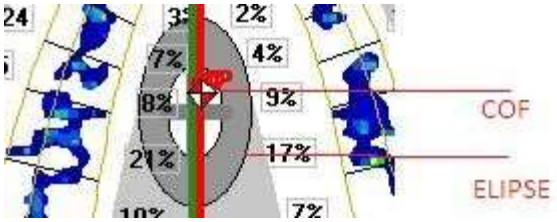


Figure 11. Pathway of COF on the gray and white ellipse area in the middle of the jaw

Occlusion time (OT) describes the time from the first tooth contact to the point at which the entire dentition is contacted when evaluating maximum interc-uspation.[142,144] This evaluates how fast the entire dentition enters the occlusion status. When this period of time is long, there is occlusion interference, and when it is short, the occlusion is considered to be stable, especially when the span is less than 0.3 seconds. Disclusion time (DT) is the time from when anterior or canine guidance is formed to the point where molar contact is lost during lateral excursion or protrusion.[142,144] As longer this period of time is, the greater the interference of molars during lateral excursion or protrusion is. A time of less than 0.5 seconds is considered normal.[151]

Not only the distribution of forces per tooth can be displayed but also distribution of forces in two halves of the jaw can be calculated. Occlusal force can be displayed by percentage (automatically by the t-scan electronic system) and all this can be determined from the recorded occlusal data (Figure 9-10).

4.5 Measurements obtained using articulating paper

In the end all the subjects were analyzed in central occlusion also with the two color articulation paper and they were captured the picture do to compare the findings. After the subjects sat upright in the dental chair, each of them was instructed to attempt to

generate their perceived maximum occlusal force while tapping through the articulation strips.

Figure 12. Articulation paper marks upper jaw

Figure 13. Articulation paper marks lower jaw

Articulation paper was used so to mark the contact points that existed in a subject's inter-cuspal position. The articulating paper was held intra-orally with Miller forceps while the subject tapped their teeth together firmly through the articulation paper 5 times in succession. Each subject was instructed to attempt to generate their perceived maximum occlusal force while tapping through the articulation paper. Standardized photographs of the marks made with articulation paper (Figure 12-13) were taken for later comparison of the occlusal force data obtained from the same subjects with T-Scan III central occlusion bite recordings. Foremost, these rely on marking the static occlusal contacts between the teeth and then describing those marks in writing or by photograph.

CHAPTER V

5 STASTICAL ANALYSIS

The Statistical analysis used data produced from Statistica 7.1 and SPSS 17.0 for Windows (StatSoft.Inc., Tulsa,OK 74104,USA).

The collected data are processed using the following statistical methods:

• Databases are formed by applying specific computer programs for that purpose. Their processing is done using standard descriptive and analytical methods.

• The attributive statistical series are analyzed by determining the coefficient of relations, proportions, rates, and by determining the statistical significance of the detected differences - Difference test.

• Numerical series are analyzed with measures of central tendency and with data dispersion measures (average and standard deviation).

• The statistical significance of the differences is analyzed with the Mann-Whitney U test.

• The statistical significance of the detected differences was tested with Student's t-test in normal distribution.

• The Kruskal-Wallis ANOVA by Ranks test

• The dependence-the association was determined by the Pearson Chi-square test

• Spearman Rank Order Correlations was developed for the connection of the variables.

• The statistical significance of the differences was analyzed by Analysis of Variance - ANOVA, since the post hoc tests have produced a Tukey HSD test.

• Validity was tested for accuracy of the T-scan as a diagnostic test for detecting occlusal contacts.

• The Shapiro-Wilk's test examined the normal distribution of the variables

• For CI (confindence interval ± 95% CI), the statistical significance for the error level is less than 0.05 (P). Differences in $P < 0.05$ were considered significant.

The results were presented as a tables and charts.

CHAPTER VI

RESULTS

A total number of subjects were 105. The study population was divided into three groups.

-The first study group (SG I) with artificial dentition (prosthetic ceramic restorations) analyzed according to gender and age consisted of 35 subjects, 40.0% were males, and a greater percentage of 60.0% were females, with age range from 22 to 65y, mean age 51.6 ± 11.6y. (Table 1-2, Chart 1-2).

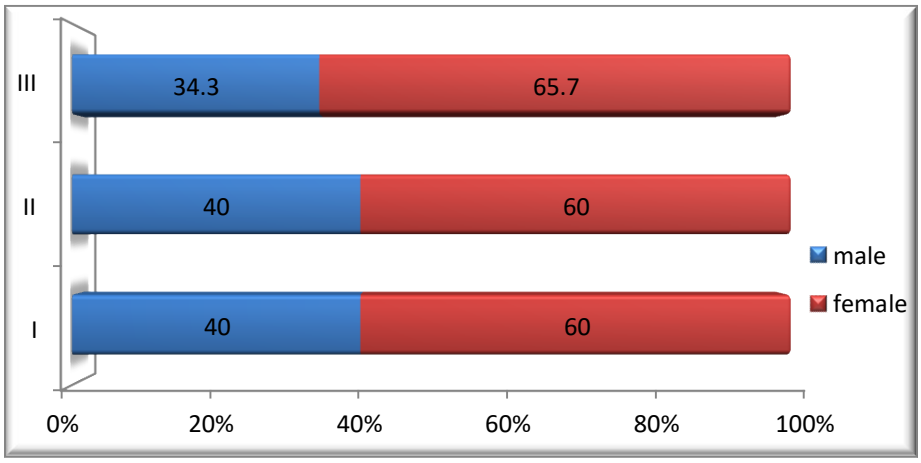
-Second study group (SG II) with TMD consisted of 35 subjects, 40.0% were males, and a greater percentage of 60.0% were females, with age range from 20 to 58y, mean age 28.6 ± 10.1y .(Table 1-2, Chart 1-2).

-Third study group / control group CR consisted of 35 subjects, 34.3% were males, and 65.7% were females, with age range from 20 to 37y, mean age 25.3 ± 4.36y. (Table 1-2, Chart 1-2).

Table 1. Presenting distribution of subjects by gender

Gender/group	I		II		III	
	Count	%	Count	%	Count	%
Male	14	40.0	14	40.0	12	34.3
Female	21	60.0	21	60.0	23	65.7
total	35	100.0	35	100.0	35	100.0

Chart 1. Distribution of subjects by gender



According to Difference tests, the percentage differences registered between group I, II and III is statistically not significant for P> 0.05 (P = 0.6217), it is about homogeneous groups in terms of gender.

Table 2. Presenting average age of subjects from all three groups

Group/ age	Means	N	Std.Dev.	Minimum	Maximum
I	51.6	35	11.63232	22.0	65.0
II	28.6	35	10.05924	20.0	58.0
III	25.3	35	4.31783	20.0	37.0

Chart 2. Average age of subjects from all three groups

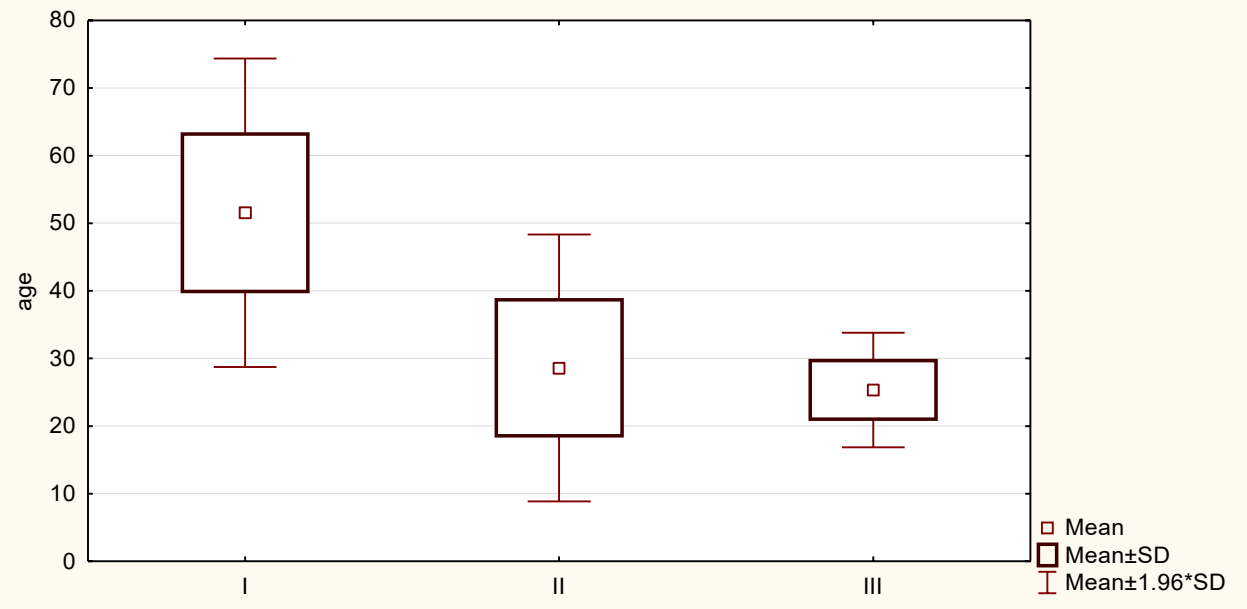


Table 3a.ANOVA test

	SS - Effect	df - Effect	MS - Effect	SS - Error	df - Error	MS - Error	F	p
age	14306.06	2	7153.029	8674.857	102	85.04762	84.10616	0.000000

Table 3b.Tukey HSD test

Group	{1} - M=51.571	{2} - M=28.600	{3} - M=25.343
I {1}		0.000104	0.000104
II {2}	0.000104		0.306074
III {3}	0.000104	0.306074	

The difference between mean age values between the three groups of subjects according to the ANOVA test is statistically significant for P <0.05 (P = 0.000000). (Table 3a)

There is a large selection of so-called post hoc tests, tests performed after the ANOVA test when it produces statistically significant results. Multiple comparison tests are also called. The purpose of these tests is to discover the difference (between multiple

samples) which is "credible" for the overall statistically significant result. According to the post hoc test-Tukey HSD test for mean age of respondents, statistical significance is due between I and II group, I and III group, P <0.05 (P = 0.000104). (Table 3b)

6.1 Fonseca Questionnaire

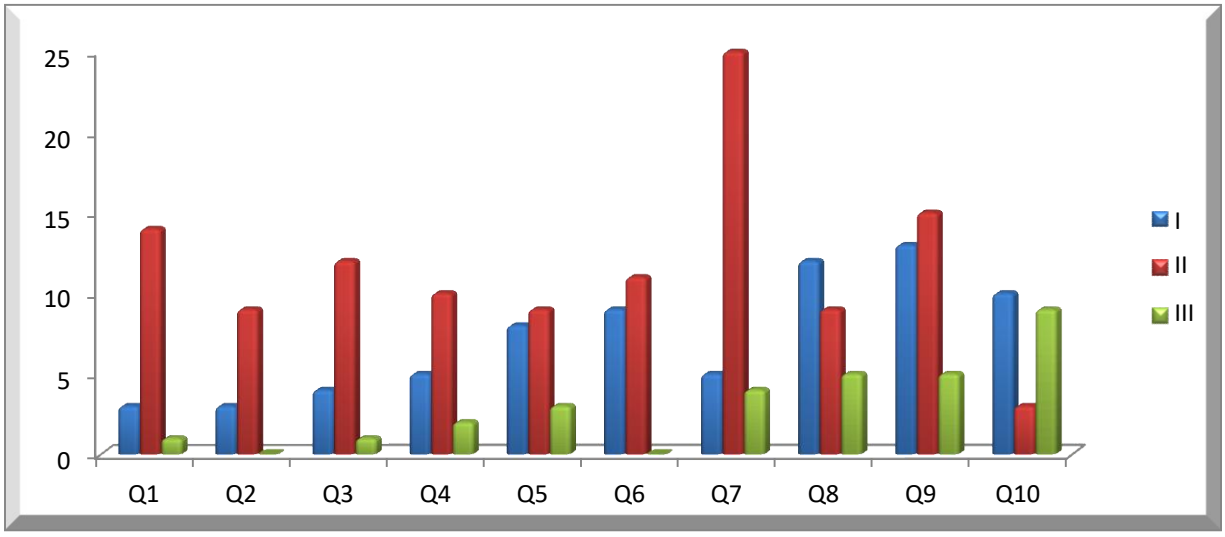
Using Fonseca questionnaire in this study, subjects were also categorized in three groups;

SG I with fixed ceramic restorations registered TMD signs in 74.3% subjects. According to this study there is high frequency of TMD in subjects with fixed ceramic restorations. We have noticed that in this group subjects have almost all signs moderately positive, but in 54,28% of subjects were more present unbalanced occlusion, then teeth clenching or grinding and increased stress. (Chart 3)

In SG II TMD signs were registered in all 35 subjects. With a special emphasis on the seventh question for the presence of clicking while chewing or during mouth opening which was present at all the subjects. Also it's interesting that in this group question about the emotional state, increased stress was apparently denied.

In the CG only 11(31.43%) subjects had signs of TMD. In some subjects 18(51.42%) TMD signs were occasionally present and they were not typical. Only 6 subjects (17.4%) had no signs of TMD at all. From all the signs in this group more dominant was presence of increased stress.

Chart 3. Display of the number of subjects in relation to the positive answer "yes" on questions Q1-Q10 in all three groups



6.2 Working Hypothesis

During this study the main point of analyze was the occlusion, quality of artificial occlusion and its influence on the appearance of the TMD signs, also frequency of appearance of TMD at healthy subjects.

All of these data were analyzed with T-Scan III and during this study was considered its usefulness.

Scientific importance of this study using computer in clinical examination of occlusion in subjects with prosthetic ceramic restorations is that it shows the frequency of non-balanced occlusion and occlusal interferences compared with articulating paper as traditional method used for control of occlusion. During measurements software display the pathway of occlusion and localization of the centre of force (COF) in ellipse.

6.2.1 Working Hypothesis 1

According to this study non-balanced occlusion in subjects with prosthetic ceramic restorations can influence the occurrence of TMD and this will be determined during operation with T-scan III analyses.

In this study after measuring occlusion in both central relation and habitual position during operation with T-scan III was analyzed deviation of the jaw in all three groups. Deviation was determined based on the position of COF on the gray and white ellipse area in the middle of the jaw (Figure 11).

According to this measurements in the I SG deviation of COF in ellipse in central relation, was present in 64,3% of cases, with the largest percentage being registered 31.4% outside the ellipse left, with 17.1% external ellipse left, with 14.3% outside the ellipse right and no deviation of the COF in ellipse was recorded only in 25.7% of cases in this group. (Table 4a, Chart 4a)

In the central relation, only 37.1% in II SG did not register the deviation of the COF in ellipse, followed by registration with 20.0% external ellipse right, with 17.1% outside the ellipse right, with 14.3% outside the ellipse left and with 11.4% external ellipse left. (Table 4a, Chart 4a).

In the central relation, 65.7% of the CG does not register the deviation of COF in ellipse; followed by registration with 14.3% external ellipse right and the remaining deviations are below 10.0%. (Table 4a, Chart 4a).

Statistically significant dependence is observed between the deviation of the COF in ellipse in the central relation and the affiliation of the three groups-Pearson Chi-square: 12.13, P = 0.002318.

Statistically significant dependence is recorded between the deviation of the COF in ellipse in the central relation and the affiliation of I SG and III CG-Pearson Chi-square: 11.28, P = 0.000782.

Statistically significant dependence is observed between the deviation of the COF in ellipse in the central relation and the affiliation of II SG and III CG-Pearson Chi-square: 5.72, P = 0.016782.

Table 4a. Deviation of the COF and its pathway in ellipse in a CR in all three groups

Deviation of the COF in ellipse in a CR /group	I		II		III	
	Count	%	Count	%	Count	%
no	9	25.7	13	37.1	23	65.7
central outside the ellipse	3	8.6			3	8.6
right external ellipse	1	2.9	7	20.0	5	14.3
right outside the ellipse	5	14.3	6	17.1		
left external ellipse	6	17.1	4	11.4	3	8.6
left outside ellipses	11	31.4	5	14.3	1	2.9
total	**35**	**100.0**	**35**	**100.0**	**35**	**100.0**

Table 5a. Deviation of the COF and its pathway in ellipse in a habitual occlusion in all three groups

Deviation of the the COF in ellipse in a Hab. Occl /group	I		II		III	
	Count	%	Count	%	Count	%
no	8	22.9	15	42.9	23	65.7
right external ellipse	1	2.9	6	17.1	4	11.4
right outside the ellipse	8	22.9	4	11.4	3	8.6
left external ellipse	8	22.9	8	22.9	3	8.6
left outside ellipses	10	28.6	2	5.7	2	5.7
total	**35**	**100.0**	**35**	**100.0**	**35**	**100.0**

In the habitual occlusion only in 22.9% of subjects in I SG registered no deviation of the COF in ellipse, followed by registration with 28.6% outside the ellipse left, with an equal percentage of 22.9% registered outside the ellipse right and external ellipse left, the remaining deviations were below 3.0%.(Table 5a, Chart 5a)

In the habitual occlusion in 42.9% of subjects in II SG, no deviation of the COF in ellipse was registered, followed by registration with 22.9% external ellipse left, with 17.1% external ellipse right, the remaining deviations were below 6.0%.(Table 5a, Chart 5a)

In the habitual occlusion in 65.7% of subjects in III CG no deviation of the COF in ellipse was registered, followed by registration with 11.4% external ellipse right, the remaining deviations were below 10.0%. (Table 5a, Chart 5a).

Chart 4a Deviation of the COF and its pathway in ellipse in a CR in all three groups

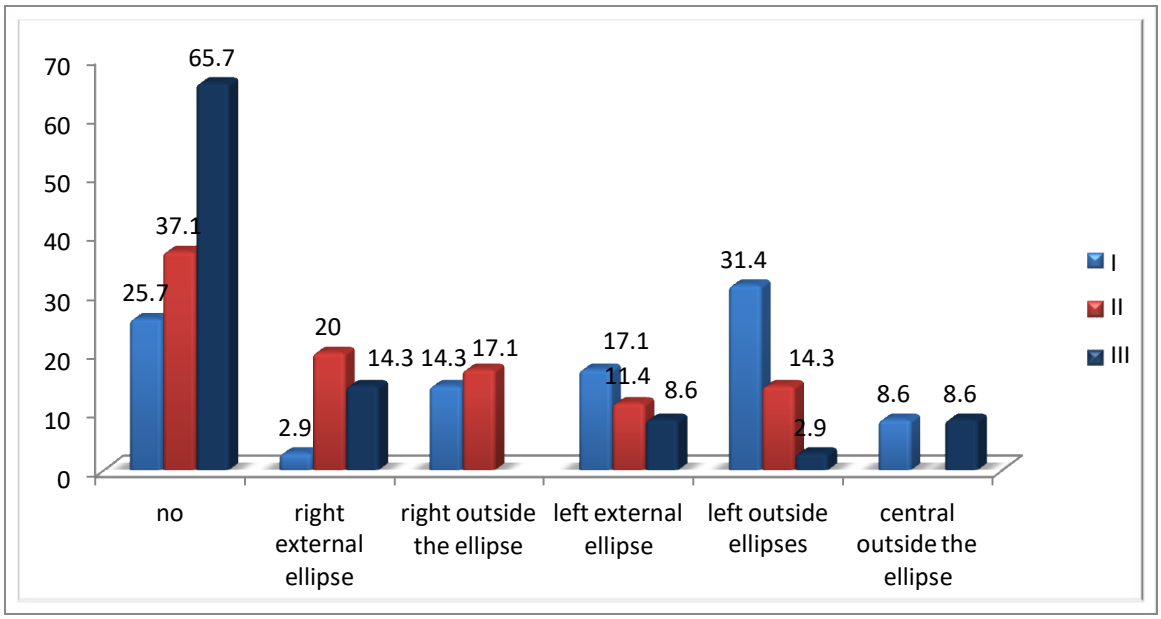
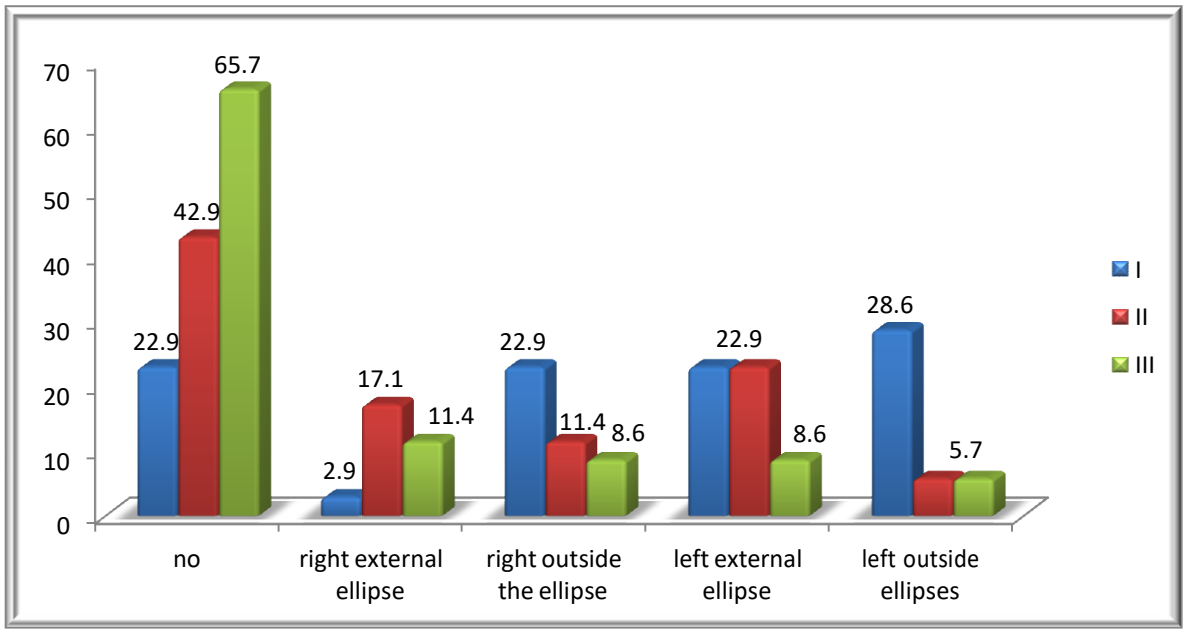


Chart 5a. Deviation of the COF and its pathway in ellipse in a habitual occlusion in all three groups



The percentage difference observed with respect to the lack of deviation of the COF in ellipse in the three groups in the habitual occlusion is statistically significant between III CG, II SG and I SG for $P < 0.05$ ($P = 0.048$; $P = 0.0003$).

Statistically significant dependence is recorded between the deviation of the COF in ellipse in the habitual occlusion and the affiliation of the three groups-Pearson Chi-square: 13.0, $P = 0.001446$.

Statistically significant dependence is recorded between the deviation of the COF in ellipse in the habitual occlusion and the affiliation of I SG and III CG-Pearson Chi-square: 13.03, $P = 0.0003070$.

Statistically significant dependence is observed between the deviation of the COF in ellipse in the habitual occlusion and the affiliation of II SG and III CG-Pearson Chi-square: 3.9, $P = 0.044930$.

Chart 4b. Overview of the deviation of the COF in ellipse in a CR at three groups

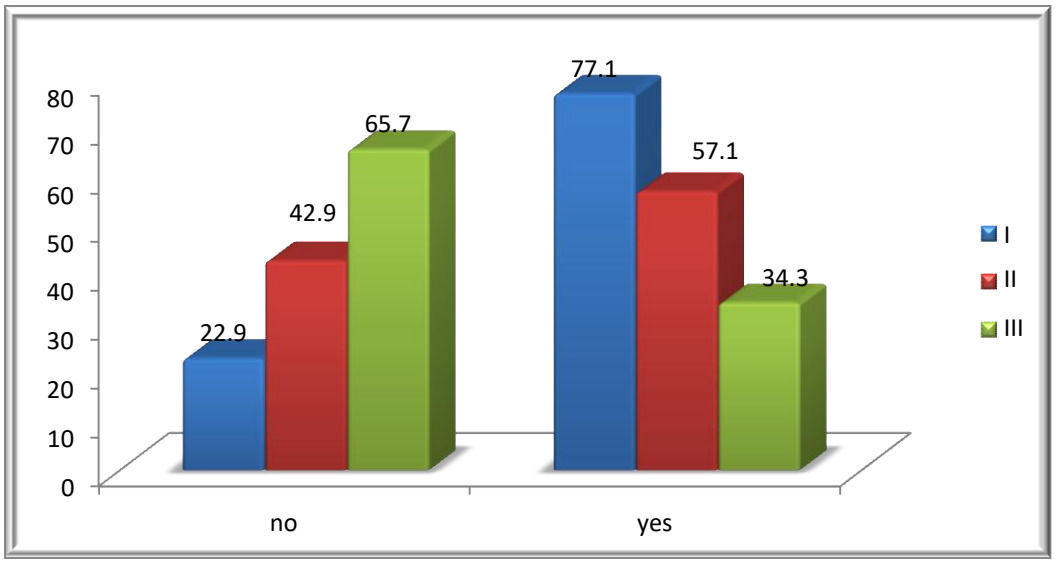
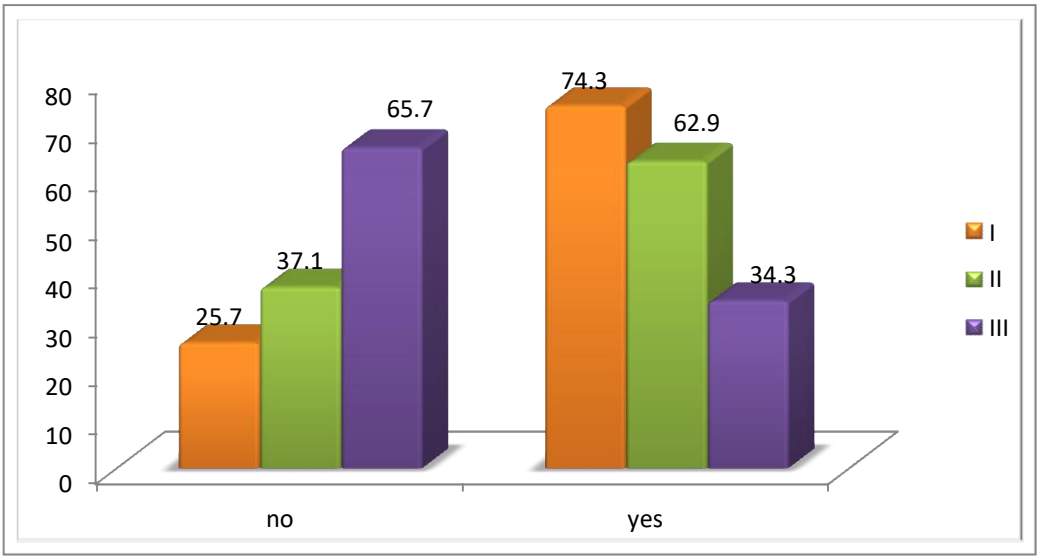


Chart 5b. Overview of the deviation of the COF in ellipse in a habitual occlusion at three groups



In III CG are noticeably fewer deviations but still were present deviations in both occlusal positions with 34.3%. While in II SG with TMD more than half of the cases respectively at 57.1% in central relation/62.9% in habitual occlusion have expressed the deviation. The most vulnerable group is I SG with 77.1% in central relation/74.3% in habitual occlusion. (Chart 4b-5b)

From these results, it has been noticed that there were no major differences between the occlusions in two positions in the occurrence of the deviation. Otherwise when the deviation was present differences between these two positions were distinguished and even more pronounced.

The I SG registered a statistically significant correlation between registrations of the TMD signs, versus the deviation of the COF in ellipse in a habitual occlusion (Spearman Rank Order Correlations- -0.387378).

The I SG registered a statistically significant correlation between the registration of the TMD signs, versus the deviation of the COF in ellipse in a central relation (Spearman Rank Order Correlations - -0.029643).

From this it can be concluded that subjects with prosthetic ceramic restorations influence the occurrence of TMD as iatrogenic factor of non-balanced occlusion.

6.2.2 Working Hypothesis 2

In this study was determined whether non-balanced occlusion at natural dentition influences the occurrence of TMD with T-scan III analyses.

Since the deviation is present in II SG with TMD but also in III CG **it can be concluded that the non-balanced occlusion is a factor that may cause the appearance of changes in the TMJ and as the result of this occurrence of TMD in future.**

The first and the second hypothesis positive.

6.2.3 Working Hypothesis 3

In this study was determined if balanced occlusion in subjects with prosthetic ceramic restorations influences the occurrence of TMD with T-scan III analyses.

The subjective feeling of subjects for balanced occlusion in I SG is 60.0% butt it is higher in relation to T-scan III measurements where a balanced incidence of 34.3% is registered, the percentage difference is statistically significant for $P < 0.05$ ($P = 0.0313$). (Table and chart 6). With Fisher exact P, one-tailed test does not detect the association between having and lack of TMD signs with a balanced occlusion or non-diagnosed TMD with T-scan III measurements. At the balanced occlusion, 11 (31.4%) subjects were registered with TMD signs, and 15 (42%) subjects with unbalanced occlusion were registered with TMD signs.

Table 6. Compared subjective feeling of subjects with T-scan III measurements for the balanced occlusion in the three groups

	subjective feeling		t-scanIII measurements	
Group I	Count	%	Count	%
balanced	21	60.0	12	34.3
non balanced	14	40.0	23	65.7
Group II				
balanced	17	48.6	16	45.7
non balanced	18	51.4	19	54.3
Group III				
balanced	31	88.6	25	71.4
non balanced	4	11.4	10	28.6

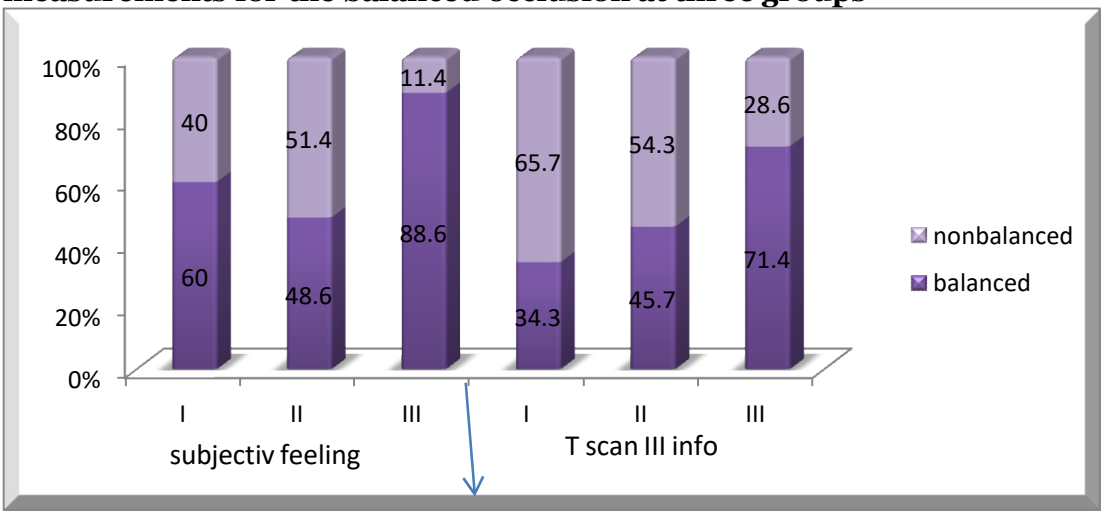
According to this study in I SG, subjects with balanced occlusion with prosthetic ceramic restorations it cannot be detected the association with TMD occurrence even so eleven subjects (31.4%) were registered with TMD signs.

6.2.4 Working Hypothesis 4

In this study was determined if balanced occlusion at natural dentition influences the occurrence of TMD with T-scan III analyses.

According to this study, association of subjects with balanced occlusion in III CG with TMD occurrence it cannot be detected. Even so according to T-scan III measurements, from 25 (71,4%) subjects with balanced occlusion, 14(40%) subjects have some signs of TMD, still in 6 subjects they appear randomly and not in regular basis (Table 6, Chart 6). It's important to mention that even unreported cases have unnoticed and undiagnosed signs of TMD.

Chart 6. Overview of subjective feeling of subjects compared with T-scan III measurements for the balanced occlusion at three groups



The subjective feeling of the subjects for balanced occlusion in III CG is 88.6%, and with T-scan III measurements balanced occlusion is registered at 71,4%, the percentage difference is statistically significant for P <0.05 (P = 0.0313) (Table 6, Chart 6).

The subjective feeling of the subjects for unbalanced occlusion in I SG is 40.0%, and with T-scan III measurements for unbalanced occlusion was registered at 65.7%. (Table 6, Chart 6).

The subjective feeling of subjects for balanced occlusion in II SG is 48.6%, and approximately equal to T-scan III measurements, where 45.8% of the balanced occlusion is registered, the percentage difference has statistically no significance for P> 0.05. (Table 6, Chart 6)

In II SG, TMD signs are registered in all subjects. The subjective feeling of subjects for unbalanced occlusion in II SG is 51.4%, and with T-scan III measurements unbalanced occlusion is registered at 54.3%. (Table 6, Chart 6)

The subjective feeling of subjects for unbalanced occlusion in III CG was 11.4%, and with T-scan III measurements unbalanced occlusion was recorded at 28.6%. (Table 6, Chart 6)

6.2.5 Working Hypothesis 5

In this research was determined whether there are differences and connections between non-balanced and balanced occlusion in subjects with prosthetic ceramic restorations influence the occurrence of TMD with T-scan analyses.

After registered occlusion in two positions central relation and habitual occlusion these results were presented:

6.2.5.1 Results from measurements in habitual occlusion

The average habitual occlusion right% in I SG is 48.1 ± 17.3, minimum 18.8, and a maximum of 92.9. The average habitual occlusion on the right% in II SG is 51.5 ± 12.6, the minimum is 23.1, and the maximum is 71.9. The average habitual occlusion right% in the III CG is 50.0 ± 8.8, minimum 34.4, and a maximum of 69.4. (Table 7, Chart 7)

The difference between the minimal and the maximal value of the occlusion on the right is with the greatest variation in I SG and II SG and the slightest variation of the difference is in the III CG.

According to the Analysis of ANOVA test, the difference between the groups were registered but there were statistically no significance for P> 0.05. (Table 7a)

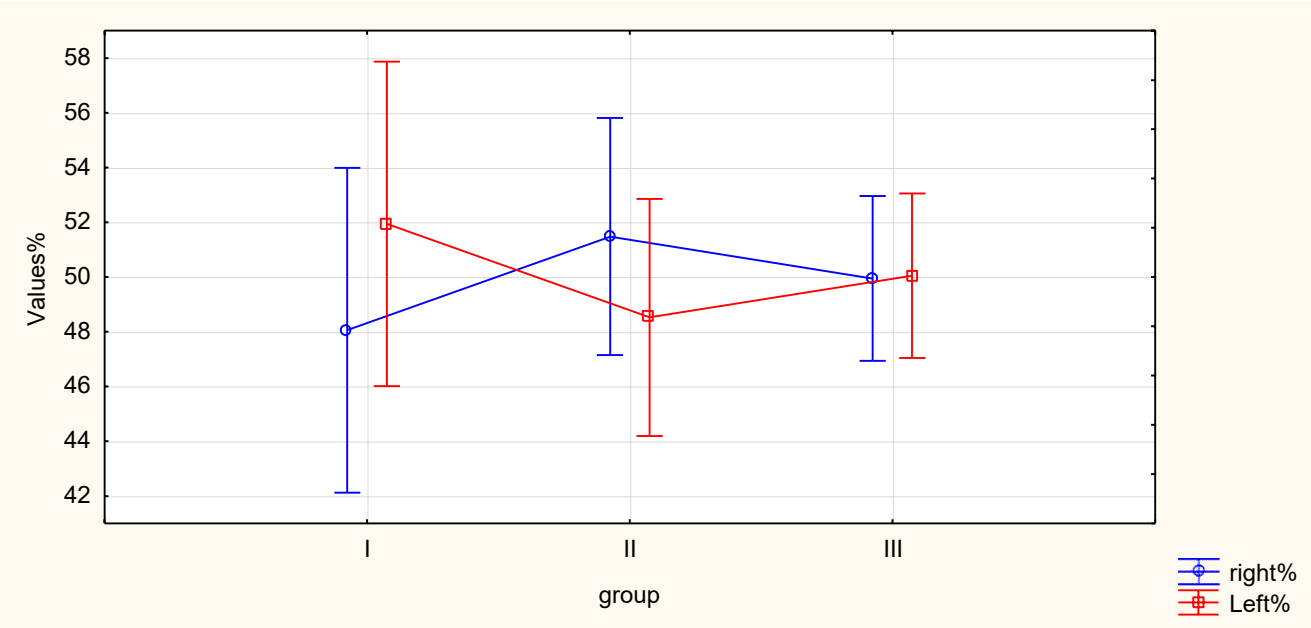
The average habitual occlusion left% in I SG is 51.9 ± 17.3, a minimum of 7.1, and a maximum of 81.2. The average habitual occlusion left% in II SG is 48.5 ± 12.6, a minimum of 28.1, and a maximum of 76.9. The average habitual occlusion left% in the III CG is 50.0 ± 8.8, minimum 30.6, and a maximum of 65.6. (Table 7, Chart 7).

Also the difference between the minimal and the maximal value of the occlusion right% is with the greatest variation in I SG, and II SG and the slightest variation of the difference is in III CG.

Table 7. A review of the average occlusion in the right and left side of the upper arch(%) in the three groups in a habitual occlusion

group	right % - Means	right % - N	right % - Std.Dev.	right % - Minimum	right % - Maximum
I	48.1	35	17.27023	18.8	92.9
II	51.5	35	12.62201	23.1	71.9
III	50.0	35	8.76045	34.4	69.4
group	**left % - Means**	**left % - N**	**left % - Std.Dev.**	**left % - Minimum**	**left % - Maximum**
I	51.9	35	17.27023	7.1	81.2
II	48.5	35	12.62201	28.1	76.9
III	50.0	35	8.75343	30.6	65.6

Chart 7. A review of the average occlusion in the right and left side of the upper arch (%) in the three groups in a Habitual occlusion



According to the Analysis of ANOVA test, the difference between the groups to be registered is statistically with no significance for P> 0.05. (Table 7a)

Table 7a. An Analysis of the ANOVA test

left %	SS - Effect	df - Effect	MS - Effect	SS -Error	df - Error	MS Error	F	p
	205.8589	2	102.9294	18162.75	102	178.0662	0.57804	0.56282
right%	SS - Effect	df - Effect	MS - Effect	SS - Error	df - Error	MS - Error	F	p
	205.8093	2	102.9047	18166.93	102	178.1071	0.57777	0.56298

The difference that is registered between the average habitual occlusion in the right and left side of the arch (-3.9) in I SG is statistically with no significance for P> 0.05. (Table 7b)

The difference recorded between the average habitual occlusionin the right and left side% (3.0) in II SG is statistically with no significance for P> 0.05. (Table 7b)

The difference that is registered between the average habitual occlusion in the right and left side% (-0.09) in III CG is statistically with no significance for P> 0.05. (Table 7b)

Table 7b. T-test display

		Mean	Std.Dv.	N	Diff.	Std.Dv. - Diff.	t	df	p	Confidence -95.0%	Confidence +95.0%
I	right%	48.1	17.27023								
	left %	51.9	17.27023	35	-3.9	34.5	-0.665544	34	0.510193	-15.7508	7.979347
II	right%	51.5	12.62201								
	left %	48.5	12.62201	35	3.0	25.2	0.693693	34	0.492587	-5.71163	11.63163
III	right%	50.0	8.760452								
	left %	50.0	8.753429	35	-0.09	17.5	-0.030884	34	0.975543	-6.10765	5.924789

6.2.5.2 Results from measurements in Central Relation

The average central relation right% in I SG is 46.5 ± 18.2, the minimum is 11.4, and the maximum is 94.4. The average central relation right% in II SG is 46.6 ± 15.4, a minimum of 5.4, and a maximum of 75.5. The average central relation right% in III CG is 50.4 ± 6.5, minimum 35.2, and a maximum of 64.0. (Table 8, Chart 8).

The difference between the minimal and the maximal value of the occlusion right% is with the greatest variation in I SG and II SG and the slightest variation of the difference is in III CG.

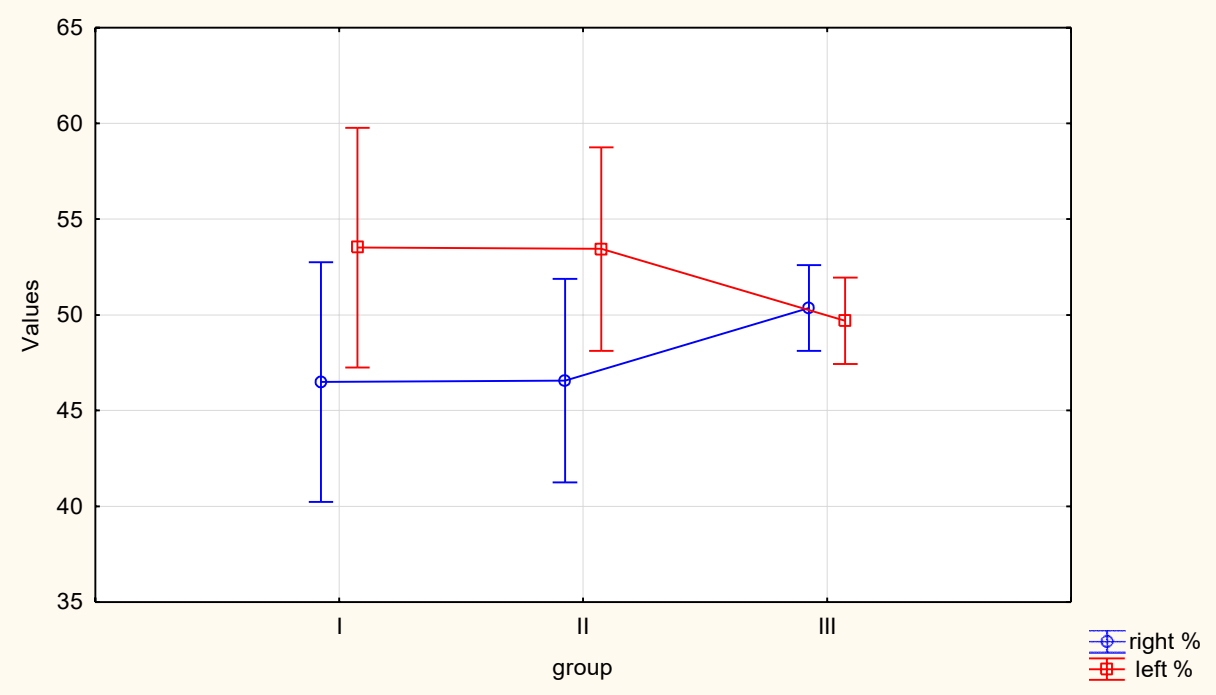
Table 8. Average occlusion in the right and left side of the upper arch (%) in the three groups in a central relation

group	right % - Means	right % - N	right % - Std.Dev.	right % - Minimum	right % - Maximum
I	46.5	35	18.24363	11.4	94.4
II	46.6	35	15.47746	5.4	75.5
III	50.4	35	6.53111	35.2	64.0
group	**left % - Means**	**left % - N**	**left % - Std.Dev.**	**left % - Minimum**	**left % - Maximum**
I	53.5	35	18.24363	5.6	88.6
II	53.4	35	15.47746	24.5	94.6
III	49.7	35	6.58610	36.0	64.8

The average of central relation left% in I SG is 53.5 ± 18.2, a minimum of 5.6, and a maximum of 88.6. The average of central relation left% in II SG is 53.4 ± 15.5, a minimum of 24.5, and a maximum of 94.6. The average central relation left% in II CG is 49.7 ± 6.6, the minimum is 36.0, and the maximum is 64.8 (Table 8, Chart 8).

The difference between the minimal and the maximal value of the occlusion right% is with the greatest variation in I SG and II SG and the slightest variation of the difference is in III CG.

Chart 8. An overview of the average occlusion in the right and left side of the upper arch (%) in the three groups in a central relation



According to Analysis of ANOVA test, the difference between the groups registered is statistically with no significance for P> 0.05. (Table 8a)

Table 8a. Display of Analysis of ANOVA test

	SS - Effect	df - Effect	MS - Effect	SS - Error	df - Error	MS - Error	F	p
right %	262.5030	2	131.2515	23711.33	102	232.4640	0.56461	0.570349
left %	332.9888	2	166.4944	20935.79	102	205.2528	0.81116	0.447184

The difference that is registered between the central relation in right and left side% (-7.0) in I SG is statistically with no significance for P> 0.05. (Table 8b)

The difference that is registered between the average central relation in right and left side% (-5.1) in II SG is statistically with no significance for P> 0.05. (Table 8b)

The difference that is registered between the average central relation in right and left side% (-0.7) in III CG is statistically with no significance for P> 0.05. (Table 8b)

Table 8b. T-test display

		Mean	Std.Dv.	N	Diff.	Std.Dv. - Diff.	t	df	p	Confidence -95.0%	Confidence +95.0%
I	**right%**	46.5	18.24363								
	left %	53.5	18.24363	35	-7.0	36.5	-1.13869	34	0.262791	-19.5567	5.510952
II	**right%**	48.3	17.94176								
	left %	53.4	15.47746	35	-5.1	31.8	-0.949201	34	0.349217	-16.0461	5.828908
III	**right%**	50.4	6.531111								
	left %	49.7	6.586103	35	0.7	13.1	0.299056	34	0.766718	-3.84161	5.167321

After registered occlusion in two positions central relation and habitual occlusion from this measurements we can consider that incidence of unbalanced occlusion is high. Differences between these two positions were evident even so there was no significance. When the deviation was present, differences were distinguished and even more pronounced.

Due to the high prevalence and variability of the complaints, TMD is diagnosed by associating signs and symptoms, as some characteristics may be frequent even in a non-patient population.

As we point it out according to T-scan III measurements and presence of TMD signs in I SG, balanced occlusion is registered in 12 subjects (34.3%). It is important to mention that only 3 subjects (8.5%) had balanced occlusion without any signs of TMD. Opposite to that 9 subjects (25,7%) had balanced occlusion but also they had TMD signs too.

According to comparison between groups even in II SG with TMD were present 10 subjects (28,57 %) with balanced occlusion.

Also in III CG where all the subjects are healthy subjects with natural dentition with full arch, TMD signs were also present in 14(40%) subjects with balanced occlusion, 8 of them (22.85%) were with more pronounced TMD signs.

*At this point we should emphasize the importance of subjects with prosthetic ceramic restoration that can influence the occurrence of future TMD problems as iatrogenic factor. It's hard to determine if there were any connections between unbalanced and balanced occlusion in the occurrence of TMD in this study because for more significant results this should be retrospective study.

This subgroup with balanced occlusion but also with TMD signs present it's important group to follow up and to analyze it's role on severity of TMD symptoms or maybe as indicator that balanced occlusion can prevent worsening TMD symptoms. Otherwise it can be also as indicator that in early stages of TMD, balanced occlusion is still present.

Supporting Analysis to Working Hypothesis

Analysis of uncompensated teeth

In order to understand and eliminate factors which influence unbalanced occlusion it deemed important to analyze also the presence of uncompensated teeth in three groups (Table 9).

Table 9. Average number of missing / uncompensated teeth in all three groups

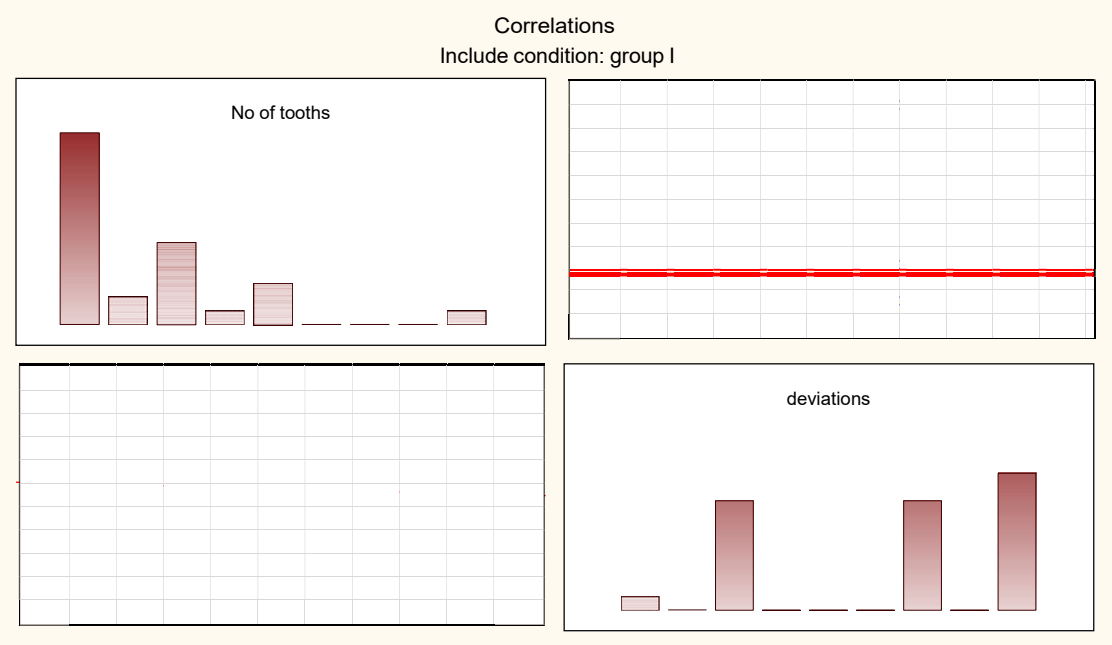
Group/ Tooth	Means	N	Std.Dev.	Minimum	Maximum
I	3.5	27	2.819852	1.0	13.0
II	2.7	19	1.521772	1.0	7.0
III		0			

The I SG did not register a statistically significant correlation between the lack of teeth versus deviation in the habitual occlusion (Spearman Rank Order Correlations- -0.083310) (Tabel 9a, Chart 9a).

Table 9a. View of the Mann-Whitney U-test

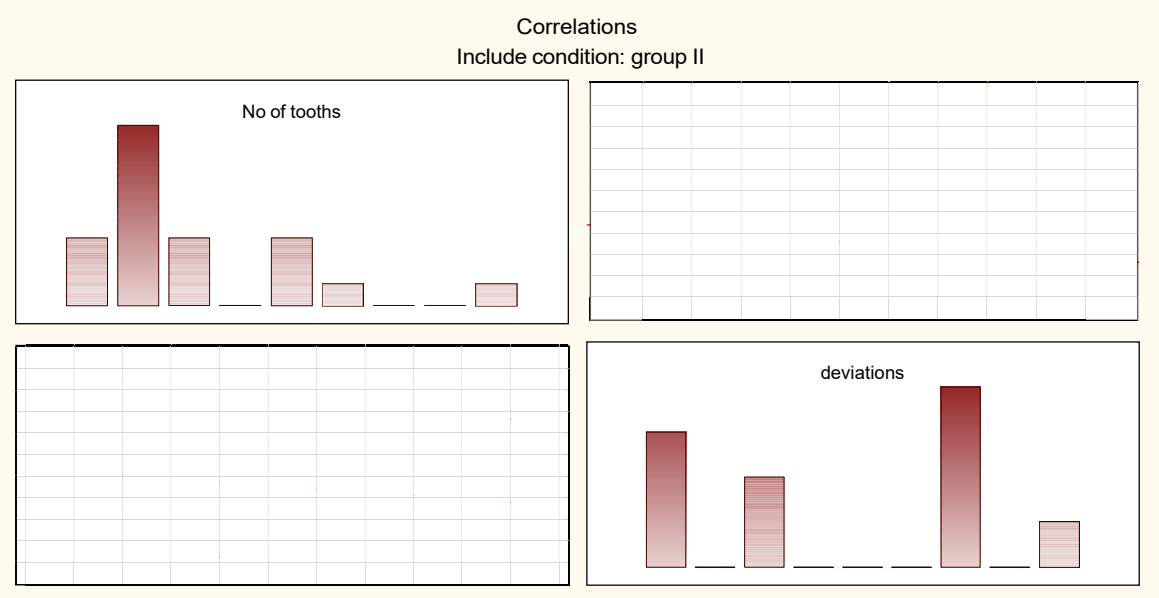
Rank Sum - Group 1	Rank Sum - Group 2	U	Z	p-value
650.5000	430.5000	240.5000	0.345792	0.729499

Chart 9a. View the correlation between the average number of missing / uncompensated teeth and the deviation of the habitual occlusion in I SG



The II SG did not register a statistically significant correlation between the lack of teeth versus deviation in the habitual occlusion (Spearman Rank Order Correlations - 0.243255). (Chart 9b)

Chart 9b. A view of the correlation between the average number of missing / uncompensated teeth and the deviation of the habitual occlusion in II SG



Analysis of occlusion time (OT)

In this study was also analyzed the occlusion time, in three groups to understand and eliminate factors that influence TMD signs. As we referred to in methodology OT describes the time from the first tooth contact to the point at which the entire dentition is contacted when evaluating maximum inter-cuspation. When this period of time is long, there is occlusion interference, and when it is short, the occlusion is considered to be stable, especially when the duration is less than 0.3 seconds.

The average occlusion time in the habitual occlusion in I SG is 1. 9 ± 0.9. No patient registered a time below 0.3s. (Table 10)

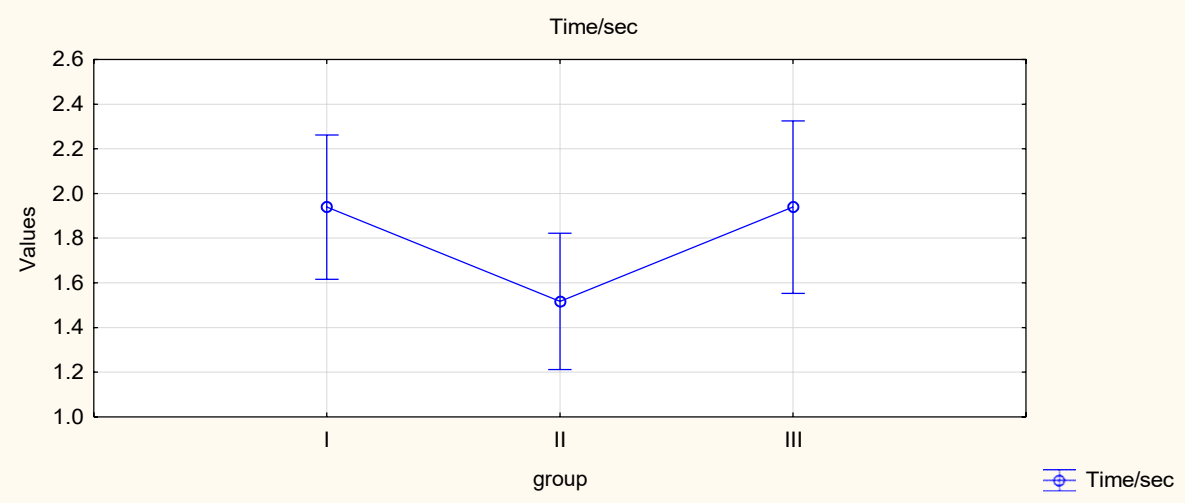
The average occlusion time in the habitual occlusion in II SG is 1.5 ± 0.88. No patient registered a time below 0.3s. (Table 10)

The average occlusion time in the habitual occlusion in III CG is 1.9 ± 1.1. One patient registers a time below 0.3 sec. ie. 0.072. (Table 10)

Table 10. Average time of occlusion in all three groups in a habitual occlusion

Group/habitu.occulsion	Time/sec - Means	Time/sec - N	Time/sec - Std.Dev.	Time/sec - Minimum	Time/sec - Maximum
I	1.9	35	0.942113	0.614	4.204
II	1.5	35	0.888546	0.371	4.031
III	1.9	35	1.124395	0.072	4.984

Chart 10. Average time of occlusion in all three groups in a habitual occlusion



The difference between the average occlusion times in the habitual occlusion between three groups according to Kruskal-Wallis, ANOVA, by Ranks-test are statistically non-significant (H 2, N = 105) = 4.232701 P = .1205) (Table 10a)

Table 10a. View of Kruskal-Wallis ANOVA by Ranks -test

group	Code	Valid - N	Sum of - Ranks	Mean - Rank
I	1	35	2042.500	58.35714
II	2	35	1555.500	44.44286
III	3	35	1967.000	56.20000

Mann-Whitney U-test **registered statistically significant difference** in the habitual occlusion between all three groups I SG vs III CG, I SG vs II SG, II SG vs III CG. (Table 10b)

Table 10b. Mann-Whitney U-test

Rank Sum - Group I	Rank Sum - Group III	U	Z	p-value	Group I	Group III
1263.000	1222.000	592.0000	0.234922	0.814270	35	35
Rank Sum - Group I	**Rank Sum - Group III**	**U**	**Z**	**p-value**	**Group I**	**Group III**
1409.500	1075.500	445.5000	1.955724	0.050498	1409.500	1075.500
Rank Sum - Group II	**Rank Sum - Group III**	**U**	**Z**	**p-value**	**Group II**	**Group III**
1110.000	1375.000	480.0000	-1.55048	0.121026	35	35

The average occlusion time in the central relation in I SG is 2.0 ± 1.1. No patient registered a time below 0.3s. (Table 11, Chart 11)

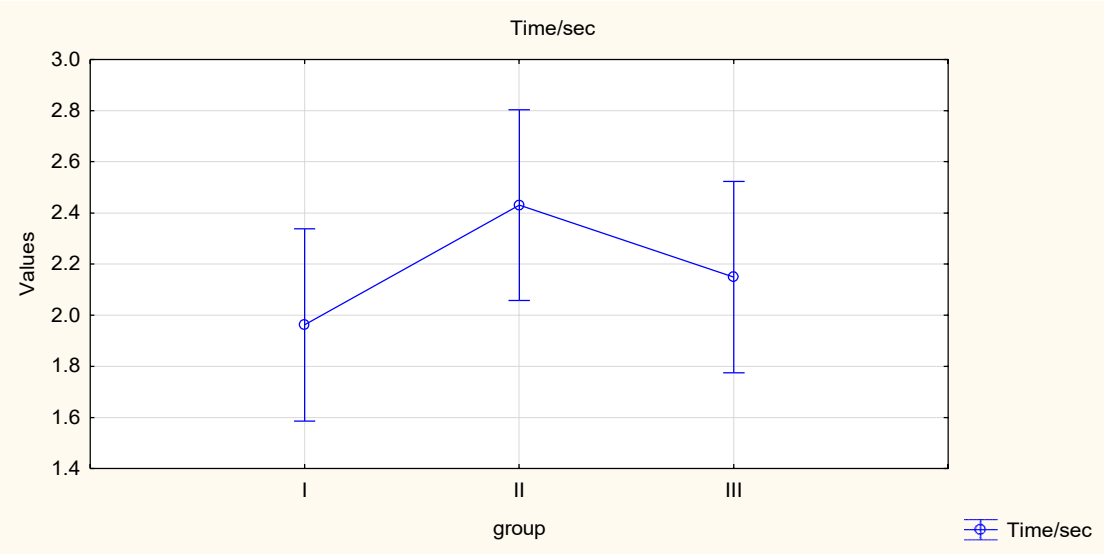
The average occlusion time in the central relation II SG is 2.4 ± 1.1. No patient registers a time below 0.3s. (Table 11, Chart 11)

The average occlusion time in the central relation in III CG is 2.1 ± 1.1. No patient registers a time below 0.3s. (Table 11, Chart 11)

Table 11. Average of OT in all three groups in the CR

Group/cent. relation	Time/sec - Means	Time/sec - N	Time/sec - Std.Dev.	Time/sec - Minimum	Time/sec - Maximum
I	2.0	35	1.094356	0.508	4.33
II	2.4	35	1.084258	0.866	6.044
III	2.1	35	1.090905	0.533	5.851

Chart 11. Average of OT in all three groups in the central relation



The difference between the average occlusion times in the central relation between the three groups according to the Kruskal-Wallis ANOVA by Ranks test are statistically non-significant (H (2, N = 105) = 4.232701 p = .1205). (Table 11a)

Table 11a. Overview of Kruskal-Wallis ANOVA by Ranks -test

Group	Code	Valid - N	Sum of - Ranks	Mean - Rank
I	1	35	1593.000	45.51429
II	2	35	2131.500	60.90000
III	3	35	1840.500	52.58571

Mann-Whitney U-test **registered statistically significant difference** in the central relation between all three groups I SG vs III CG, II SG vs III CG, and also between group I SG vs II SG. (Table 11b)

Table 11b. View of the Mann-Whitney U-test

Rank Sum - Group I	Rank Sum - Group II	U	Z	p-value	Group I	Group II
1060.000	1425.000	430.0000	-2.13779	0.032535	35	35
Rank Sum - Group I	**Rank Sum - Group III**	**U**	**Z**	**p-value**	**Group I**	**Group III**
1163.000	1322.000	533.0000	-0.927941	0.353439	1163.000	1322.000
Rank Sum - Group II	**Rank Sum - Group III**	**U**	**Z**	**p-value**	**Group II**	**Group III**
1336.500	1148.500	518.5000	1.098260	0.272092	1336.500	1148.500

The difference between the average occlusion time in the habitual occlusion (1.5sec) and the central relation (2.4sec) in **II SG according to the t-test is statistically significant** for P <0.05 (P = 0.000254), the other differences that are registered in the I SG and III CG are statistically non-significant (Table 11)

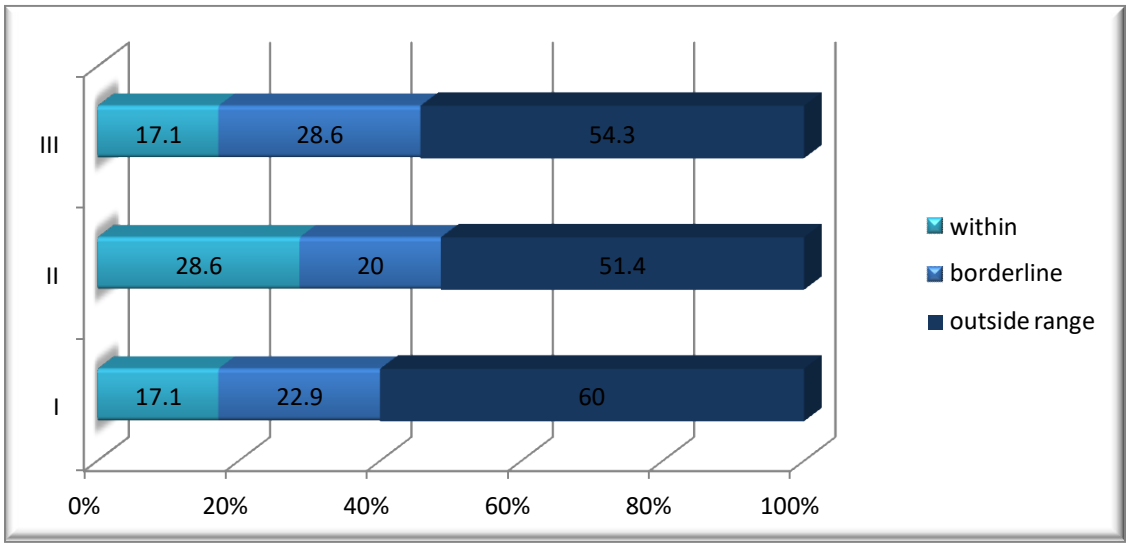
In all three groups, average occlusion time is outside range, and considering that when this period of time is long there were occlusion interferences registered, 60.0% in I SG, 51.4% in II SG and 54.3% in III CG. The average occlusion time within range is registered in the largest percentage in II SG, 28.6%, and also 17.1% in I SG and III CG. (Table 12, Chart 12)

The percentage difference registered between the groups relative to the average occlusion time is statistically non-significant for P> 0.05.

Table 12. Display of OT differential in all three groups

OT differential/ Group	I		II		III	
	Count	%	Count	%	Count	%
within range	6	17.1	10	28.6	6	17.1
borderline range	8	22.9	7	20.0	10	28.6
outside range	21	60.0	18	51.4	19	54.3
total	**35**	**100.0**	**35**	**100.0**	**35**	**100.0**

Chart 12. Display of OT differentials in all three groups



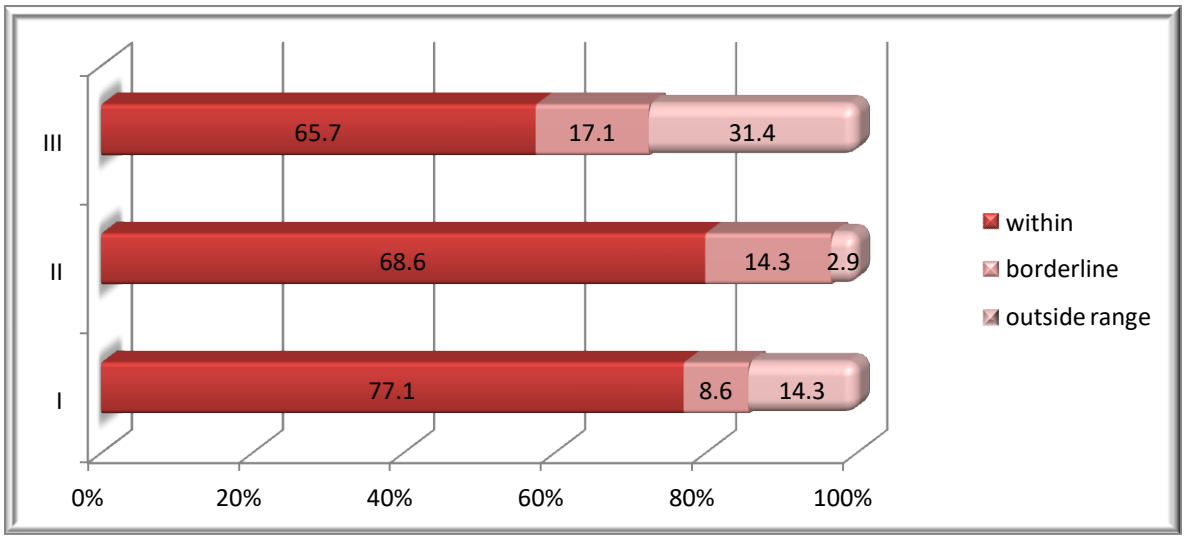
Disclusion time (DT) is the time from when anterior or canine guidance is formed to the point where molar contact is lost during lateral excursion or protrusion. As longer this period of time is the greater the interference of molars during lateral excursion or protrusion it is. A time of less than 0.5 seconds is considered normal.

In all three groups, DT was within range, 77.1% in I SG, 68.6% in II SG and 65.7% in III CG. Too long DT or outside range is registered in the highest percentage in subjects 31.4% in III CG, 17,1% in II SG and 14.3% in I SG. (Table 13, Chart 13)

Table 13. Displays the DT differential in the three groups

	I		II		III	
DT differential/ Group	**Count**	**%**	**Count**		**Count**	**%**
within range	27	77.1	24	68.6	23	65.7
borderline range	3	8.6	5	14.3	1	2.9
outside range	5	14.3	6	17.1	11	31.4
total	35	100.0	35	100.0	35	100.0

Chart 13. Display of the DT differential in the three groups



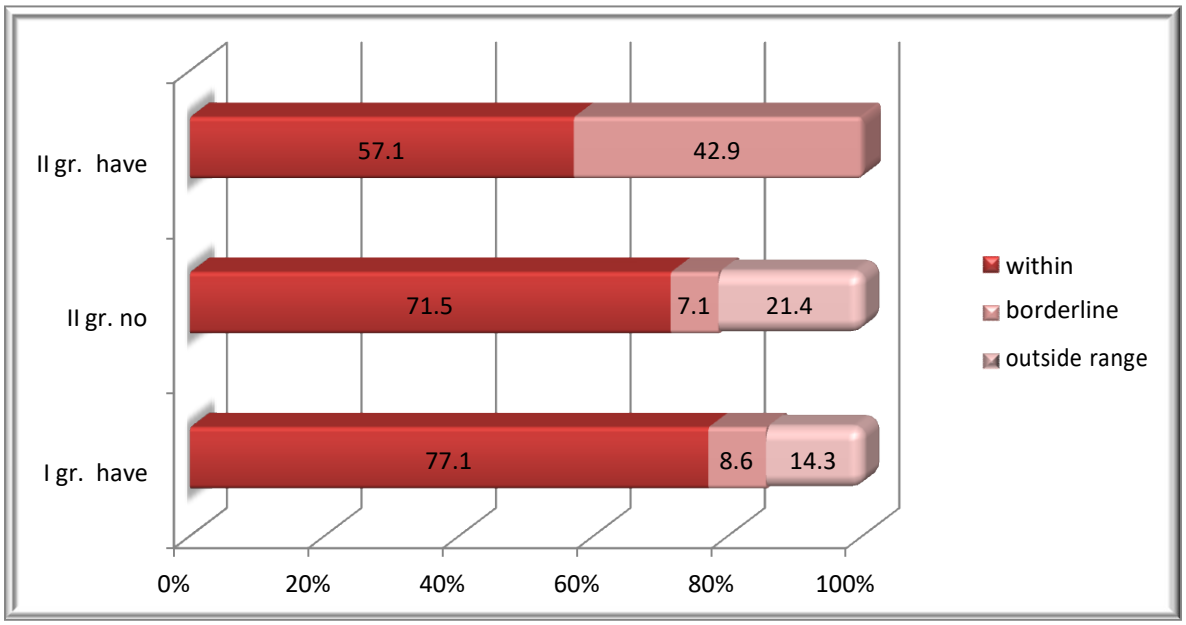
The difference of DT outside range is statistically significant between groups III CG 31.4% vs II SG 2.9%.) for P <0.05 (p = 0.0016), the difference of DT between remaining groups is statistically with no significance for P> 0.05.

Table 13a. View of DT differential in Group I and II with respect to having and not having prosthetic ceramic restorations

	I		II			
	Have PCR		No PCR		Have PCR	
DT differential/ Group	**Count**	**%**	**Count**	%	**Count**	%
within range	27	77.1	20	71.5	4	57.1
borderline range	3	8.6	2	7.1	3	42.9
outside range	5	14.3	6	21.4		
total	35	100.0	28	100.0	7	100.0

Prolonged DT in subjects in I SG with prosthetic ceramic restorations occurs in 14.3%, and in II SG in 21.4% in subjects with no prosthetic ceramic restorations. (Table 13a, Chart 13a)

Chart 13a. DT in I SG and II SG in relation to having and not having prosthetic ceramic restorations



According to these results we can register that OT was outside range in all three groups and were registered significant difference between two positions in central relation and habitual occlusion and was related with frequency of premature contacts and asymmetry in the occlusal force. Discclusion time(DT) in this study was not significant in large group of subjects also time less than 0.5 seconds is considered normal DT. TMD subjects had a significantly higher frequency of premature contacts.

6.2.6 Hypothesis 6

According to this research it has been determined if there are any changes in measurements with articulating paper and computer analyses with T-scan III.

T-scan III system analyze overcomes the known limitations of articulating paper, it quantifies and displays relative occlusal force information that often occur from relying solely on the combination of dental articulating paper and patient feel. T-Scan III system readily identifies the very first contact point that precedes numerous other contact points that transitorily occur during occlusal functional movements.

In I SG group from 22 deviations, localization of the first contact point in 5 subjects (22.7%) is registered to the right and in 4 subjects (18.2%) to the left. (Table 14, Chart 14)

Only 9 subjects 25,7% have first contact point on the other side where the force of the occlusion is dominant and this attributes to connections with premature contact point the rest complies with the side where the force of the occlusion is dominant.

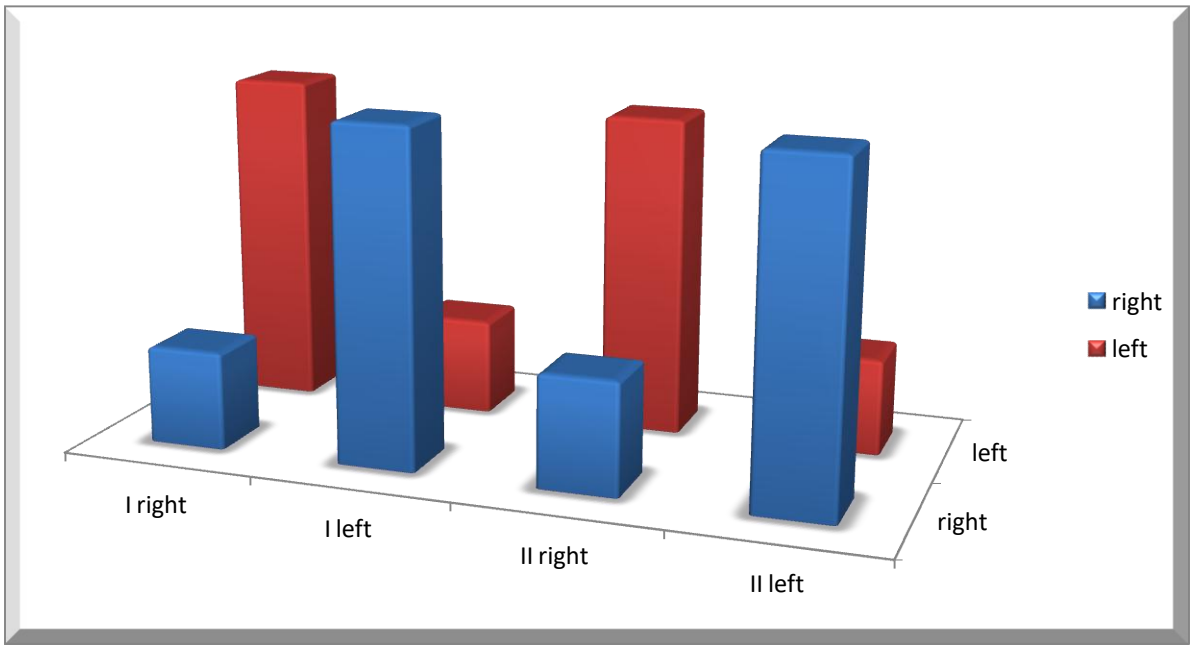
In II SG from 23 deviations, localization of the first contact point in 6 subjects (26.1%) is registered to the right and in 4 subjects (17.4%) to the left. (Table 14, Chart 14). Only 10 subjects 28,5% have first contact point on the other side where the force of the occlusion is dominant in this II SG.

On III CG there are only 5 subjects that have deviation and 3 subjects have first contact on the other side where the deviation and the dominant occlusal force is.

Table 14. Display of correlation between first contacting teeth with the side of the deviation in I SG and II SG

deviation/Group/tooth	I SG right		I SG left		II SG right		II SG left	
	Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
right	5	22.7	14	77.8	6	26.1	14	77.8
Left	17	77.3	4	22.2	17	73.9	4	22.2
total	22	100.0	18	100.0	23	100.0	18	100.0

Chart 14. Display of teeth that contact first and left with right and left deviation in I SG and II SG

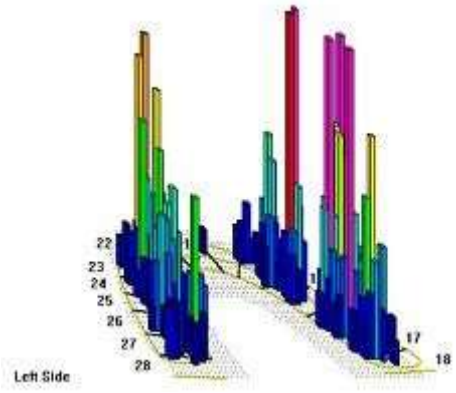


The recorded occlusal force data offers the operator improved information about occlusal contact locations that demonstrate excessive occlusal force, when compared to the highly subjective method of "judging" paper mark size appearance characteristics (Figure 14a-b).

(a)  (b) 

Figure 14. Qualitative method /Occlusal force distribution using articulation paper: (a) upper jaw and (b) lower jawl images of a healthy participant

Also as very important indicator is that with T-scan can be recorded force of the occlusion on every half of the arch. It's mainly important to know which side of TMJ is more overloaded with force and where is center of occlusion localized (Figure 15a-b).

(a) 

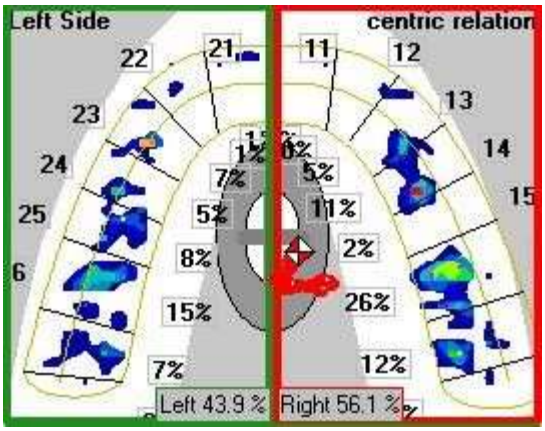
(b) 

Figure 15. Quantitative method / Occlusal force distribution using T-Scan III: (a) Two-dimensional and (b) three-dimensional images of a healthy participant

When we compare this visual contact point with software data we can understand better those contact points with articulation paper without misunderstanding their size or intensity or subjective feeling of the subject.

In this subject it is presented a jaw deviation during opening and closure of the mouth (Figure 16-17).

(a) 

(b) 

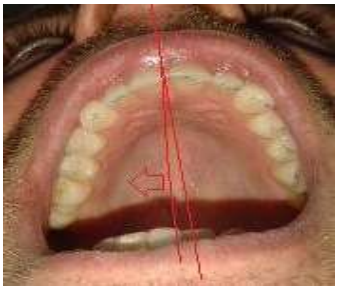
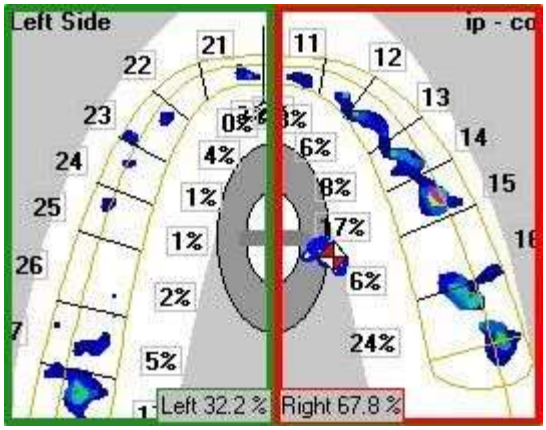
(c) 

Figure 16. Qualitative method /Occlusal force distribution using articulation paper (a) frontal view (b) upper jaw and (c) deviation of the jaw during mouth opening images of a II SG, subject with TMD

One of the causes is early contact on the last molars. All this, after an analysis performed with articulation paper, could not be defined as lack of the information gathered from visual aspect only. When we gather both information's from T-Scan III and articulation paper it easier to identify the cause.

(a) 

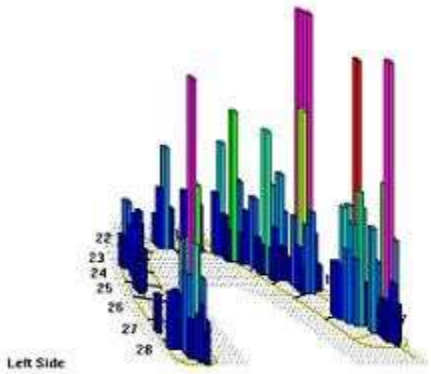
(b) 

Figure 17. Quantitative method / Occlusal force distribution using T-Scan III
(a) two-dimensional and
(b) three dimensional images of same subject with TMD deviation on the right

With this method were evaluated occlusal tooth prints using articulating paper compared to T-Scan III images. The tooth and the contact location of the largest paper mark in a quadrant were recorded for comparison (Figure 18-20).

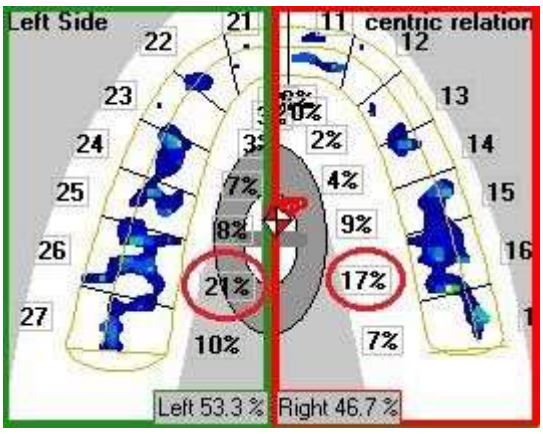
(a) 
(b) 

Figure 18. Identification of excessive force on region of molars
(a) with articulation paper and (b) 2D image with T-Scan III

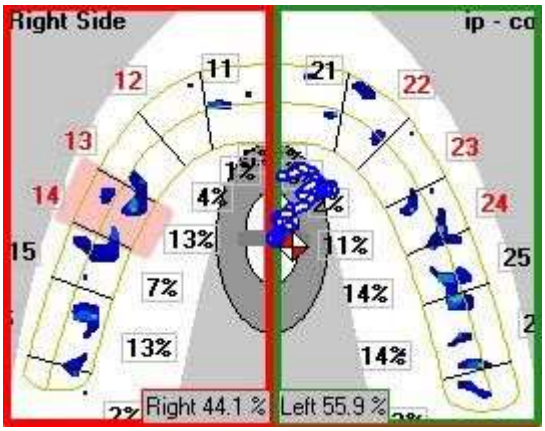
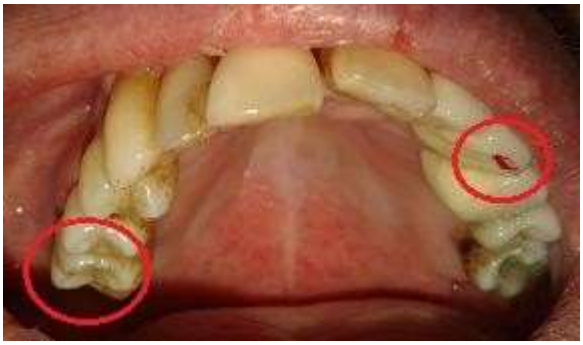
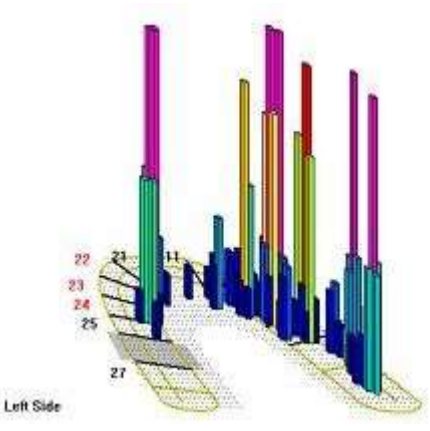
(a)  (b) 

Figure 19. Interpretation of paper marks (a) with articulation paper and (b) T-Scan III with 2D image I SG

(a)  (b) 

(c) 

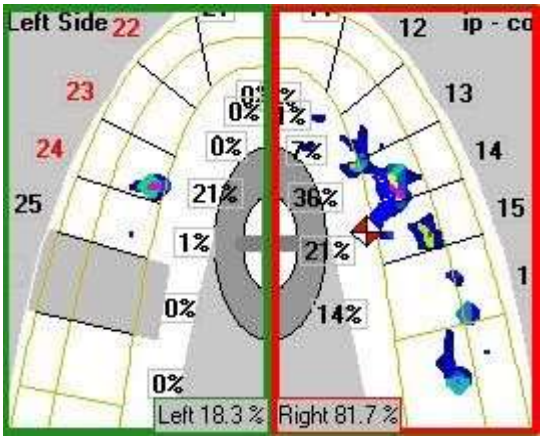
(d) 

Figure 20. View of the location of excessive force in a habitual occlusion compared and assisted with articulation paper and T-scan: (a,b,c,d) in I SG with prosthetic ceramic restorations

For the comparative analyze of the sixth hypothesis about the accuracy of T scan III as a diagnostic test for the detection of tooth contact in the habitual occlusion in the three groups were analyzed in tables below (Table 15-17a,b) and it's reported:

The accuracy of T scan as a diagnostic test for the detection of tooth contact in the habitual occlusion in the first group is analyzed in Table 15a. Out of the total of 560 analyzed teeth, the actual positive are 64, false positive are 55. 441 negative findings were obtained, of which 384 are truly negative, 57 are false negative results.

Table 15a. Comparison of two tests with articulation paper and T scan in the habitual occlusion in I SG

I SG	*Articulation papers*		
T scan	Test Positive	Test Negative	Totals
Test Positive	64	55	119
Test Negative	57	384	441
Totals	121	439	560

T-scan scores in the first group are: sensitivity 53.0%, specificity 87.5%, positive predictive value 54.8% - CI 95% (0.44-0.62), negative predictive value 87.1% - CI 95% (0.83-0.89). The global accuracy is 80.0%. (Table 15b)

Table 15b. Display of the test accuracy I SG

I SG	95% Confidence Interval		
	Estimated Value	Lower Limit	Upper Limit
Prevalence	0.216071	0.183144	0.252969
Sensitivity	0.528926	0.436427	0.619562
Specificity	0.874715	0.839215	0.903478
For any particular test result, the probability that it will be:			
Positive	0.2125	0.179801	0.249219
Negative	0.7875	0.750781	0.820199
For any particular positive test result, the probability that it is:			
True Positive (Positive Predictive Value)	0.537815	0.444337	0.628819
False Positive	0.462185	0.371181	0.555663
For any particular negative test result, the probability that it is:			
True Negative (Negative Predictive Value)	0.870748	0.834969	0.899895
False Negative	0.129252	0.100105	0.165031

The accuracy of T scan as a diagnostic test for detecting tooth contact in the habitual occlusion in II SG is analyzed in (Table 16a). Out of the total of 560 analyzed teeth, the actual positive are 46, false positive are 85. 429 negative findings were obtained, of which 369 are truly negative, 60 are false-negative results.

Table 16a. Comparison of two tests of articulation paper and T scan in the habitual occlusion in II SG

II group	*Articulation papers*		
T scan	Test Positive	Test Negative	Totals
Test Positive	46	85	131
Test Negative	60	369	429
Totals	106	454	560

Table 16b. Display of the test accuracy II SG

II SG	Estimated Value	95% Confidence Interval	
		Lower Limit	Upper Limit
Prevalence	0.189286	0.158171	0.224751
Sensitivity	0.433962	0.339123	0.533648
Specificity	0.812775	0.773151	0.846991
For any particular test result, the probability that it will be:			
Positive	0.233929	0.199912	0.271663
Negative	0.766071	0.728337	0.800088
For any particular positive test result, the probability that it is:			
True Positive (Positive Predictive Value)	0.351145	0.271198	0.439964
False Positive	0.648855	0.560036	0.728802
For any particular negative test result, the probability that it is:			
True Negative (Negative Predictive Value)	0.86014	0.822846	0.890817
False Negative	0.13986	0.109183	0.177154

The accuracy of T scan in the second group is: sensitivity 43.4%, specificity 81.3%, positive predictive value 35.1% - CI 95% (0.27-0.43), negative predictive value 86.0 % - CI 95% (0.82-0.89). The global accuracy is 74.1%. (Table 16b)

The accuracy of T scan as a diagnostic test for the detection of tooth contact in the habitual occlusion in III CG is analyzed in (Table 17a). Of the total of 560 analyzed teeth, the actual positive are 80, false positive are 57. 423 negative findings were obtained, of which 335 are truly negative, 88 are false-negative results.

Table 17a. Comparison of the two tests of articulation paper and T scan in the habitual oclussion in III CG

III CG	*Articulation papers*		
T scan	Test Positive	Test Negative	Totals
Test Positive	80	57	137
Test Negative	88	335	423
Totals	168	392	560

Table 17b. Display of the test accuracy III CG

III CG	Estimated Value	95% Confidence Interval	
		Lower Limit	Upper Limit
Prevalence	0.3	0.262658	0.340131
Sensitivity	0.47619	0.399161	0.554326
Specificity	0.854592	0.814867	0.887185
For any particular test result, the probability that it will be:			
Positive	0.244643	0.210014	0.282838
Negative	0.755357	0.717162	0.789986
For any particular positive test result, the probability that it is:			
True Positive (Positive Predictive Value)	0.583942	0.496569	0.666536
False Positive	0.416058	0.333464	0.503431
For any particular negative test result, the probability that it is:			
True Negative (Negative Predictive Value)	0.791962	0.749487	0.829022
False Negative	0.208038	0.170978	0.250513

The accuracy of T scan in III CG is: sensitivity 47.6%, specificity 85.4%, positive predictive value 58.4% - CI 95% (0.49-0.66), negative predictive value 79.2% - CI 95% (0.74-0.82). The global accuracy is 74.1% (Table 17b).

As the subject of this research is considering the reliability, validity and usefulness of the instrument T - Scan III we can emphasize that the accuracy of T scan as a diagnostic test for the detection of tooth contact in the habitual occlusion

comparing two tests with articulation paper and T scan III was analyzed and T scan scores in general are: sensitivity 48.0%, specificity 84.7%, positive predictive value 49.1%, negative predictive value 84.1%. Sow from this results global accuracy is 76.1%.

From this we consider that T-Scan III it certifies its role as an adjuvant therapeutic device in detecting occlusal interferences.

6.2.7 Zero Hypotheses

According to our research artificial occlusion in subjects with prosthetic ceramic restorations has no influence on the occurrence of TMD**.**

But during this study on contrary was found that artificial occlusion with prosthetic ceramic restorations on many cases play an important role as iatrogenic factor that influence the occurrence of TMD. That's why this hypothesis is NEGATIV.

CHAPTER VII

DISCUSSION

From the information gathered, it seems to be evident that occlusal interferences can lead to the development or to an increase in the severity of TMD.

Considering that many etiologic factors, such as para-functional and postural habits, but also psychological and occlusal factors, are usually attributed to the onset of TMD and also to the perpetuation of the muscular-related disturbances, [43] it is necessary to understand the anatomy and morphology of the TMJ in order not to misinterpret a normal situation as an abnormality. [152] The theories of TMD etiology, that have made the largest impact, are related to various types of occlusal imperfection.

Occlusion is a very important subject within the profession of dentistry, especially if it's related to orthodontics, restorative dentistry and prosthodontics; however, its relevance to the etiology of TMDs is questionable, especially in chronic condition.[153,154]

The lack of research in this area is largely due to occlusal disorders themselves, which have never been formally defined using repeatable criteria.[149] Nevertheless, the practicing clinician's "gold standard" for diagnosing occlusal disorders is a combination of patient self report of problem and the occlusal examination.[155]

Clinicians are interested that new restorations are fabricated in harmonious contact relative to the opposing teeth. Sometimes, however, the patient has tooth pain and one of the possible reasons for tooth pain is excessive occlusal loading. In this context, it is necessary to evaluate the tooth for the presence of a supracontact. [16,77]

Masticator performance has been correlated with occlusion and the occlusal contact area; patients with better masticator performance have well-distributed occlusal contact areas, whereas patients with malocclusion have lower masticator performance than those with normal occlusion.[156,157]

Studies have also shown that impaired masticator function can adversely affect the quality of life.[158,159] Studies have found a substantial influence of TMD and facial pain on Oral Health Related to Quality of Life (OHRQoL) in TMD patients.[159-162]

Dahlström and Carlsson[163] after a systematic review concluded that subjective TMD symptoms had a greater impact on OHRQoL than did clinical findings of TMD, and that the more painful and severe the TMDs were, the greater the impact was.

In contrary many studies have tried to minimize or to fade at all influence of occlusion on accuracy of TMD. [161]

According to the study of Pullinger and Seligman [19], occlusal characteristics are co-factors in the development of TMD in only a small proportion of patients, and the majority of the associated factors seem to be non-occlusal.

In addition, some occlusal variations, such as anterior open bite in adults, may be a consequence rather than an etiologic factor for TMD. Group of authors have not found any association between occlusal features and TMD.[164,165] They failed to find any relationship between overbite, over-jet and self-reported TMD symptoms. [19,115,164,165]

Also several epidemiological investigations were unable to show that naturally occurring features such as centric relation, balanced occlusion, working or protrusive occlusal 'interferences', various occlusal guidance patterns, missing teeth and oral/ dental para-functions are meaningfully associated with TMD signs and symptoms. [20,149,153]

Even though the current consensus suggests that there is no a causal link between TMD and occlusion, the prevalence of the signs and symptoms of TMD has been found to be higher in malocclusion patients compared to the normal population. [20,68,165,166]

In particular, it must be pointed out that the role of dental occlusion cannot be considered negligible because it may determine the patterns of load distribution on the

TMJ, thus acting as a factor that could influence the overall resistance of the musculoskeletal system.[167]

One surprising result in one of the studies was that occlusal asymmetry seems to be associated with contra lateral muscular asymmetry and the balancing of muscular activity is a more challenging goal than Centering the Occlusal Force which, on the other hand, is an immediate result.[46] These side-related discrepancies have been reported previously in several of Kerstein´s studies. [168,169]

Certain occlusal factors (occlusal interferences and tooth contact) have been suggested to have a role in the development of facial pain. [25,170-172]

However, it has been found that the presence of painful TMD may influence mandibular positions and movements, thus possibly leading to occlusal disturbances. [120,46] Similarly, degenerative changes in the TMJs can lead to changes in occlusal relationships. [46] This means that many of the occlusal 'imperfections' observed in these patients may be consequences rather than causes of TMD.[120] As such, they should not be analyzed or adjusted until symptoms abate (if at all). Furthermore, TMD patients who also require prosthodontic rehabilitation should have that treatment postponed until the pain condition has been resolved. [120]

Thus, findings associating dental instability and TMJ clicking, although with little clinical relevance, should be supported at least in part where stable occlusion is important to keep the physiologic relationship between joint structures.[167]

Factors that have been found to be associated especially with facial pain are para-functional activity, depression, health anxiety and chronic widespread pain. [171,172]

The possibility that occlusal interference results in TMD has been investigated in one study in humans using a double-blind randomized design. It was found that subjects without a history of TMD show fairly good adaptation to interferences. In contrast, subjects with a history of TMD develop a significant increase in clinical signs and self - report stronger symptoms (occlusal discomfort and chewing difficulties) in response to interferences. [173]

Also in this study we found that subjects with a history of TMD develop a significant increase in clinical signs and self-report stronger symptoms. Subjects with prosthodontic rehabilitation also have presented stronger symptoms and have a greater discrepancy and occlusal asymmetry. In the other hand control group with non-patient subjects are not left apart from TMD symptoms and occlusal asymmetry but generally they were considerably on the beginning stage of TMD severity as non-diagnosed subjects.

Numerous etiological and therapeutic theories are based on this presumed association and have been applied to justify the use of several therapeutic approaches, such as occlusal appliance and anterior repositioning appliance therapies, occlusal adjustment , restorative procedures and orthodontic and orthognathic treatments. [174]

Conversely, many TMD experts hold opposing views [173], and various types of dental interventions, including routine orthodontic treatment, have been reported as causes of TMD. [7] In fact, these interferences can be formed by uneven tooth wear, but also by restorative procedures performed incorrectly, which can leads to a disharmony between the articulation of the teeth and the position of the centric relation in TMJ. [175]

In the work published by Magnusson et al. [13], it was concluded that occlusal factors are weakly associated to TMD, though forced laterality between CR and Maximum Inter-cuspidation, and unilateral cross-bite deserve consideration as possible local risk factors in the appearance of TMD. [13, 153]

According to previous studies conducted on subjects with adequate occlusion and no dysfunction, the process occurs with symmetrical activity between the left and right masseter and anterior temporal muscles. [133, 176]

The relationship between occlusion, mastication and dental disorders, is not well understood because of the lack of accurate, quantitative measures of occlusal parameters. [177] According to numerous studies this has been elaborated in order to highlight the possible differences between the position of CR and MIC. [77,110,176]

In this study as in several reviews that have related the majority of toothed subjects demonstrate a discrepancy between the CR and MIC positions.

Controversy continues about what is considered an ideal condyle-fossa relationship when the teeth establish MIC. [94,109] If any premature occlusal contact changes the jaw closing arch, the condyles might be displaced to achieve a maxillo-mandibular relationship in MIC, thus avoiding premature contact. [94]

Even so contradictions exist as how occlusal changes affect the function of the TMJ, [95,104] in this study comparing results between study groups it is clear that occlussal changes affect TMJ and also prosthetic ceramic restorations if they are not well articulated can affect TMJ in future.

Also differences between the CR and MIC should not be ignored because depending on the mandibular position also previous studies [94,97.109,110] have shown that CR and MIC discrepancies are frequently present in the general population, in symptomatic as often as in asymptomatic subjects.

According to the results of this study, the analyzed subjects presented differences between these two positions, however, when submitted to a statistic analysis, those differences were not significant. It could be presumed that, in spite of the samples presented various occlusal measurements; these were in relative balance or were not yet capable of generating alterations condyle / fossa relation.

As in this study also Soo Young Kim Weffort et al. [94] have found a positive correlation between these two positions.

In spite of the great importance of differentiation of these two condylar positions in any dentistry modality and of the results achieved in this study, attention must be given to the fact that each patient has unique features that should be carefully examined in order to obtain a suitable result.

In order to obtain and compare results from different clinical studies, there was a need for using reliable and valid instruments to measure TMD severity within the

sample, which also consisted of non-patient volunteers who could present TMD symptoms [60] and for that reason questionnaires have been created to address the main clinical TMD findings and assign clinical indexes for patient classification in terms of severity levels [60,148,149]

There is no scientific evidence that shows articulation paper mark size, or mark appearance characteristics, can accurately describe varying occlusal loads exists. [134,177]

In fact, the literature does not support articulating paper as being accurate or reliable. Carey et al. [134] using 600 paper marks, showed no direct relationship could be found between paper mark size and applied occlusal load. The authors concluded when clinicians select teeth to adjust, they should not assume the size of paper markings can reliably describe a contact's force content.

As in one study examined how frequently the largest, the most prominent paper mark observed in a quadrant of paper markings, described the most forceful tooth, Qadeer et al.[131] showed that the largest paper mark in a quadrant is not the most forceful contact in that quadrant.

Schelb et al.[178] and similarly, Saad et al.[177] found that paper mark size is proportional to paper thickness, not to the applied occlusal load.

Anderson et al.[179] reported on the reliability of dentists' ability to evaluate occlusal contacts in the inter-cuspal position. Halperin et al. [180] found that some recording methods (those with a stiff marking media) induced artifacts in the contact detection process. Furthermore articulating paper demonstrates a high degree of making false positive markings. [77,181]

Similar to Kerstein and Radke [182] that found that clinician interpretation of the paper marks varied widely when using the principles of mark size and color-depth as indicators of occlusal force levels;

In this study we have registered high degree of false positive markings. But more important than consistency of marked tooth with articulation paper and with T-san III

is the percentage of force that this software displays. In this we can rely on during occlusion analyzes.

To analyze occlusions recently, T-Scan has become more popular to record the pattern of occlusion. Even though T-Scan system precisely and dynamically records the time, force and area of occlusal contacts, views on the reliability of the T-Scan system as a method for occlusal contact registration has always been questioned, especially regarding its repeatability and accuracy.

Previous studies on the performance of occlusal indicators have focused on comparing their sensitivity, reliability, validity and practical and no study has investigated whether the presence of an indicator affects muscle function during occlusion.[183]

Some authors like Forrester et al. found that T-Scan and articulating paper significantly influence neuromuscular function during occlusion and therefore may not represent valid means of identifying occlusal contacts that occur under natural dentition conditions. [183]

The T-Scan III system is a quantitative and reliable method for occlusal evaluation, and represents a potential substitute for occlusal indexes. [151]

Articulating paper which is used for clinical testing of occlusion has drawbacks: the picture is two-dimensional and not adequate for evaluating the distribution of forces during occlusion [74] Digital analysis allows obtaining additional information about occlusion time, the centre of the occlusal force and the distribution of forces on both sides of the mandible. According to some authors, occlusion time is related with premature contacts and occlusion instability.[142]

The T-Scan is much more informative than an examination with articulator paper due to proper visualization of the problem. Thus, T-Scan is good for assessing occlusal discrepancies and can be used to describe the pre and postoperative occlusal contact distribution during treatment planning and follow-up. [151]

The T-Scan III helps us to measurably adjust and create a balanced force distribution between the left and right arch halve. Also in this study when comparing T-Scan III data with the paper markings, we can see the accidental force determination errors caused by observing paper mark size that appear to indicate teeth which are receiving more force, but in reality when forces are measured with the T-Scan III, we find that another region is receiving more force.

With the evolution of time, other methods have finally reached to a stage of computer aided determination of occlusal contact points and the use of T-scan pressure sensitive films and early system insufficiencies were improved in newest version of Tscan III.[156]

In this research we have found that sensitivity of the T-scan III always recorded percentage of force for particular occlusal contacts which were actually present and that in many cases it differs from the size of the trace that is caused by occlusal contacts with articulation letter.

In some cases tooth that is visually identified with articulation paper in premature supra contact, it even differs from the tooth that have higher percentage of force checked with T-san III ensuring proper occlusal adjustment.

The pros of the T-scan system include not only its objectivity and reproducibility, but also the fact that it can detect occlusal changes over time.

This system was able to measure the parameters that time-related factors, occlusal papers, and the occlusal indexes could not show. In addition, this method is currently the only one available for studying the dynamic characteristics of occlusion.[168]

Also, other clinical and laboratory research has confirmed the pressure sensitivity, accuracy, and stability of relative force loadings and the reproducibility of results obtained via the T-Scan system. [151]

Kalachev et al. [184] found T-Scan to be a valuable and reliable system for the localization and distribution of occlusal contacts in dynamic articulation.

According to Iwase et al. [185], the maximum occlusal contact area during chewing is nearly identical to the statically determined maximum possible occlusal contact area.

Also Koos et al.[139] reported that the level of accuracy is acceptable and no interferences provoked from change in foil or repeated measuring was detected with T-Scan III. The author didn't find any inaccuracy as mentioned in the past, which may be due to an upgrade in T-Scan III.

Furthermore at early stage also Mizui et al.[31] used the T-Scan system to study the difference in occlusion balance between patients with TMJ dysfunction and patients with normal TMJ function. The group with normal function showed balanced bilateral occlusion according to the T-Scan index, with the center of force appearing in the first molar region.

Therefore, T-scan is a way to assess how a patient's bite is functioning. Further studies evaluating occlusion results may relate it to functional needs. [186]

On the other hand, the patients with TMJ dysfunction showed an asymmetrical, imbalanced occlusion. Flaws of this study include, a small sample size and no blinding of the examiners.[31]

Relying on these results, also in this study determined with the T-Scan system, we found that subjects with a history of TMD self-reported stronger symptoms, occlusal contacts were asymmetric and the center of effort was not always located in the first molar region. Subjects from a group with ceramic prosthetic restorations were impacted even more.

Premature contacts can result in condyle displacement, which may potentially cause friction and increased intra-articular pressure on the TMJ. Both situations are harmful to the TMJ and contribute to the alteration of the structure of the TMJ. If the capacity of a subject to adapt to the situation is exceeded, the TMJ and disorders of the masticatory muscles may occur. [76,139,169]

Prolonged disoclusion time, [76] frequency of premature contacts and asymmetry in the occlusal force,[68,76,187] and intracapsular joint disorder[187] lead to various temporo-mandibular joint related problems.

Prolongation of occlusion time may also influence the pathological wear of occlusal surfaces. [188]Digital occlusal analysis in patients with temporo-mandibular joint disorders may allow evaluating the relationship between occlusal factors and pathological conditions of the temporo-mandibular joint.[189]

To evaluate dynamic occlusion and the usefulness of occlusion evaluation, Kerstein and Wright [168]reported an increase in DT in patients with chronic fascial pain disorder, and occlusal adjustment decreased DT, thus improving symptoms and confirming the effectiveness of the T-Scan system in occlusion analysis.

In this study was found that subjective data are not exact when compared with measurements reported with electronic device T-scan III, also after distributing attributive data of occlusal balance subjectively reported and compared with measurements analyzed with electronic system T-scan III were found many differences in all three groups. DT in this study was not significant in large group of subjects but OT was outside the range at all three groups.and was related with frequency of premature contacts and asymmetry in the occlusal force .

TMD subjects had a significantly higher frequency of premature contacts and greater bilateral asymmetry in the occlusal force**.** Also in this study at 65.7% of subjects with normal dentitions force of occlusal contacts were symmetrical with no deviation of the COF in the ellipse registered.

The success of the T-Scan system was negatively affected by repeated use of the sensors.

CHAPTER VIII

CONCLUSION

This study concluded that there were obvious differences of balanced occlusion in all three groups with predomination of disharmonic relation between the arches with overload of the occlusal force on the one side at the groups with TMD and fixed dentures.

Samples must be large enough to prove statistical significance and render the conclusions clinically valid.

Also it can be concluded that high frequency of non-balanced occlusion in subjects with prosthetic ceramic restorations influence the occurrence of TMD as iatrogenic factor of non-balanced occlusion.

This study convincingly proved the inadequacy of the control and correction of occlusion in fixed prosthetic ceramic restorations only using articulating paper and subjective feelings of the subjects, as it concluded that subjective data are not exact with measurements reported with electronic device T-scan III.

After comparing results using articulating paper as traditional method of control and using computer unit T - Scan III in detecting occlusal interferences we can evaluate its reliability and we can give special importance to the necessity of using this device.

From this we consider that T-Scan III it certifies its role and usefulness as an adjuvant therapeutic device in detecting occlusal interferences as latest technology which can help improve clinical results and minimize destructive occlusal forces that are not seen with traditional occlusal indicators alone.

During the delivery of the dental ceramic restorations in future we have to consider better occlusion in order not to progress severity of TMD or even be the cause as iatrogenic factor on it occurrence.

In addition, long-term instrumentation studies with long-term follow-ups are needed to assess the effectiveness of occlusal treatments. Also in future subjects with prosthetic ceramic restorations with TMD signs present but with balanced occlusion it's important to follow up and to analyze it's role on severity of TMD symptoms or maybe as indicator that balanced occlusion can prevent worsening TMD symptoms.

CHAPTER IX

EXPECTED SCIENTIFIC BENEFITS

This research according to T-scan analyses determined that non-balanced occlusion in subjects with prosthetic ceramic restorations was influencing the occurrence of TMD.

Also our research determined that evident differences appear when measurements were done by computer analyses with T-scan compared to articulating paper.

Despite of the development of such an advanced computerized system of treatment and new dental materials have not yet overcome the traditional methods that are routinely used to test occlusion.

Until now, dentists continue to encourage use of articulation paper (primarily) as device for the evaluation of occlusal contacts before the adjustments. Dentists continue to rely on subjective feeling of patients and their statement about the nature of the feelings as occlusal level of comfort, as an indicator of appropriate treatment.

Traditional methods of control and correction of occlusion at prosthetic ceramic restorations using articulating paper is not achieving a balanced occlusion and should be supplemented by T-scan computer analysis.

Monitoring a digital movie of the patients bite it is much more reliable than just eyes alone, because *T-Scan* III quantifies the amount of relative occlusal force, which enables us to predictably identify and locate traumatic occlusal contacts and in that way to find occlusal stability.

Finally, from a clinical viewpoint, one of the most important objectives in providing any form of dental or medical therapy is patient safety and recognition of each patient's unique expectations, concerns and preferences.

CHAPTER X

APPLICATION OF THE RESULTS OF THE RESEARCH

Proposed and implemented in the clinic optimal control technique and correction of occlusion using computer analysis for clinical balanced occlusion, as well as to monitor the occlusion phases of preventive control.

In order to achieve bilateral occlusal balance first of all we have to take into consideration the deprogramming of both asymptomatic and symptomatic subjects prior to the registration of the CR, eliminate the subject's neuromuscular response to the habitual occlusion and finally a correction is recommended so during delivery of ceramic restoration everything underlies the control of unit T-Scan III. When used in conjunction with articulating paper, T-Scan's precise, actionable data gives you the ability to diagnose and treat occlusion accurately and with confidence. Digital software helps clinicians to identify premature contacts, high forces, and interrelationship of occlusal surfaces.

Whether eliminating destructive forces on a new restoration, or performing an occlusal analysis and adjustment procedure, T-Scan helps you balance your patients' occlusions with precision and accuracy.

At the stages of medical checkups it's recommended monitoring occlusion using T-Scan III, especially in patients receiving full arch ceramic restorations.

Such advances are likely to help to customize and enhance the quality of care we provide to patients with TMJ disorders.

One important outcome of the modern understanding of occlusion should be avoidance of occlusion-changing procedures in healthy functioning patients.

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