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COMPARISON OF ORTHODONTIC TREATMENT DURATION AND PEER ASSESSMENT INDEX SCORES OF CLASS II PATIENTS

MASTER THESIS

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ABBREVIATIONS

PAR	Peer Assessment Rating
WHO	World Health Organization
FDI	Federation Dentaire Internationale
IOTN	Index of Orthodontic Treatment Need
DHC	Dental Health Component
AC	Aesthetic Component
SMBI	Swedish Medical Health Board
MOCDO	Missing teeth, Overjet, Crossbite, Displacement of contact points, Overbite
ICON	Index of Complexity, Outcome and Need
DAI	Dental Aesthetic Index
SASOC	Social Acceptability Scale of Occlusal Conditions
HLD	Handicapping Labio-lingual Deviation index
CalMod	California Modified
T1-T2	Time 1- Time 2
SD	Standard Deviation
ABO	American Board of Orthodontics

OGS	Objective grading system
ANB	A point Nasion B point
SNA	Sella Nasion A point
SNB	Sella Nasion B point
FMA	Frankfurt Mandibular plane angle
IMPA	Incisor mandibular plane angle
GoGN-SN	Sella-Nasion plane to Gonion-Gnathion plane
TPI	Treatment Priority Index
DI	Discrepancy Index
PAR	Peer Assessment Rating
iPAR	Initial PAR
f PAR	Final PAR
Pc PAR	Percentage PAR
Dif PAR	Difference PAR
TEI	Treatment Efficiency Index
HG	Headgear
%	Percentage
=	Equal
>	More than

<	Less than

SUMMARY

Comparison of orthodontic treatment duration and peer assessment index scores of Class II patients

The purpose of this retrospective study was to evaluate and compare the treatment duration and occlusal effectiveness of the nonextraction and extraction treatment protocol in patients with Class II malocclusion.

The records of 157 Class II patients were collected from the archive of Orthodontic Department of Yeditepe University. The patients were allocated into two groups regarding treatment modality. The nonextraction group was comprised of 81 patients (42 females, 39 males) with a mean age of 12.5±2.5 years and the extraction group was composed of 76 patients (25 females, 51 males) with a mean age of 14.5±3.7 years. Pre- and post-treatment dental models were evaluated using Peer Assessment Rating index (PAR) and the treatment duration was noted. Initial PAR (iPAR), final PAR (fPAR), PAR difference (DifPAR), percentage PAR reduction (PcPAR) and treatment efficiency index (TEI) were calculated. Pretreatment cephalometric measurements were performed. The data was statistically evaluated.

In both groups, mean fPAR scores were statistically significantly lower than the mean iPAR scores ($p<0.001$). There was no statistically significant difference between groups in DifPAR, PcPAR, TEI and treatment duration ($p>0.05$). However, fPAR of the extraction group were statistically higher compared to that of the nonextraction group ($p<0.05$). In the extraction group, the boys showed longer treatment duration and iPAR scores compared to the girls ($p<0.05$). There was a significant and positive correlation between iPAR and fPAR as well as PcPAR. No significant correlations were revealed between cephalometric variables and PAR scores.

Nonextraction and extraction treatment of Class II malocclusion showed similar occlusal improvement, treatment efficiency and duration. The initial severity of the malocclusion seems to affect the final outcome but has no influence on treatment duration.

Keys words: Class II malocclusion, Nonextraction, Extraction, Treatment duration, PAR

ÖZET

Sınıf II hastalarda ortodontik tedavi süresi ve 'Peer Assessment Index' skorlarının karşılaştırılması.

Bu retrospektif çalışmanın amacı, Sınıf II maloklüzyonlu hastalarda çekimli ve çekimsiz tedavinin süresini ve oklüzal etkinliğini karşılaştırmaktır.

Çalışma kapsamında Yeditepe Üniversitesi Ortodonti Anabilim Dalı arşivinde bulunan 157 Sınıf II maloklüzyonlu hastanın kayıtları değerlendirmeye alındı. Hastalar tedavi şekillerine göre iki gruba ayrıldı. Çekimsiz grupta yaş ortalaması 12.5±2.5 yıl olan 81 hasta (42 kız, 39 erkek) bulunurken, çekimli grupta yaş ortalaması 14.5±3.7 yıl olan 76 hasta (25 kız, 51 erkek) bulunmaktaydı. Tedavi öncesi ve sonrası dental modeller "Peer Assessment Index" (PAR) kullanılarak değerlendirildi ve tedavi süreleri kaydedildi. Başlangıç PAR (bPAR), sonuç PAR (sPAR), PAR farkı (farkPAR), PAR yüzdesindeki azalma (yüzdePAR) ve tedavi etkinlik indeksi (TEİ) hesaplandı. Tedavi öncesine ait sefalometrik ölçümler yapıldı. Veriler istatistiksel olarak değerlendirildi.

Her iki grupta da, ortalama sPAR skorları bPAR skorlarından istatistiksel olarak anlamlı derecede düşük bulundu ($p<0.001$). Gruplar arasında farkPAR, yüzdePAR, TEİ ve tedavi süresi açısından fark gözlenmedi ($p>0.05$). Bununla birlikte, çekimli grubun sPAR skoru çekimsiz grubunkinden anlamlı düzeyde yüksek bulundu ($p<0.05$). Çekimli grupta, kızlarla karşılaştırıldığında, erkeklerin tedavi süreleri daha uzun ve bPAR skorları daha yüksekti ($p<0.05$). Korelasyon değerlendirmesi, bPAR ile sPAR ve bPAR ile yüzdePAR arasında anlamlı ve pozitif bir ilişkiyi ortaya koydu. Diğer yandan, PAR skorları ile sefalometrik ölçümler arasında bir ilişki bulunamadı.

Sınıf II maloklüzyonun çekimli ve çekimsiz tedavisi benzer oklüzal sonuçlar oluşturarak aynı düzeyde etkili bulunmuştur. Tedavi süresi açısından çekimli ve çekimsiz tedaviler arasında fark yoktur. Maloklüzyonun başlangıçtaki şiddeti tedavi sonucunu etkilemekle birlikte bunun tedavi süresi üzerinde etkisi yoktur.

Anahtar kelimeler: Sınıf II maloklüzyon, Çekimli, Çekimsiz, Tedavi süresi, PAR.

1. INTRODUCTION

Class II malocclusion is a major reason that patients seek orthodontic treatment. A combination of dental and skeletal factors composes the charecteristics of this discrepancy. Skeletal Class II malocclusions refer to the jaw relationship meaning the mandible is positioned distally relative to the maxilla. Dental Class II malocclusions are characterized by distal relationship of the mandibular dental arch relative to maxillary dental arch.

Treatment of Class II malocclusion is one of the most controversial issues in contemporary orthodontics because of the extensive variability of treatment strategies. Treatment modalities for correction of class II malocclusion can be extraction or non-extraction protocol including orthopedic, functional therapies and intraoral or extraoral distalizers (1, 2.). The fundamentals of Class II functional therapy rely on the stimulation of mandibular growth by forward positioning of the mandible and encouraging skeletal changes due to condylar displacement and modification of the muscle anatomy. Functional appliances cover a range of removable and fixed appliances that alter the position of the mandible both sagitally and vertically (3). Other than functional appliances, intramaxillary elastics can be also used to correct dental relationship rather than correcting the skeletal discrepancies similar to dentoalveolar effects of fixed functional appliances (4). On the other hand, the use of orthopedic forces with headgears produces skeletal as well as dental changes contributing to the correction of class II malocclusions (5, 6). However, the treatment of Class II malocclusion without extractions usually requires patient compliance except for fixed functional appliances.

Another treatment option for correction of Class II malocclusion involves extractions of two or four premolars (7). Extraction of the maxillary first premolars is generally indicated when the patient has completed growing and has good alignment in the mandibular arch (8). The treatment protocol with 2 maxillary premolar extractions requires retraction of the maxillary anterior teeth to reduce the overjet and correct the canine relationship, resulting in Class II molar relationships after treatment. Whereas extraction of 4 premolars is indicated primarily for crowding in the mandibular arch, a skeletal discrepancy, or a combination of both, in growing patients (1, 9).

The factors that must be considered when deciding to the treatment approach depend on the individual characteristics of malocclusion, the age and cooperation of the patient. Although the clinician has some clues on whether to extract or not in Class II patients, the debate on nonextraction and extraction treatment of Class II malocclusions still continues against the extensive literature comparing the effects of both modalities on occlusal, skeletal and esthetic outcomes. Controversial results regarding occlusal effectiveness of both treatment methods exist in orthodontic literature. Some of the authors support that there is no significant differences (10), whereas others claim that extraction method leads to better occlusal outcomes at the end of the treatment (11-13).

Treatment duration, which depends on both patient and clinician related factors, is another main concern for both patient and clinician. The number of missed appointments, bracket breakages, poor oral hygiene, poor cooperation of patient and the skills of the clinician are among the factors that increase treatment length (14-16). In addition, the severity of the initial malocclusion, the initial overjet and ANB angle, the age of the patient as well as the treatment modality, the prescription of headgear or Class II elastic wear and the type of Class II appliance used may influence the length of the treatment (12-16). Some have reported that nonextraction therapy resulted in shorter treatment time whereas others could not reveal any difference between extraction and nonextraction treatment modalities perhaps due to aforementioned numerous factors affecting the treatment duration (10, 17, 18.).

Therefore the aim of this study is to compare the treatment time and occlusal effectiveness of nonextraction and extraction treatment of subjects with Class II malocclusion.

2. LITERATURE REVIEW

2.1. Occlusion and malocclusion

2.1.1. Characteristics of normal occlusion

In 1972, Andrews (19) after studying 120 persons found that these persons had the following same characteristics which he considered as the six keys for normal occlusion:

1) Molar relationship: The distal surface of the distobuccal cusp of the upper first permanent molar makes contact and occludes with the mesial surface of the mesio buccal cusp of the lower second molar. The mesiobuccal cusp of the upper first permanent molar sits in the groove between the mesial and middle cusps of the lower first permanent molar.

2) Crown angulations: The gingival portion of the long axis of each crown is distal to the incisal portion, varying with the individual tooth type.

3) Crown inclination: Upper and lower anterior crown inclination is sufficient to resist over eruption of anterior teeth and also sufficient to allow proper distal positioning of the contact points of the upper teeth in their relationship to the lower teeth, permitting proper occlusion of the posterior crowns. A lingual crown inclination exists in the upper posterior crowns. It is constant and similar from the canines through the second premolars and is slightly more pronounced in the molars. The lingual crown inclination in the lower posterior teeth progressively increases from the canines through the second molars.

4) No rotations.

5) No spaces.

6) The occlusal plane deviates from flat to a slight curve of Spee.

2.1.2. Definition and classification of malocclusions

Malocclusion describes the disorders occurring in the occlusion, meaning variations of occlusion from the norms. Dr. Angle classified the malocclusions into three categories according to the anteroposterior relationships of the dentition (20)

Class I: The dental arches exhibit normal mesio-distal relation.

Class II: There is a distal relation of the mandibular dental arch related to the maxillary arch with the mandibular first molar locking more than one half cusp distal to the normal relation. Division I: Narrow maxillary arch with protruded upper incisors and increased overjet. Division II: Overlapping and lingual inclination of maxillary incisors and deepbite.

Class III: There is a mesial relation of the mandibular arch related to the maxillary arch with the first molar locking more than one-half mesial to normal with the maxillary first molar (20).

Skeletal classification of the malocclusion describes the relationships of skeletal components. The successor orthodontists developped Angle's original dental classification to describe maxillary and/or mandibular anteroposterior skeletal discrepancies. For example, they named skeletal discrepancies associated with Class II malocclusions skeletal Class II relationships, indicating that the Class II malocclusion is a result of position or size anomaly or discrepancy of the jaws rather than the malposition of the teeth. But it is also known that these skeletal Class II relationships often are associated with Class II dental malocclusions.

2.2. Characteristics and treatment alternatives of Class II malocclusions

Class II malocclusions may have dental and/or skeletal origin. Several morphological variations leading to Class II malocclusion can be listed as follows: 1) The maxilla is overdeveloped (the maxilla and the maxillary teeth are anteriorly positioned in relation to the cranial base) with the mandible being in a normal position and size. 2) The maxillary teeth are anteriorly placed in the maxilla whereas the relationship of the maxilla to the mandible can be normal. 3) Maxilla is well developed and positioned whereas the mandible is posteriorly positioned although has a normal size. 4) Maxilla is well developed and positioned whereas the mandible is underdeveloped. 5) The mandibular teeth are posteriorly placed on an adequate base. 6) The final variation comprises various combinations of the aforementioned factors (21, 22).

The clinician has several options for correction of Class II malocclusion according to the diagnosis and age of the patient; these alternatives are growth modification, dental camouflage and orthognathic surgery (23, 24).

2.2.1. Growth Modification

The growth modification aims to alter the unacceptable skeletal relationship by modifying the patient's remaining facial growth to a favorable jaw relationship. In Class II malocclusions, if the patient is still growing, the growth of the maxillomandibular complex may be directed to correct the skeletal discrepancy either by restraining midfacial growth or stimulating mandibular growth, or combining these two startegies. Growth modification of the maxilla and the mandible can be achieved by using different appliances such as headgears, functional appliances or a combination of both. (25, 26).

In cases of maxillary prognathism, headgear generates orthopedic forces to inhibit or redirect maxillary growth as well as dental effects causing distalization of the upper dentition (27-31). Extraoral force against the maxilla decreases the amount of forward and/or downward growth by changing the pattern of the apposition of the bone at the sutures. Class II correction is obtained as the mandible grows forward whereas the growth of the maxilla is restrained. Although maxillary excess is among the causes of Class II malocclusion, it was demonstrated that most individuals with Class II Division 1 malocclusion have mandibular skeletal retrusion, with a smaller percentage showing maxillary protrusion (32).

Treatment of mandibular deficiency in adolescence requires functional jaw orthopedics. (33). Logic of functional appliances is based on the functional matrix theory of Moss (3). This theory is based on the concept that, they act by modifying the muscle anatomy, in this way creating and promoting harmonious facial growth They encourage skeletal changes, due to mandibular forward position by stimulating growth at skeletal cartilage. To be successful, a functional appliance must displace the condyles a critical distance for a critical amount of duration. The amount of condylar displacement rarely is considered due to the fact that functional appliances reposition the condyles adequately to be effective if it is worn enough (3). In functional appliance treatment, additional growth is supposed to occur in response to the movement of the mandibular condyle out of the fossa, mediated by reduced pressure or by altered muscle tension on the condyle. More generally, functional appliances show effect on the mandible but produce a smaller restraining effect on the forward growth of the maxilla as well (34). There is a variety of these removable or fixed appliances correcting Class II malocclusion such as Bionator, Twin-block, Herbst, Jasper Jumper, etc. (4-6). Besides the skeletal effects, functional appliances also have dentoalveolar effects (35). They place a distal force against the upper incisors, tipping them lingually. Most functional appliances exert a protrusive effect on the mandibular dentition. With the fixed functional appliances, usually there is a greater dental change due to the continuous force.

Class II elastics can be another effective option for correcting Class II malocclusions, with their results being mainly dentoalveolar. Cases of normal skeletal jaw relationship with nonprotruded mandibular incisors are the ideal indication for Class II elastic usage. However, they have little effect on growth modification, probably because they do not displace the condyles far enough (22).

2.2.2. Dental Camouflage

Functional appliances can be used in growing patients up to adolescence to correct Class II malocclusion. But beyond the adolescent growth spurt, too little growth remains to correct skeletal problems. An alternative to surgical approach is the camouflage treatment, which is displacing the teeth relative to their supporting bone to compensate for the underlying skeletal discrepancy (for example, distalization of the upper dentition and retraction of the maxillary incisors in Class II malocclusion) (36). The objective is to correct the malocclusion while making the skeletal problem less apparent. Therefore, tooth extractions to provide space for the necessary tooth movement are often performed in camouflage treatment of Class IIs (26, 37-40). In 1930s, extraction method became popular because growth modification was thought to be ineffective. However, the detrimental effects of extraction on facial profile had started to be questioned by the orthodontists later on (41). Proffit (42) summarized the good candidates for extraction treatment as:

1- Too old for growth modifications

2- Mild to moderate skeletal Class II in late adolescence with some remaining growth

3- Good alignment of the teeth to allow extraction spaces to control anteroposterior dental relationships

4- Good vertical facial proportions (neither extreme short or long face)

2.2.3. Studies on occlusal effectiveness of extraction versus nonextraction treatment

In assessing the quality of orthodontic result the clinician should take into consideration several factors. The treatment method plays a significant role in the treatment result. However the studies comparing the outcomes of different treatment modalities to correct Class II malocclusions revealed contradictory findings. Janson et al. (11) compared the effectiveness of extraction and non-extraction treatment. They used a sample of 112 records divided into 2 groups. The first group comprised 43 patients treated with nonextraction approach. The second group was composed of 69 patients treated with 2 maxillary premolar extractions. They evaluated the occlusal outcomes using peer assessment rating (PAR). They concluded that 2 maxillary premolar extraction appeared to have greater efficiency than the nonextraction therapy in Class II malocclusion. The same authors further investigated the occlusal outcomes of the patients treated by two maxillary premolar extraction and without extraction 2.4 years after treatment (43). They evaluated a sample of 59 records with Class II malocclusion. The first group included 29 patients treated without extractions. The second group included 30 patients treated with 2 maxillary premolar extractions. The dental casts were obtained before, after the treatment and 2.4 years after the treatment. They came to the conclusion that there was no difference in the occlusal stability in the treatment of patients with complete Class II malocclusion without extractions or with 2 maxillary premolar extractions.

Cansunar and Uysal (44) in 2014 compared the occlusal outcomes between the nonextraction, 2 maxillary premolar extraction and 4 premolar extraction group and they found statistically significant differences in the occlusal outcomes between the three groups. The nonextraction patients had more teeth in occlusion than did the 4 premolar extraction patients and finished with more satisfactory sagittal dental relationships. The 4 premolar extraction group had the least satisfactory sagittal dental relationships. However there was no significant difference between groups in terms of alignment, marginal ridge height, buccolingual inclination, overjet, and interproximal contact measurements. On the other hand, the findings of other studies suggest that the treatment is becoming challenging when a full Class II molar relationship must be completely corrected (12, 13, 26, 45-49) based on the logic that nonextraction Class II treatment requires twice as much anchorage reinforcement and consequently more patient's cooperation (13, 47, 50, 51). Although some authors found that the extraction treatment protocol gives greater treatment efficiency compared to the nonextraction (11), Holman et al. (52) evaluated the treatment outcomes comparing 100 extraction and 100 nonextraction patients showed that both groups were statistically identical at the end of the treatment. In accordance with these findings, several studies supported that extractions did not influence the treatment success (52-55). Xu et al. (56) compared orthodontic treatment outcomes in Chinese patients with borderline problems treated with and without extractions. They found no statistically significant differences for tooth alignment, overbite, overjet, midline symmetry, or posterior occlusion. Similarly, Anthopoulou et al. (57) who evaluated and compared the treatment outcomes in extraction and nonextraction treatment protocol using the ABO grading system revealed that both treatment modalities had the same quality. Furthermore, Farhadian et al. (54) found that the final occlusion of patients treated without extractions did not seem more acceptable than that of the 4 premolar extraction patients in terms of alignment, occlusal contact, occlusal relationship, interproximal contact and root angulation.

There are studies investigating one stage vs two stage treatment regarding the treatment outcomes in Class II malocclusion. Several studies suggest that 2-phase produces better occlusal results (58-60) however, controversies exist about this subject (61-63).

Some authors suggested that number of extractions affected the outcome of treatment (46, 64). Janson et al. (46) in 2004, after comparing a group of 81 patients treated with 2 premolar extractions to a group of 50 patients treated with 4 premolar extractions concluded that treatment of Class II malocclusion with 2 premolar extractions gives a better occlusal success than 4 premolar extraction. Similarly, Cansunar and Uysal (44) revealed that 2 premolar extraction resulted in better sagittal correction of the occlusion compared to 4 premolar extraction. As the number of extraction increases, the efficiency of the occlusion is less satisfactory.

The sex of the patient might play a role in the quality of treatment result with the males showing less occlusal efficiency compared to the females according to Williems et al. (65) with several other studies reinforcing the same result (65-68). On the other hand, the conclusions of Schafer et al. (69) in 2011 state that there seemed to be no correlation between the two factors (69, 70). Furthermore, the initial age and initial severity seems to play a role in the quality of treatment results with several studies stating that a younger age would be more favorable in Class II treatment (71-76). Growth potential might be associated with occlusal outcomes. Patient’s cooperation and the amount of required anchorage can contribute to the treatment result (56, 57, 77-87). If the necessary compliance level is not achieved, the occlusal results are comprised (72-76, 88).

Another factor which might affect the treatment outcomes is related to the orthodontist. Some claimed that university's treatment outcomes ended up in higher level of quality (89, 181), whereas others stated no difference of treatment outcomes between university graduate orthodontic programs and private orthodontic practices (70).

Furthermore, another factor that may influence the treatment outcome is the cephalometric characteristics of the patient (90). Janson et al. (91) in a study conducted in 2008 compared the initial cephalometric characteristics of complete Class II Division 1 malocclusions treated with 2 or 4 premolar extractions in order to verify their influence on the occlusal success rate in these treatment protocols. The initial cephalometric characteristics of the groups did not influence the occlusal success rate of these 2 treatment modalities. However, Kim et al (92) in 2000 tried to assess the predictive value of 41 commonly used cephalometric parameters with regard to pretreatment severity and treatment outcomes. The cephalometric parameters explained 39.2% of the pretreatment severity variance, 17.9% of posttreatment severity variance, 15.7% of relative treatment improvement variance (92).

2.3. Occlusal Indices

Occlusal indices are quantitative assessment tools, employing continuous or numbered scales of malocclusion for epidemiological purposes and for a number of administrative applications. An orthodontic treatment need index assigns a specific score to each malocclusion feature according to the severity of the malocclusion (93).

Richmond et al. (94) created an orthodontic index which is a numerical scale consisted of specific features of the malocclusion, making it possible to determine certain parameters such as treatment need or severity of malocclusion in an objective way. This score is assigned with a certain weighting relative to the certain index used.

2.3.1. Properties of indices

In 1966, the World Health Organization (WHO) defined the following properties that an index should process (95).

a) Validity**:** An index is said to be valid if it measures what it aims to measure. If a problem exists, it must detect it exactly and without error. In other words, it must identify the patients with the most detrimental malocclusions or those who would most benefit from treatment.

b) Objectivity**:** The index design must attempt as far as possible to exclude examiner subjectivity.

c) Reliability (accuracy or reproducibility)**:** This is the degree of match between the results obtained when an index is applied to the same sample by different examiners or by the same examiner on different occasions.

d) Simplicity: It must be able to be used by non-specialists.

e) Flexibility: An index must be easily modified over duration in the light of new research, discoveries or considerations.

f) Sensitivity**:** It must recognize the individuals with need of orthodontic treatment.

g) Specificity: It must recognize individuals with mild orthodontic problems that there is no need for orthodontic treatment.

Furthermore, they should be recognized from the majority of orthodontics. They should recognize the aesthetic parameter in occlusion (95).

2.3.2. Uses of indices

Shaw et al. (95) highlighted the following uses of the indices:

- Classifying, planning and promoting treatment standards.

- Assisting dentists and pediatric dentists to identify patients with orthodontic treatment need.

- Identifying patient prognoses and obtaining the patients informing them of the risks and treatment stability in both severe and borderline cases.

- Assessing the difficulty of the treatment that a particular patient must follow.

- Assessing the results of the treatment.

In 2001 Abdullah and Rock (96) further developed the indices considering the following aims:

1) To classify malocclusions in order to facilitate communication between the professionals.

2) To compile a database to facilitate epidemiological studies.

3) To classify cases according to the complexity of their treatment.

4) To determine treatment needs and priorities.

5) To identify the aesthetic aspects that affect the treatment need.

The main purpose of occlusal indices is to select patients who will benefit from orthodontic treatment in a particular health system.

2.3.3 Types of indices

There are five different types of indices, classified by Angle for facilitating the communication between professionals (95, 97).

- Epidemiologic indices: They record every trait of malocclusion to estimate the prevalence of malocclusion in a given population. They were described by Bjork et al. (98), the FDI method or Summer's (99, 100) occlusal index.

- Treatment need indices: They have been developed to categorize the malocclusion according to the extent of the level of treatment need. Draker's (101) Handicapping Labio-lingual Deviation index (HLD), Grainger's (102) treatment priority index, Salzmann's (103) handicapping malocclusion assessment and Summer's occlusal index. (104, 105). They calculate every trait of malocclusion.

- Treatment outcome indices: They have been used to assess the result of the treatment. Summer's (100, 103) index was firstly introduced and later PAR was further developed for this purpose.

- Treatment complexity index: There haven't been described any such index but the need of public health orthodontics is recognized and efforts are undergone to develop one.

2.3.3.1. Index of Orthodontic Treatment Need (IOTN)

In 1989 Brook and Shaw (106) developed the IOTN and called it the Index of Orthodontic Treatment Need**.** It has two separate components, the Dental Health Component (DHC) and an Aesthetic Component (AC). They are both separately measured and they cannot be combined to give unique score. However, they can be used for the assessment of orthodontic treatment need.

Assessing the complexity of malocclusion helps to (106):

1) Identify the most proper setting in which the patient receives treatment (i.e. hospital, private practice etc).

2) To inform the patient about likely success of the treatment.

3) To identify cases which are more difficult and may take longer treatment duration.

The Dental Health Component is loosely based on the Swedish Medical Health Board (SMBI). The original form of this Swedish index was developed having 4 categories of need (grade 1 to 4). In 1976 Linder-Aronson et al. (107), revised the index and added a fifth category, the grade zero and describing subjects with no need for treatment (Table 2.1)

In Table 2.1 the DHC has five grades rating from grade one “no need” where there is no need for orthodontic treatment to grade five “very great need” (93). The rating is necessary to describe the worst occlusal trait of malocclusion and sets the priority of orthodontic treatment need. Hierarchical scales are used (in a descending order), missing teeth, overjet, crossbites, displacement of contact points, and overbite (including open bite). The acronym “MOCDO” has been used to memorize the hierarchical scale. For example, if two or more different occlusal traits achieve the same DHC score the scale defines which should be recorded. Only the worst occlusal anomaly is recorded (108).

Table 2.1. Dental Health Components of the IOTN

Grade 5	Very Great Need
5i	Impeded eruption of teeth (with the exception of third molars) due to crowding, displacement, the presence of supernumerary teeth, retained deciduous teeth and any pathological cause.
5h	Extensive hypodontia with restorative implications (more than tooth missing in any quadrant) requiring pre-restorative orthodontics.
5a	Increased overjet greater than 9 mm.
5m	Reverse overjet greater than 3.5 mm with reported masticatory and speech difficulties.
5p	Defect of cleft lip / and palate.
5s	Submerged deciduous teeth.
Grade 4	Great need
4h	Less extensive hypodontia requiring pre-restorative orthodontics and space closure to obviate the need for prosthesis.
4a	Increased overjet greater than 6 mm but less than 9 mm.
4b	Reverse overjet greater than 3.5 mm with no reported masticatory and speech difficulties.
4m	Reverse overjet greater than 1 mm but less or equal than 3.5 mm with recorded masticatory and speech difficulties.
4c	Anterior or posterior crossbites with greater than 2 mm discrepancy between retruded contact points and intercuspal position
4l	Posterior lingual crossbite (scissors bite) with no functional occlusal contact in one or both buccal segments.

4d	Severe contact points displacements of teeth greater than 4 mm.
4e	Extreme lateral or anterior open bite greater than 4 mm.
4f	Increased and complete overbite with gingival or palatal trauma.
4t	Partially erupted teeth tipped and impacted against adjacent teeth.
4x	Presence of supernumerary (e.g. Supplemental teeth)
Grade 3	Borderline need
3a	Increased overjet greater than 3.5 mm but less or equal to 6 mm with incompetent lips.
3b	Reverse overjet greater than 1 mm less or equal than 3.5 mm.
3c	Anterior or posterior crossbites with greater than 2 mm discrepancy between retruded contact points and intercuspal position
3d	Contact point displacement of teeth greater than 2 mm but less or equal to 4 mm.
3e	Lateral or anterior open bite greater than 2 mm but less or equal to 4 mm.
3f	Increased and complete overbite without gingival or palatal trauma.
Grade 2	Little need
2a	Increased overjet greater than 3.5 mm but less or equal to 6 mm with competent lips.
2b	Reverse overjet greater than 0 mm but less or equal to 1 mm.
2c	Anterior or posterior crossbites with greater than 1 mm discrepancy between retruded contact points and intercuspal position

2d	Contact point displacement of teeth greater than 1 mm but less or equal to 2 mm.
2e	Anterior or posterior open bite greater than 1mm but less or equal to 2 mm.
2f	Increased overbite more or equal to 3.5 mm without gingival contact.
2g	Pre-normal or post-normal occlusions with no other anomalies. Includes up to half a unit discrepancy.
Grade 1	No need for orthodontic treatment. Extremely minor malocclusions including displacements less than or equal to 1 mm.

Every occlusal characteristic contributes to the longevity and functioning of the dentition and is defined and cut off into five grades. The index can be applied both clinically and in dental casts with some differences in the definition of some traits in the cast. There is a specially designed ruler used for this purpose (Fig. 2.1) (93).

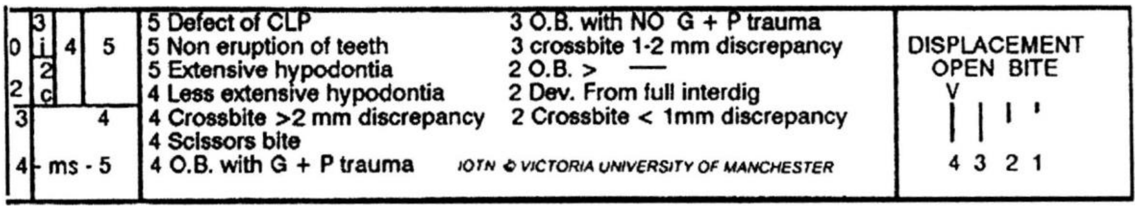

Fig. 2.1. Index of Orthodontic Treatment Need (Dental Health Component), (under permission of Shaw, published in Am J Orthod and Dentofacial Orthop in 1995) (95).

Dental diseases are site specific and are not considered important ones for being recorded. The most severe anomalies are the basis for grading the person's need for orthodontic treatment. Summing scores for several individual traits is not performed. The Esthetic Component consists of a series of 10 different photographs scaled from 1 represented the best to 10 representing the worst one. In 1987 Evans and Shaw (109) conducted a study, after taking 1000 intraoral photographs of 12 years old children they designed an index for measuring the Esthetic Component (Fig. 2.2)

Fig. 2.2. The Aesthetic Component of the IOTN (under permission of Shaw published in Am J Orthod and Dentofacial Orthop in 1995) (95).

Calculation of the scores takes up to 1-3 minutes. The patient after looking himself to the mirror identifies the esthetic component with one of the ten photographs and the perception of malocclusion of the patient is observed.

Lunn et al. (110) in order to make the IOTN quicker and easier to use and improve its reliability proposed reducing the number of IOTN and AC grades from 10 to 3. These proposals were accepted by the Manchester team that had developed the IOTN.

- AC 1-4: Little or no need for treatment.
- AC 5-7: Moderate need for treatment.
- AC 8-10: Great need for treatment.

Nowadays, the two components are calculated separately and the individual needs orthodontic treatment when the IOTN DHC grade is 4 or 5 or the IOTN AC is in the grades 8-10 group. In this case, we can identify if the child needs orthodontic treatment for dental reasons (DHC) or for aesthetical reasons only (AC). Several studies have examined the validation and reliability of the IOTN index and it has been extensively proved (111-113). The IOTN is currently used in the United Kingdom for prioritizing public orthodontic care services. It is simple, easy and it is the most cited index in the literature.

2.3.3.2. Index of Complexity, Outcome and Need (ICON)

Drs Charles Daniels and Stephen Richmond (113) of Cardiff University created this index. It was based on the opinion of 97 orthodontists from 8 European countries and the United States. They examined the need of 240 sets of pre-treatment study casts and treatment outcome of 98 post treatment records. The ICON is a single unique index used as a tool for assessing the complexity outcome and need for orthodontic treatment. The unique characteristic of ICON is that, it includes the aesthetic factor as an integral part of the treatment need. It assesses the treatment need, outcome and complexity.

Assessing the complexity helps to: 1) Identify the most proper setting in which the patient can receive treatment (i.e. general practice, dental office or hospital). 2) To inform the patient about likely success of the treatment. 3) Classify difficult cases that may take longer treatment duration (93).

ICON includes five occlusal components: the Aesthetic Component, which is similar to the aesthetic component of IOTN, upper and lower crowding or spacing, presence of crossbite, degree of open bite/overbite and, the fit in the buccal segment of posterior and anterior region. Table 2.2 presents the method calculating the ICON index either on casts or, clinically. The clinician after identifying and calculating each occlusal anomaly gives a certain score which is weighted and summed to give the final ICON score (Table 2.2) (93, 96).

Table 2.2. The ICON scoring method and its components.

	Components	Score						Weight
		0	1	2	3	4	5	
1	Aesthetic assessment	Score 1-10						7
2	Upper arch crowding	< 2 mm	2.1-5 mm	5.1-9 mm	9.1-13 mm	13.1 -17 mm	> 17 mm	5
	Lower ach crowding	< 2 mm	2.1-5 mm	5.1-9 mm	> 9 mm		Impacted teeth	5
3	Crossbite	No crossbite	Crossbite present					5
4	Incisor open bite	Edge to edge	< 1 mm	1.1-2 mm	2.1-4 mm	> 4 mm		4
	Incisor overbite	< 1/3 lower incisor coverage	1/3 to 2/3 coverage	2/3 up to fully covered	Fully covered			4
5	Buccal segment A-P	Cusp to embrasure only, Class I,II or III	Any cusp relation up to but not including cusp to cusp	Cusp to cusp				3

The clinician measures the various occlusal traits and gives a certain score which reflects the patient’s need for orthodontic treatment. Each component can be measured either on casts or clinically and then weighted and summed up. Every individual score greater than 44 indicates the need for orthodontic treatment. On the other hand, in terms of orthodontic treatment effectiveness, a score that is equal or less than 31 indicates that the result of orthodontic treatment is acceptable clinically. The table 2.3 shows the complexity grades for the ICON. On the table 2.4 the orthodontic treatment outcome and the improvement of orthodontic treatment are assessed (93).

Table 2.3. Treatment complexity

ICON complexity Grade	Score Range
Easy	< 29
Mild	29 - 50
Moderate	51 - 63
Difficult	64 -77
Very Difficult	> 77

Table 2.4. Improvement categories of treatment therapy according to ICON index.

Improvement Grade	Score Range
Greatly improved	> -1
Substantially improved	-25 to -1
Moderately improved	-53 to -26
Minimally improved	-85 to -54
Not improved or worse	< - 85

The main advantage of ICON over IOTN is that it can measure the complexity of malocclusion and assess the outcome. The ICON is simple, easy to use and can be measured either on casts, or on patients, it is valid or reliable (114, 115). On the other hand there seems to be some limitations (106). It is heavily weighted for aesthetic reasons and is greatly influenced by clinician's opinion. It may reduce its objectivity (113).

2.3.3.3 Dental Aesthetic Index (DAI)

Dental Aesthetic Index was created by Cons et al. (116) as an orthodontic tool. This index relates the clinical aesthetic and dental components to define a single score; which, reflects the magnitude of malocclusion. It is based on the index Social Acceptability Scale of Occlusal Conditions (SASOC) developed earlier by the same authors (116-118).

In 1986 Cons et al. (118) wanted to create a different kind of malocclusion index which reflected the dental aesthetics of public perception. A sample of 1337 study models used in a previous study and, a random sample of 200 photographs were used which depicted occlusal configurations. Approximately 2000 adults and adolescents rated the aesthetics of photographs of casts in occlusion from frontal and lateral view. An international committee elected 49 occlusal features to form an occlusal index and they chose these photographs to represent these features (117, 118).

A regression analysis was used to correlate the opinion of the public about dental aesthetics with the anatomical measurements of occlusal characteristics selected by the orthodontists. In this case, 10 occlusal characteristics were finally selected every which of them was multiplied by the correlated weighting. The sum is finally added by the number 13, which gives the final result of DAI (Table 2.5).

Table 2.5. Characteristics of DAI index with the regression coefficients (modified from Carlos Bellot-Acris, 2012) (107).

	Regression coefficients	
DAI components	Actual weights	Round weights
1) Number of missing visible teeth.	5.76	6
2) Assessment of crowding in the incisal segments: 0 = no segments crowded; 1 = 1 segment crowded; 2 = 2 segments	1.15	1

crowded.		
3) Assessment of spacing in the incisal segments: 0 = no segments spaced; 1 = 1 segment spaced; 2 = 2 segments spaced.	1.31	1
4) Measurement of any midline diastema in mm.	3.13	3
5) Largest anterior irregularity on the maxilla in mm.	1.34	1
6) Largest anterior irregularity on the mandible in mm.	0.75	1
7) Measurement of anterior maxillary overjet in mm.	1.62	2
8) Measurement of anterior mandibular overjet in mm.	3.68	4
9) Measurement of vertical anterior open bite in mm.	3.69	4
10) Assessment of antero-posterior molar relation; largest deviation from normal either left or right, 0 = normal, 1 = 1/2 cusp either mesial or distal, 2 = 1 full cusp or more either mesial or distal.	2.69	3
Constant	13.36	13

The DAI was developed for permanent dentition but, it can also be used for mixed dentition by simply excluding the missing permanent teeth if they are expected to be erupted during the normal duration range. The final score is then compared with the corresponding one in a scale in order to identify its position to dental aesthetic that is socially and most acceptable. The higher the score, the further it is from the socially accepted. When the index score is higher than 36, this shows serious occlusal anomaly and orthodontic treatment is necessary (Table 2.6) (106).

Table 2. 6. The DAI treatment malocclusion and need categories for orthodontic treatment.

DAI score	Malocclusion severity	Treatment need category
⩽ 25	Normal / minor	No treatment need / slight need
26-30	Definite	Treatment elective
31-35	Severe	Treatment highly desirable
⩾ 36	Very severe / Handicapping	Treatment mandatory

The basic advantage is that it can easily be calculated by an experienced clinician in less than 2 minutes without the radiographs. The main limitations of DAI index are that, it excludes basic anomalies such as crossbites, impacted teeth, central line discrepancies and, deep overbite (119-121). However, these limitations can be easily identified by the dentists and can be easily referred to an orthodontist. However, the above limitations should be considered when the index is used for epidemiological reasons and the occlusal anomalies should be recorded.

The index is quick, easy, simple and reliable with a high level of validity. Cons et al. (117) in 1996 revealed that there seems to be high intra-class correlation. Nowadays, it has been included in the WHO oral health survey which is a major step for it to be used as a universal method for evaluating malocclusions. Although DAI was initially based on dental records of white adolescents in the United States, it was accepted by the World Health Organization as a cross-cultural international index. (116-118, 122-127).

2.3.3.4. Handicapping Labio-lingual Deviation index (HLD)

The Handicapping Labio-lingual Deviation Index was first introduced by Draker (1960) and used in USA to identify those with medically handicapped malocclusions. It measures the degree of handicap caused by different malocclusions (128).

In 1998 Parker (129) modified this index naming it California (CalMod) due to the weakness of the original index to record serious malocclusions such as impacted teeth, missing, spacing between teeth and transverse discrepancies (midline deviations and crossbites) and used as a cut-off the 26 score. The index records 12 different factors: overjet, overbite, open bite, cleft lip-palate, anterior crowding, mandibular protrusion, labio-lingual spread, deep impinging overbite, severe traumatic deviations, crossbite of individual anterior teeth, ectopic eruption of anterior teeth, and posterior unilateral crossbite (Table 2.7) (128-129).

Table 2.7. The California Modification of the Handicapping Labio-Lingual Deviation Index the HLD (CalMod) index.

No	Condition	Score
1	Cleft palate deformity	
2	Cranio-facial anomaly	
3	Deep impinging overbite When the lower incisors destroy the soft tissue of the palate. Tissue laceration and / or clinical attachment loss must be present.	
4	Crossbite of individual anterior teeth. When clinical attachment loss and recession of the gingival margin are present.	
5	Severe traumatic deviations Attach a description of condition, ie loss of premaxilla by burn, trauma or	

	pathology	
6	Overjet greater than 9 mm Reverse overjet greater than 3.5 mm	
7	Overjet (=9 mm)	(mm)
8	Overbite including the reverse overbite	(mm)
9	Mandibular protrusion (reverse overjet = < 3.5 mm)	(mm) 5
10	Open bite	(mm) 4
11	Ectopic eruption: Count each tooth, excluding third molars	(count) 3
12	Anterior crowding : Score one point for the maxilla, and/ one point for the mandible / two points maximum for the anterior crowding.	(0,1,or2) 5
13	Labio-Lingual spread Arch-length insufficiency must exceed 3.5 mm excluding mild rotations that may react favorably to stripping or mild expansion procedures.	(mm)
14	Posterior unilateral crossbite Must involve 2 or more adjacent teeth, one of which mild expansion procedures.	4
		Total score

If there is any of the above situations from 1-6, it is not necessary to further calculate the index because it shows there is a requirement for orthodontic treatment. Otherwise, the sum from 7 to 14 must be above 26 so we can consider that the individual needs orthodontic treatment. Cooke et al. (130) mentioned that the cut-off 26 showed low sensitivity (25.9%) and high specificity (96.9%).

2.3.3.5. Peer Assessment Rating (PAR)

In 1992 Richmond et al. (131) developed a new occlusal index to assess the results on completing orthodontic treatment. After assessing 320 models by 74 orthodontists and dentists by the British Orthodontist Standards Working Party the index took its final form. (132) A scoring system was developed. The index records characteristics regarding the following:

1) Maxillary and mandibular dental segments

2) Right and left posterior occlusion

3) Overbite

4) Overjet

5) Midline deviation (132).

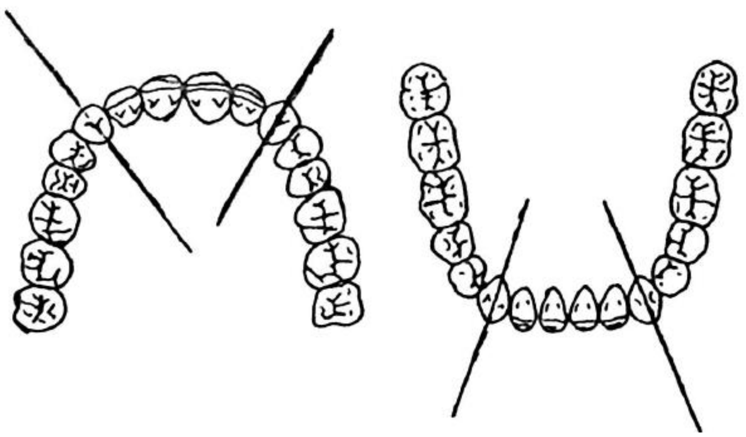

Fig. 2.3. Division of arches into 3 recording zones: left posterior, right posterior and anterior.

Maxillary and mandibular anterior and buccal segments of dental arches

The dental arch is divided into three recording segments, left buccal, right buccal and anterior (Fig. 2.3). The records of occlusal features are spacing, crowding and impacted teeth. Displacements are recorded as the shortest distance between contact points of neighboring teeth parallel to the occlusal plane. The greater the displacement, the greater the PAR score. Displacements and impactions are added to give an overall score for each recording zone. The scores for the displacements are shown in the Table 2.8 (133).

Table 2.8. Displacement scores.

Score	Discrepancy
0	0 mm to 1 mm
1	1.1 mm to 2 mm
2	2.1 mm to 4 mm
3	4.1 mm to 8 mm
4	Greater than 8 mm
5	Impacted tooth

- For every impacted tooth, incisor or canine there is a score of 5. A tooth is considered impacted when the space for eruption is equal or less than 4 mm.
- If the contact point displacement is a result of prosthetic or poor restorative work, the displacement is not recorded.

- Contact points between deciduous teeth are not recorded.
- Displacements between deciduous and permanent teeth are not recorded.
- In the mixed dentition the average widths are used to calculate the deficiency.
- For every occlusal trait there is a certain score which is weighted according to the table 2.9. The scores are applied to the dental features of a certain malocclusion and the sum of these scores ranks the malocclusion to which a weighting is added (134). The first validation exercise used the opinion of a panel of 74 dentists in Great Britain (131). The second used the opinion of a panel of 11 orthodontists in private practice in western Pennsylvania (135). In the US-based weighting system the lower labial segment was weighted 0. However the British-based weighting system was used in order to take into account the lower labial segment (133).

Table 2.9. The PAR weighting system

PAR Components	British Study	US Study
Upper labial segment alignment	1	1
Lower labial segment alignment	1	0
Overbite	2	3
Overjet	6	5
Midline	4	3

Right buccal segment relationship	1	2
Left buccal segment relationship	1	2

Buccal occlusion

It is recorded for both left and right sides in three dimensions of space. The discrepancies are recorded when the teeth are in occlusion. The recording zone is from the canine to the first or second or third molar when the teeth are in occlusion. The anterior-posterior, vertical and transverse dimensions are summed for each buccal occlusion (Table 2.10).

Table 2.10. Buccal occlusion assessments. (Temporary developmental stages and submerging deciduous teeth are excluded).

Score	Discrepancy
Antero-Posterior	
0	Good interdigitation Class I, II and II
1	Less than half unit discrepancy
2	Half a unit discrepancy (cusp to cusp)
Vertical	
0	No discrepancy in intercuspation

1	Lateral open bite at least two teeth greater than 2 mm.
Transverse	
0	No cross-bite
1	Cross-bite tendency
2	Single tooth in cross-bite
3	More than one tooth in cross-bite
4	More than one tooth in scissor-bite

Overjet

Positive overjet and cross-bite are recorded from left to the right lateral incisor with the most prominent incisor recorded. The ruler is held parallel to the occlusal plane and radial to the line of the arch. If there is increased overjet and canine in crossbite the scores are summed. If increased overjet is due to bad restorations then, it is not recorded (Table 2.11).

Table 2.11. Overjet measurements.

Score	Discrepancy
Overjet	
0	0-3 mm

1	3.1-5 mm
2	5.1-7 mm
3	7.1-9 mm
4	Greater than 9 mm
Anterior Cross-bites	
0	No discrepancy
1	One or more teeth edge to edge
2	One single tooth in cross bite
3	Two teeth in cross-bite
4	More than two teeth in cross-bite

Overbite

It records the vertical overlap or openbite of anterior teeth including the lateral incisors. It is correlated with the coverage of lower incisors or the degree of open bite. The tooth with the greatest overlap is recorded (Table 2.12).

Table 2.12. Overbite Measurements

Score	Discrepancy
Open Bite	
0	No open bite
1	Open bite less than and equal to 1 mm
2	Open bite 1.1-2 mm
3	Open Bite 1.1-2 mm
4	Open bite greater than or equal to 4 mm
Overbite	
0	Less than or equal to one third coverage of the lower incisor
1	Greater than one third, but less than two thirds of the lower incisor
2	Greater than two thirds coverage of the lower teeth
3	Greater than or equal to full tooth coverage

Midline

It records the midline deviation related to the lower central incisors. If a lower incisor is missing then it is not recorded (Table 2.13).

Table 2.13. Central assessments

Score	Discrepancy
0	Coincidence and up to one-quarter lower incisor width
1	One quarter to one –half incisor width
2	Greater than one-half lower width

A specially designed ruler to facilitate the measurements as presented in the Fig. 2.4, Fig.2.5 a, b can be used.

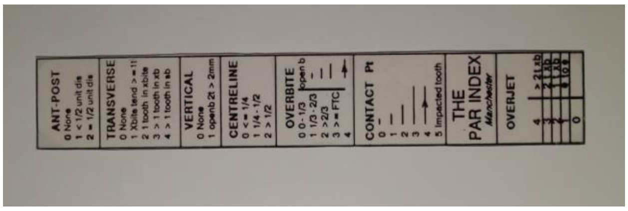

Fig. 2.4. The PAR ruler.

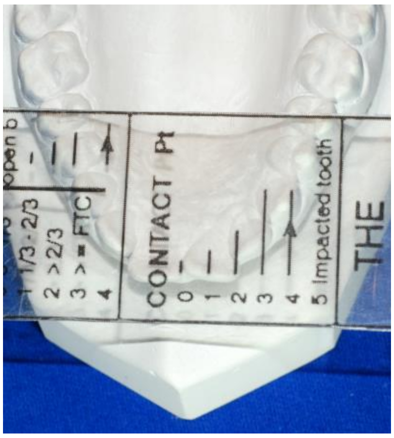

Fig. 2.5 a. Measurement of the displacements of the contact points from occlusal view.

Fig. 2.5 b. Measurement of the overjet.

There are three principle ways to show the change during orthodontic treatment with the PAR Index (139).

A. Absolute reduction in the weighted PAR score.

B. Nomogram.

C. Percentage reduction in the weighted PAR score.

The percentage reduction in the weighted PAR score gives a more sensitive assessment than the absolute change or when using the nomogram alone (139). The percentage PAR score reduction indicates the success of treatment. The degree of improvement is organized into three categories: ‘Worse-no different’, ‘Improved’ and ‘Greatly improved’. There must be at least 30 percent PAR score reduction and ‘Improved’, and a change of at least 22 points for it to be assigned as ‘Greatly improved’. (134, 136-138) The percentage reduction method of detecting the improvement of orthodontic treatment is known to reflect the change relative to the pretreatment score. A high standard of treatment is considered when the percentage reduction in weighted PAR score is high. The stages of improvement can be classified as represented in Table 2.14 (139). These criteria used on PAR changes make it possible to compare the treatment outcome and the long-term results.

Table 2.14 The values for each stages of improvement (139).

Improvement	Nomogram classification	PAR score change (Percentage reduction)
Worse or no different	< 30%	< 30%
Improved	≥ 30% , < 22 PAR	30-69%
Greatly improved	≥ 70%, 22 PAR	≥ 70%

The PAR index was designed specifically to provide a more objective assessment of treatment success. (140-147). The PAR index has been shown to have good intra-and interexaminer reliability, with intraclass correlation coefficients of 0.95 and 0.91 respectively (131). It can be a useful tool in assessing objectively treatment outcomes (133). The study casts of pretreatment, immediate posttreatment and posttreatment after few years can be measured with PAR index to assess the quality of treatment (146, 147). With the PAR, we can assess the treatment standards and determine the success of the treatment (148-150). The PAR index is considered simple, objective and reliable for evaluating the quality of treatment outcome and stability after orthodontic treatment (151, 152). Several studies have been conducted which demonstrate the method for assessing the stability after orthodontic treatment using the PAR index (144, 145, 153-156). The PAR index has been extensively used as a method of audit in Europe (156-160). The PAR index was developed to quantify the extent to which a dentition deviates from an ideally formed dental arch and occlusion (160). However, it does not evaluate functional occlusion, periodontal health, root resoption, tooth angulations, patient satisfaction and treatment duration (133, 161). Investigating the connection between the indices it seems that ICON may effectively replace PAR and IOTN in terms of determining the need and outcome. (162, 163).

Nowadays, many orthodontists incorporate digital orthodontic records into their clinical practice to assist with treatment diagnosis and planning. However, there are few studies in the literature with controversial results regarding the validity and reliability of assessing the occlusion on digital models (164, 165).

2.4. Factors influencing treatment duration.

Popowich et al. (14) in their study in 2005 investigated the factors that can influence the treatment duration for patients with Class II malocclusion. They used a sample of 237 active retention patients divided into 3 groups. From the patients the following data were collected: 1) patient information, 2) models, 3) pretreatment cephalograms and 4) treatment information. They concluded that, the severity of the initial malocclusion, initial age, overjet and ANB angle have a positive correlation to treatment time.

Moreover, the type of Class II appliance used, the duration of class II elastics, the number of debondings and the average of duration between the appointments can be significant factors (166). Further studies have agreed that, there seems to be certain characteristics for each patients that can predict the treatment duration such as: poor oral hygiene, bracket breakages, debonding and reposition, poor elastic wear, correction of antero-posterior buccal occlusion and extraction or nonextraction treatment option can increase the treatment length (14-16, 51).

On the other hand, studies showed that extraction can prolong the duration of treatment compared to nonextraction therapy. Mavreas and Athanasiou (16) in a systematic review conducted in 2008 concluded that, not only the extraction therapy increases the treatment duration, but also the age plays a significant role. The earlier the treatment starts, the longer the duration and also the technique applied, the skills and the severity of initial malocclusion play an important role (16, 166-170). In addition, the severity of the initial malocclusion, the initial overjet and ANB angle, the age of the patient as well as the treatment modality, the prescription of headgear or Class II elastic wear and the type of Class II appliance used may influence the length of the treatment duration (12-16, 26 46, 39). O'Brien et al (159) used the PAR Index to investigate the factors influencing the treatment duration on a sample of patients with Class II division 1 malocclusion. They found a correlation between pretreatment occlusal index score and treatment duration. However, they found lack of correlation between the posttreatment PAR scores and treatment duration. Other studies were also in agreement with the above conclusions (103, 133, 171).

Several studies confirmed that the number of extracted teeth played an important role in the duration of the treatment with the number of extracted teeth positively correlated with the increase in treatment duration (171, 172). In a study conducted by Holman et al. (58) in 1998, they compared a group of 100 patients treated with extractions and 100 patients treated with nonextraction treatment. They found that extraction treatment lasted longer than nonextraction. On the other hand, a retrospective study conducted by Janson et al. (10) in 2011, compared the treatment durations of Class II patients who were treated with nonextraction therapy and four premolar extractions. Eighty four patients were selected and divided into two groups. Group 1 included 48 patients with four first premolar extractions with a mean age of 13.03 years. Group 2 consisted of 36 patients without extractions with a mean age of 13.13 years. They could not reveal any significant difference in terms of treatment time between treatment modalities, which is in accordance with the results of several other studies (10, 171-173). However, Janson et al. (59) in 2006 compared a group of 49 patients treated with 2 maxillary premolar extractions to a group of 48 patients treated with 4 premolar extractions. They concluded that the 2 premolar extraction protocol had shorter treatment time.

In a study by Bondevik (176) in 1995 it was suggested that age has a high correlation with treatment duration. Study models of 94 patients treated with combined activator-headgear were collected along with information of the patients regarding age and treatment duration. According to their findings as the age increases the treatment time increases as well. On the other hand, a study conducted by Stuart et al. (177) after comparing a sample of 32 adults to 40 adolescents came to the conclusion that, there seems to be no significant difference in the treatment duration. This conclusion was reinforced by other studies that suggest that the initial age of the patient and the sex plays no significant role in the duration but the patient’s compliance seems to be the major factor (178, 179). However, contrasting with the findings on the increased treatment duration as the age increased (180-182). Tulloch et al. (180) in 2004 suggested that early treatment appeared to be less efficient and produced no reduction in the average treatment time.

3. MATERIALS AND METHOD

3.1 Materials

In this study, we used a sample of 157 subjects selected from the archive of Yeditepe University, Department of Orthodontics. Pre and posttreatment dental models and initial cephalometric radiographs were collected and initial and final age, treatment duration and treatment mechanics were recorded for every patient. Before data collection names on charts, pretreatment lateral cephalometrics and models were covered in order to be a blinded investigated sample.

3.1.1. Selection criteria

The selected subjects should include the following criteria: 1) Sagittal Class II relationship in the beginning of the treatment, 2) treatment protocol with use of headgear and/or functional appliances for the correction, or 3) treatment protocol included extractions of 2 or 4 premolars, 4) complete course of orthodontic treatment with full maxillary and mandibular fixed appliances with edgewise mechanics, 5) no agenesis or tooth anomalies, 6) no cleft lip palate, 7) no impacted or supernumerary teeth, 8) all teeth erupted up to first molars, 9) no orthognathic surgery patient.

3.1.2. Study groups

In our study, we used a sample of 154 patients, divided into two groups (Table 3.1). Group 1 comprised of 81 patients with a mean age of 12.52±2.52 years, treated without extractions. Group 2 consisted of 76 patients with a mean age of 14.49±3.69 treated with extractions. Nonextraction treatment included the use of headgear, removable or fixed functional appliances or Class II elastics in combination with fixed orthodontic appliances (Table 3.2.). Extraction protocol included removal of 4 premolars or 2 maxillary premolars (Table 3.3.).

Table 3.1. Initial age and gender distribution of the groups

Variable	Initial Age (years) Mean ± SD	Gender	
		Female	Male
Nonextraction (n=81)	12.52 ± 2.52	42	39
Extraction (n=76)	14.49 ± 3.69	25	51

Table 3.2 Mechanics used to correct Class II relationships in nonextraction group

Mechanics	Nonextraction
Class II elastics	24
Removable Functional Appliances	22
Fixed Functional Appliances	20
Headgear	15

Table 3.3. Extraction pattern of extraction group

Variable	Initial Age (years) Mean ± SD	Gender	
		Female	Male

2 premolar extraction (n=31)	14.29 ± 3.53	16	15
4 premolar extraction (n=37)	14.54 ± 3.84	23	14

3.2. Method

Measurements on dental models and cephalometric radiographs were carried out. Four weeks later, in order to test intra-examiner reliability 15 casts and radiographs were selected randomly and remeasured by the same examiner.

3.2.1 Dental model measurements: PAR index calculation

In the current study, to evaluate the severity of malocclusion in the initial and final phase the Peer Assessment Rating (PAR) index was used (44). The pretreatment and posttreatment dental study models were blindly measured regarding maxillary and mandibular tooth alignment (labial alignment, crowding and spacing) buccal posterior segment relationship (right and left sides, anteriorposterior, vertical, transverse) overbite, overjet and midline discrepancies. Each set of models were evaluated in maximum intercuspation with a specially designed PAR ruler. A complete description of PAR ruler was presented in the Development of the PAR index (Peer Assessment Rating: reliability and validity) (36).

The dental arch was divided into three segments, left buccal, right buccal and anterior for both upper and lower arch (Fig. 2.1).

- Buccal segments: From the mesial anatomical contact point of the first permanent molar to the distal anatomical point of the canine (Figure 2.1).

- Anterior segment: It was recorded from the mesial contact point of canine to the mesial contact point of the opposite side (Figure 2.1).

In the current study, we recorded the following occlusal features: crowding, spacing, and impacted teeth. Displacements were recorded as the shortest distance between the contact points of adjacent teeth parallel to the occlusal plane. The displacements between the first, second and third molars were not recorded.

Impacted teeth was considered when the space for the eruption of this teeth was less than 4 mm.

- Buccal occlusion: It was recorded for both right and left side in three planes of space. The scores were recorded when the teeth are in occlusion. The anterior-posterior, vertical and transverse discrepancies were summed up for each buccal occlusion (Figure 4.1, 4,2).

- Overjet: Positive overjet and crossbites were recorded from right lateral to left lateral incisor. The most prominent aspect of any incisor was recorded. The ruler was held parallel to the occlusal plane and radial to the line of action (Fig. 2.5). In cases of increased overjet with crossbite at the same time the scores were summed up for each irregularity.

- Overbite: Vertical overlap of upper anterior teeth to lower incisors or open bite was recorded (Figure 4.1, 4.2). Lateral incisors were also included in the recording with the greatest overlap measured.

- Centerline: The midline deviation was recorded related with the lower incisor (Figure 4.1, 4.2). If a lower incisor is missing or extracted then it is not measured.

For every calculated component of malocclusion severity, a respective weighting was used as suggested by the panel of 74 dentists in Great Britain. In the current study, we used the British-based weighting system, which is 6 for overjet, 2 for overbite, 4 midline discrepancy, 1 right and left buccal occlusion and, 1 for upper and lower labial segment anterior alignment (36). Scores for each feature were summed and initial PAR score (iPAR), final PAR score (fPAR) were obtained.

The amount of improvement was assessed by the treatment changes before and after the orthodontic treatment as DifPAR (iPAR – fPAR). The percentage of PAR reduction (PcPAR) which is a better estimate of occlusal improvement expressed as PcPAR=iPAR-fPAR/iPAR% (58, 123, 150, 171). The treatment efficiency index (TEI) was evaluated by the relationship between PcPAR and TT in months expressed as TEI= PcPAR/TT. The TEI increased when a greater PcPAR was associated with a shorter TT.

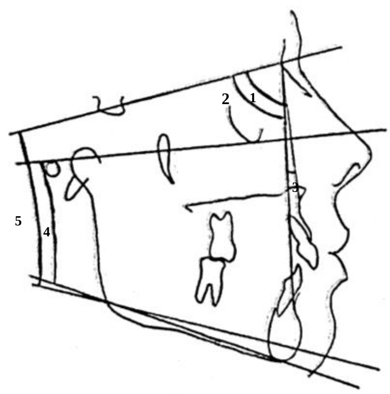

Fig 3.1. Skeletal cephalometric variables: 1, SNA: angle between sella-nasion plane and nasion-A point. 2 SNB: angle between sella-nasion plane and sella-B plane. 3, ANB: angle between nasion-A plane and nasion-B plane. 4, FMA: angle between mandibular plane and Frankfort horizontal plane. 5, GoGn-SN: angle between gonion-gnathion plane and sella-nasion plane.

3.2.2. Cephalometric measurements

Lateral cephalometric radiographs of the patients were obtained at the beginning of treatment of both groups to evaluate the morphologic characteristics. Lateral cephalograms taken in natural head position were digitized and these data were analyzed with Dolphin Imaging Software. The cephalometric variables are summarized in Figure 3.3.

Statistical Analysis

Statistical calculations were performed with (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) program for Windows. Besides standard descriptive statistical calculations (mean and standard deviation), one way ANOVA was used in the comparison of groups, post Hoc Tukey multiple comparison test was utilized in the comparison of subgroups, independant t test was used in the comparison of two groups, and Chi square test was performed during the evaluation of qualitative data. Pearson correlation test was used to determine the relationships between the variables. Statistical significant level was established at $p<0,05$.

4. RESULTS

4.1. Evaluation of Method Error

One week after the first measurements, the measurements were repeated and intraexaminer reliability values were determined with the intraclass correlation coefficient (ICC). The operator was consistent in the repeated measurements; the interclass correlation coefficients were between 0.882 and 0.998. ICCs of 0.75 or above are usually considered to be good and above 0.9 to be excellent.

4.2. Comparison of nonextraction and extraction group

There was no statistically significant difference of gender or the vertical growth pattern distribution between the nonextraction and extraction groups ($p>0.05$) (Table 4.1.)

Table 4.1. Comparison of gender and vertical growth pattern distribution of the nonextraction and extraction group (Chi square test)

Variable		Nonextraction (n= 81)	Extraction (n=76)	p
Sex	Male	48.15%	32.89%	0.075
	Female	51.85%	67.11%	
Vertical Growth Pattern	Normal	37.04%	38.16%	0.455
	Low	23.46%	15.79%	
	High	39.51%	46.05%	

The initial and final ages differed significantly between groups ($p<0.01$). However, there was no statistically significant difference between the treatment durations of the nonextraction and extraction groups ($p>0.05$) (Table 4.2.). Table 4.3 shows the comparison of pretreatment cephalometric measurements of the groups. SNA, SNB and ANB angles did not show statistically significant differences between groups ($p>0.05$) whereas FMA and GoGn-SN angles were higher in the extraction group compared to nonextraction group ($p<0.01$).

In both groups, the initial PAR scores were significantly greater than the final PAR scores ($p<0.001$) (Table 4.4). When the initial PAR scores were compared, there was no significant difference between groups ($p>0.05$). When the final PAR scores were compared, the extraction group had significantly higher score than nonextraction group ($p<0.05$).There was no statistically significant difference in PAR difference, percentage of PAR difference and TEI between groups ($p>0.05$).

Table 4.2. Comparison of initial and final ages and treatment time between nonextraction and extraction groups (independent t test)

	Nonextraction (n= 81)		Extraction (n=76)		
Variable	Mean	SD	Mean	SD	p
iAge (years)	12.52	2.52	14.49	3.63	0.00015***
fAge (years)	15.78	2.70	17.49	3.58	0.00114**
TT (months)	39.13	13.95	36.10	15.64	0.20214

SD: Standard deviation, iAge: Initial age, fAge: Final age, TT: Treatment time,

p: probability values

******p<0.01, *******p<0.001

Table 4.3. Comparison of pretreatment cephalometric measurements of the nonextraction and extraction groups (independent t test)

	Nonextraction (n=81)		Extraction (n=76)		
Variables	Mean	SD	Mean	SD	p
SNA	79.34	3.32	80.34	3.23	0.057
SNB	74.05	3.43	74.7	2.83	0.204
ANB	5.37	1.35	5.7	1.53	0.153
FMA	26.04	3.60	28.06	5.53	0.007**
GoGn-SN	35.16	4.32	37.59	5.10	0.002**

SD: Standard deviation   SD: Standard deviation

p: probability values

**p<0.01

Table 4.4. Comparison of PAR scores of the nonextraction and extraction groups (independent t test, ‡ dependent t test)

	Nonextraction (n =81)		Extraction (n=76)		
Variable	Mean	SD	Mean	SD	p
iPAR	39	13.80	42.2	13.04	0.138

fPAR	13.95	5.43	16.29	6.21	0.013*
p‡	0.0001***		0.0001***		
DifPAR	25.05	11.87	25.91	11.38	0.645
PcPAR	61.83	15.50	59.93	13.48	0.415
TEI	1.70	1.03	2.05	1.29	0.05

SD: Standard deviation, iPAR:initial PAR, fPAR:final PAR, DifPAR: PAR difference, PcPAR: Percentage PAR.

p: probability values

***** p< 0.05, *******p<0.001

4.2.1. Classification of the cases according to pcPAR reduction in nonextraction and extraction group

In the nonextraction group 3.70% patients were classified as ‘worse/no different’, 70.37% as ‘improved’ and 25.93% as ‘greatly improved’ cases. In the extraction group, 2.63% patients were classified as ‘worse/no different’, 76% as ‘improved’ and 21.37% as ‘greatly improved’ cases (Table 4.5).

Table 4.5. Stages of improvement of both groups

Classification	Nonextraction (n=81)	Extraction (n=76)
Worse/ no difference	3.70%	2.63%
Improved	70.37%	76%

Greatly Improved	25.93%	21.37%

3.2.1.1 Case analysis

Case 1

The use of PAR index in an extraction case was illustrated. Pre and posttreatment dental casts and the derivation of unweighted and weighted individual scores were shown in in Fig.4.1 and Table 4.6, respectively. The initial score was 21 and has been reduced to 16, a reduction of 5 points. The case illustrated a Class II Division 1 malocclusion with an overjet greater than 10 mm, an overbite greater than 1/3 but less than 2/3 of coverage of lower incisor, centerline less than 1/4 off. The molar relationship was Class II at the right and left side.

As a result of orthodontic treatment with maxillary premolar extraction, the overjet was reduced to 3.1-5 mm, the overbite has been corrected within the normal range. The buccal segments were improved although the buccal teeth are not fully intercuspating. The overall alignment has been improved although in the posterior segments of the upper and lower arches, there were displacements that still needed to be corrected. However, when the individual components were weighted the overall score changed. In this case, the PcPAR reduction was 51% which is considered as improvement as it was between 30-70%.

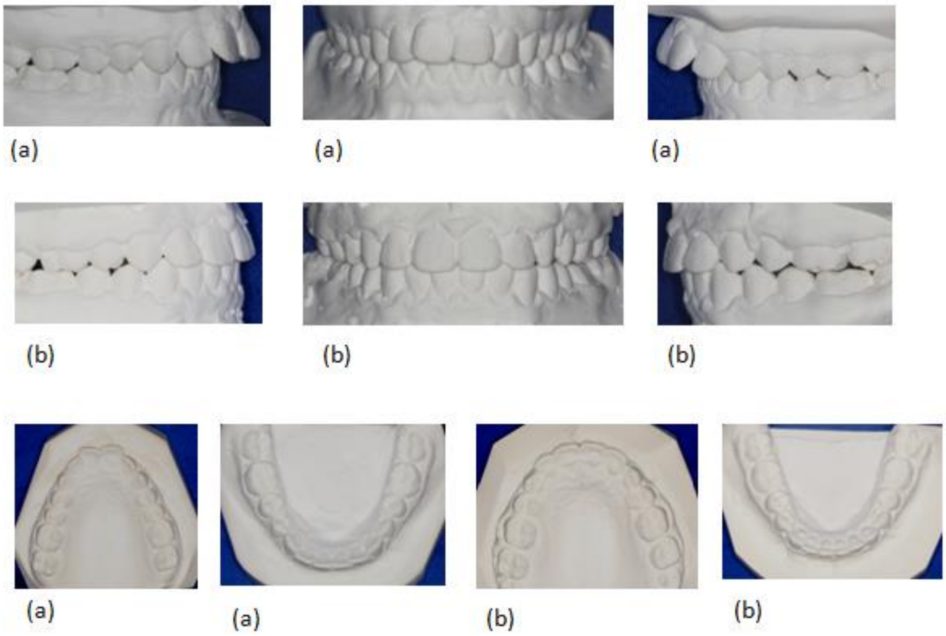

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Fig. 4.1. Case analysis 1: (a) pretreatment and (b) posttreatment dental casts illustrating the reduction of PAR score from 21 to 16.

Table 4.6. Derivation of PAR scores of Case 1 (Fig. 4.1).

PAR components	Before treatment	Total	Weighted	After treatment	Total	Weighted
Upper right segment	(6-5),0,(5-4),0, (4-3),1	1	1	(6-5),1, (5-3),1	2	2
Upper anterior segment	(3-2),0 ,(2-1),1 , (1-1), 1	2	2	(3-2),0, (2-1),0, (1-1), 0	0	0
	(1-2),2 ,(2-3),0,	2	2	(1-2),0, (2-3),0	0	0
Upper left segment	(6-5),0, (5-4),0, (4-3),1	1	1	(6-5),1, (5-3),1	2	2
Lower right segment	(6-5),1,(5-4),1, (4-3),1	3	3	(6-5),1, (5-4),2, (4-3),1	4	4
Lower anterior segment	(3-2),1,(2-1),0, (1-1),0	1	1	(3-2),0, (2-1),0, (1-1),0	0	0
	(1-2),0, (2-3),0,	0	0	(1-2),0, (2-3),0	0	0
Lower left segment	(6-5),1, (5-4),2, (4-3),1	4	4	(6-5),1, (5-4),2, (4-3),1	4	4
Right buccal occlusion	Not good inderdigitation	1	1		1	1
Overjet	Greater than 10 mm	4	24	Between 3.1-5 mm	1	6
Overbite	>1/3 but < 2/3 of lower incisor	1	2	Within the normal range	0	0
Centreline	Coincident and up to 1/4 of lower incisor width	0	0	Coincident and up to 1/4 of lower incisor width	0	0
Left buccal occlusion	Not good inderdigitation	1	1	Cusp to cusp	2	2
Total		21	42		16	21

Case 2

A nonextraction case with pre and posttreatment dental casts was illustrated in Fig.4.2. The derivation of unweighted and weighted individual scores was given in Table 4.7. The right molar is in full Class II relationship and the left molar had less than half unit discrepancy. The overjet was between 5.1-7 mm and the overbite was equal to full tooth. The centerline was off more than 1/4 of lower incisor.

At the end of orthodontic treatment, the overjet was reduced to 3.1-5 mm, the overbite had been improved and was between 3.1-5mm. The buccal segments had been improved although the buccal teeth were not fully intercuspating. Less than half Class II molar relationship was apparent. The overbite was more than 1/3 but less than 2/3 of coverage of lower incisor. The centerline was coincident. The overall alignment had been improved. When the individual components were weighted the overall score changed. In this case, the PcPAR reduction was 64% which was considered as 'improved' because it was between 30- 70%.

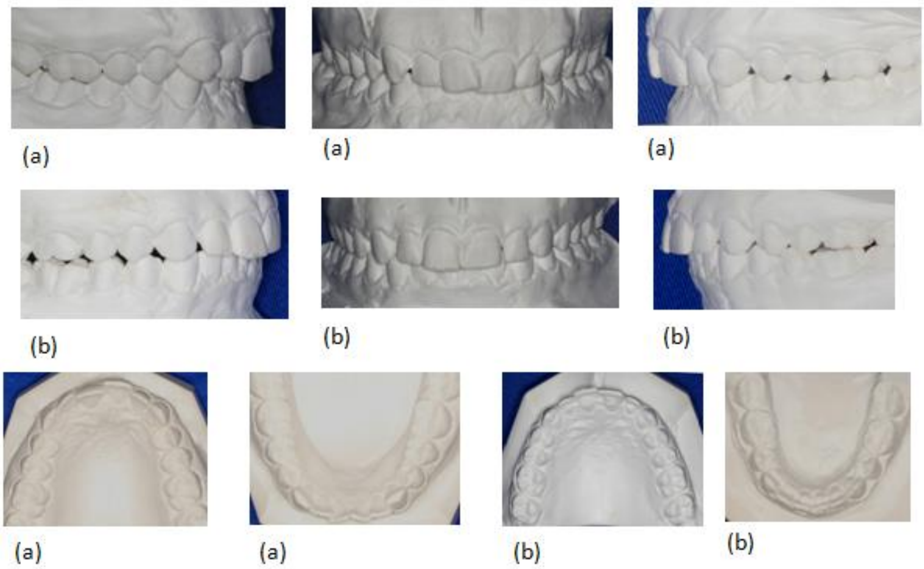

Fig. 4.2. Analysis of a nonextraction : (a) pretreatment and (b) posttreatment dental casts illustrating the reduction of PAR score from 20 to 7.

Table 4.7. Derivation of PAR scores of Case 2 (Fig. 4.2).

PAR components	Before treatment	Total	Weighted	After treatment	Total	Weighted
Upper right segment	(6-5),0, (5-4),1, (4-3)0	1	1	(6-5),0,(5-4),0, (4-3),1	1	1
Upper anterior segment	(3-2), 2, (2-1),0, (1-1),2	4	4	(3-2),0, (2-1),0, (1-1),0	0	0
	(1-2), 0, (2-3),2	2	2	(1-2),0, (2-3),0	0	0
Upper left segment	(6-5),1, (5-4),1, (4-3)0	2	2	(6-5),0, (5-4),1, (4-3),1	2	2
Lower right segment	(6-5),1, (5-4),0, (4-3), 0	1	1	(6-5),0, (5-4),0, (4-3)0	0	0
Lower anterior segment	(3-2),1, (2-1),0, (1-1),0	1	1	(3-2),0, (2-1),0, (1-1),0	0	0
	(1-2),0, (2-3),0	0	0	(1-2),0, (2-3),0	0	0
Lower left segment	(6-5),0, (5-4),0, (4-3),0	0	0	(6-5),0, (5-4),0, (4-3).0	0	0
Right buccal occlusion	Less than 1/2 Class II	1	1	Less than 1/2 Class II	1	1
Overjet	Between 5.1-7 mm	2	12	Between 3.1-5mm	1	6
Overbite	equal to full tooth	3	6	>1/3 but < 2/3 of coverage of lower incisor	1	2
Centreline	> 1/4 width of lower incisor width	1	4	Coincident	0	0
Left buccal occlusion	Cusp to cusp	2	2	Less than 1/2 Class II	1	1
Total		20	36		7	13

Case 3

Pre and posttreatment dental casts and the derivation of unweighted and weighted individual scores were shown in in Fig.4.3 and Table 4.8, respectively. The initial score was 38 and has been reduced to 13, a reduction of 25 points. The case illustrated a Class II malocclusion with an overjet between 7.1-9 mm , an overbite greater than 1/3 but less than 2/3 of coverage of lower incisor, centerline between 1/4 to half width of lower incisor. The molar relationship was Class II at the right and left side.

As a result of orthodontic treatment with maxillary and mandibular premolar extractions, the overjet and overbite have been corrected within the normal range. The buccal segments were improved. The overall alignment has been improved although in the posterior segments of the upper and lower arches, there were displacements that still needed to be corrected. However, when the individual components were weighted the overall score changed. In this case, the PcPAR reduction was greater than 70% which is considered as greatly improved.

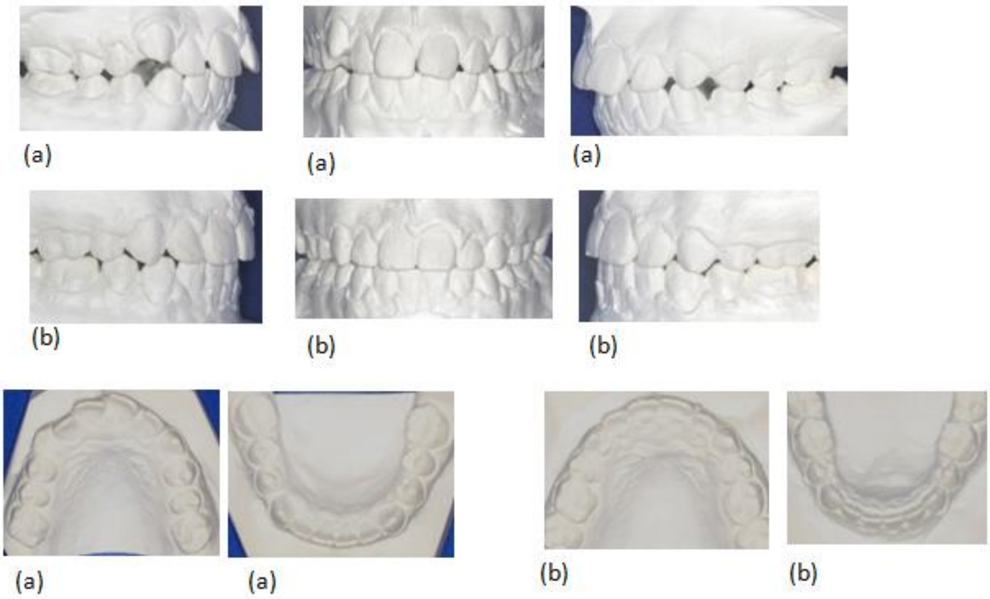

Fig. 4.3. Case analysis 3: (a) pretreatment and (b) posttreatment dental casts illustrating the reduction of PAR score from 38 to 13.

Table 4.8. Derivation of PAR scores of Case 3 (Fig. 4.3).

PAR components	Before treatment	Total	Weighted	After treatment	Total	Weighted
Upper right segment	(6-5),1,(5-4),2, (4-3),2	5	5	(6-4),1, (4-3),2	3	3
Upper anterior segment	(3-2),2 ,(2-1),1, (1-1), 2	5	5	(3-2),1, (2-1),0, (1-1), 0	1	1
	(1-2),2 ,(2-3),2,	4	4	(1-2),0, (2-3),1	1	1
Upper left segment	(6-5),1, (5-4),1, (4-3),3	5	5	(6-5),2, (5-3),2	4	4
Lower right segment	(6-5),1,(5-4),1, (4-3),1	3	3	(6-4),1 (4-3),1	2	2
Lower anterior segment	(3-2),1,(2-1),0, (1-1),0	1	1	(3-2),0, (2-1),0, (1-1),0	0	0
	(1-2),0, (2-3),0,	0	0	(1-2),0, (2-3),0	0	0
Lower left segment	(6-5),2, (5-4),2, (4-3),2	6	6	(6-4),0, (4-3),1	1	1
Right buccal occlusion	Cusp to cusp	2	2	Less than half unit discrepancy	1	1
Overjet	Between 7.1-9 mm	3	18	0-3 mm	0	0
Overbite	Greater than 1/3 but less than 2/3 coverage of lower incisor	1	2	Less than 1/3 of lower incisor	0	0
Centreline	1/4 - 1/2 lower width	1	4	Within the normal range	0	0
Left buccal occlusion	Cusp to cusp	2	2	Class I	0	0
Total		38	57		13	13

Case 4

A nonextraction case with pre and posttreatment dental casts was illustrated in Fig.4.4. The derivation of unweighted and weighted individual scores was given in Table 4.9. The right and the left molar had less than half unit discrepancy Class II discrepancy. The overjet was between 5.1-7 mm and the overbite was greater than 2/3 but less than full coverage of lower incisor tooth. The centerline was off more than 1/4 of lower incisor. The initial PAR score was 33 and the final 7, a reduction of 26.

At the end of orthodontic treatment, the overjet was reduced to 3.1-5 mm, the overbite had been improved between 1/3 to 2/3 coverage of lower incisor. The buccal segments had been improved although the buccal teeth were fully intercuspating in Class I molar relationship. The centerline was coincident. The overall alignment had been improved, however there are displancements in upper and lower posterior segments. When the individual components were weighted the overall score changed. In this case, the PcPAR reduction was 73% which was considered as 'greatly improved' because it was b 30- 70%.

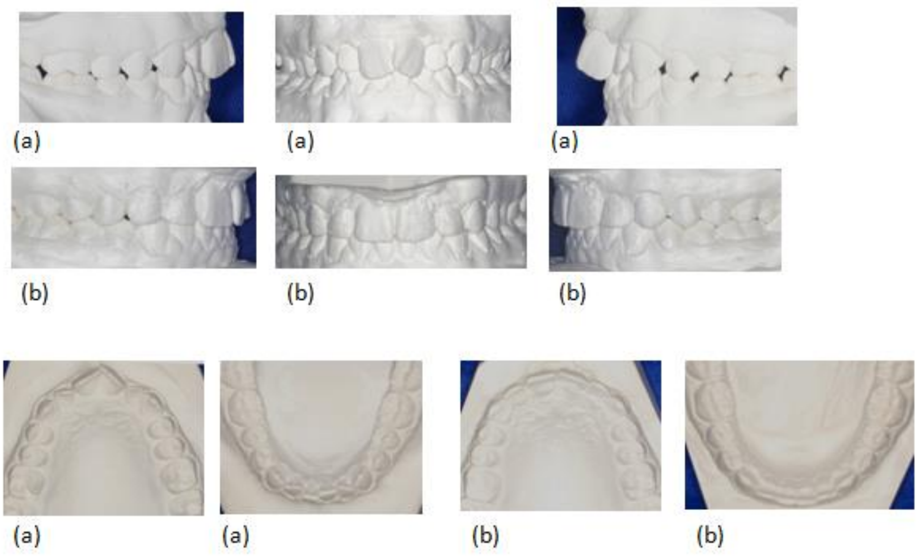

Fig. 4.4. Case analysis 4: (a) pretreatment and (b) posttreatment dental casts illustrating the reduction of PAR score from 33 to 7.

Table 4.9. Derivation of PAR scores of Case 4 (Fig. 4.4).

PAR components	Before treatment	Total	Weighted	After treatment	Total	Weighted
Upper right segment	(6-5),1, (5-4),0,(4-3),2	3	3	(6-5),0, (5-4),0, (4-3)	0	0
Upper anterior segment	(3-2),1, (2-1),0 , (1-1), 1	2	2	(3-2),0, (2-1),0, (1-1), 0	0	0
	(1-2),2, (2-3),1,	3	3	(1-2),0, (2-3),0	0	0
Upper left segment	(6-5),1, (5-4),1, (4-3),2	4	4	(6-5),0, (5-3),1	1	1
Lower right segment	(6-5),2, (5-4),1, (4-3),1	4	4	(6-5),1, (5-4),0, (4-3),1	2	2
Lower anterior segment	(3-2),1, (2-1),2, (1-1),2	5	5	(3-2),0, (2-1),0, (1-1),0	0	0
	(1-2),0, (2-3),0,	0	0	(1-2),0, (2-3),1	1	1
Lower left segment	(6-5),1, (5-4),2, (4-3),1	4	4	(6-5),1, (5-4),0, (4-3),0	1	1
Right buccal occlusion	Less than half unit	1	1	Class I	0	0
Overjet	Between 5.1 - 7mm	2	12	Between 3.1-5 mm	1	6
Overbite	Greater than 2/3 of lower incisor	2	4	Greater than 1/3 but less than 2/3 of lower incisor	1	2
Centreline	>1/4 width of lower incisor	1	4	Within the normal range	0	0
Left buccal occlusion	Cups to cusp	2	2	Class I	0	0
Total		33	48		7	13

Case 5

Pre and posttreatment dental casts and the derivation of unweighted and weighted individual scores were shown in in Fig.4.5 and Table 4.10, respectively. The initial score was 30 and has been reduced to 18, a reduction of 12 point. The case illustrated Class II with an overjet between 3.1-5mm and overbite and centerline within the normal range. The molar relationship in right and left side was half a unit discrepancy Class II.

As a result of orthodontic treatment with maxillary and mandibular premolar extractions, the overjet remained between 3.1-5 mm. Overbite was greater of ¼ but less than ½ of lower incisor. The buccal segments were Class II in both sides with teeth not fully interdigitating. The overall alignment has been improved although in the posterior segments of the upper arches, there were displacements that still needed to be corrected. However, when the individual components were weighted the overall score changed. In this case, the PcPAR reduction was 25% which is considered as "worse" as it was lower than 30%.

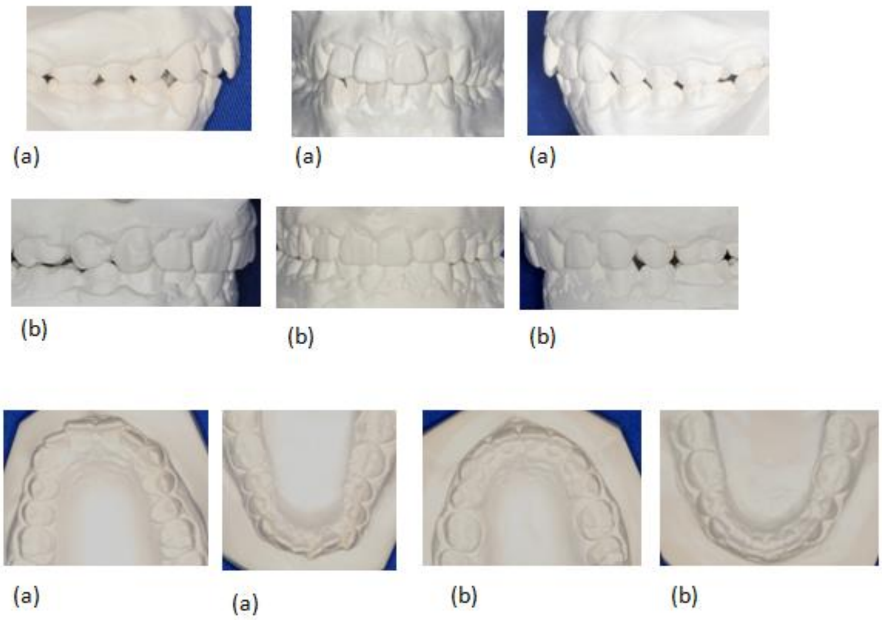

Fig. 4.5. Case analysis 5: (a) pretreatment and (b) posttreatment dental casts illustrating the reduction of PAR score from 30 to 18.

Table 4.10. Derivation of PAR scores of Case 5 (Fig. 4.5).

PAR components	Before treatment	Total	Weighted	After treatment	Total	Weighted
Upper right segment	(6-5),0,(5-4),1, (4-3),2	3	3	(6-4),1, (4-3),2	3	3
Upper anterior segment	(3-2),1 ,(2-1),2 , (1-1), 0	3	3	(3-2),0, (2-1),0, (1-1), 0	0	0
	(1-2),2 ,(2-3),1,	3	3	(1-2),0, (2-3),2	2	2
Upper left segment	(6-5),0, (5-4),1, (4-3),2	3	4	(6-4),2, (4-3),2	4	4
Lower right segment	(6-5),1,(5-4),1, (4-3),2	4	4	(6-5),1, (5-3),0	1	1
Lower anterior segment	(3-2),2,(2-1),1, (1-1),2	5	5	(3-2),0, (2-1),0, (1-1),0	0	0
	(1-2),0, (2-3),0,	0	0	(1-2),0, (2-3),0	0	0
Lower left segment	(6-5),1, (5-4),2, (4-3),1	4	4	(6-5),1, (5-3),0	1	1
Right buccal occlusion	Cusp to cusp	2	2	Class II	2	2
Overjet	Between 3.1 to 5 mm	1	6	Between 3.1 to 5 mm	1	6
Overbite	Within the normal range	0	0	Greater than 1/3 but less than 2/3 of lower incisor	1	2
Centreline	Within the normal range	0	0	>1/4 width of lower incisor	1	4
Left buccal occlusion	Cusp to cusp	2	2	Cusp to cusp	2	2
Total		30	36		18	27

Case 6

A nonextraction case with pre and posttreatment dental casts was illustrated in Fig.4.6. The derivation of unweighted and weighted individual scores was given in Table 4.11. The right and left molar is in full Class II relationship. The overjet was between 5.1-7 mm and the overbite was greater of 1/3 but less than 2/3 of lower incisor. The centerline was in the normal range.

At the end of orthodontic treatment, the overjet was remained between 5.1-7 mm, the overbite had been increased to greater of 2/3 but less than full coverage of lower incisor. The buccal segments were on right side less than hald unit Class II molar relationship and cusp to cusp Class II relationship on left side. The overbite still remained more than 1/3 but less than 2/3 of coverage of lower incisor. The centerline was coincident. When the individual components were weighted the overall score changed. In this case, there was no difference in the PAR score, there was negative PcPAR -0.04% and it was considered as ‘no difference’.

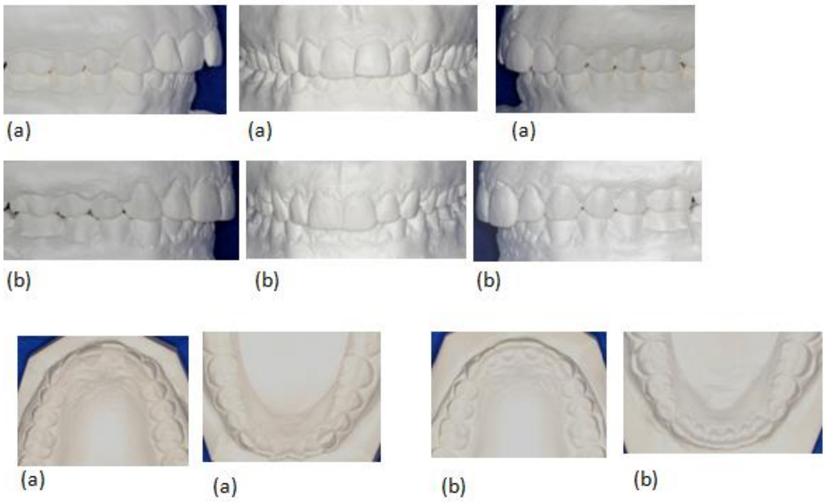

Fig. 4.6. Case analysis 6: (a) pretreatment and (b) posttreatment dental casts illustrating that PAR score remained to 12.

Table 4.11. Derivation of PAR scores of Case 6 (Fig. 4.6)

PAR components	Before treatment	Total	Weighted	After treatment	Total	Weighted
Upper right segment	(6-5),0,(5-4),0, (4-3),1	1	1	(6-5),1, (5-4),0, (4-3) 0	1	1
Upper anterior segment	(3-2),0 ,(2-1),0, (1-1), 1	1	1	(3-2),0, (2-1),0, (1-1), 0	0	0
	(1-2),0 ,(2-3),0,	0	0	(1-2),0, (2-3),0	0	0
Upper left segment	(6-5),0, (5-4),1, (4-3),1	2	2	(6-5),1, (5-4),1, (4-3) 0	2	2
Lower right segment	(6-5),0,(5-4),0, (4-3),0	0	0	(6-5),1, (5-4),0, (4-3),0	1	1
Lower anterior segment	(3-2),0,(2-1),0, (1-1),0	0	0	(3-2),0, (2-1),0, (1-1),0	0	0
	(1-2),1, (2-3),0,	1	1	(1-2),0, (2-3),0	0	0
Lower left segment	(6-5),0, (5-4),0, (4-3),0	0	0	(6-5),1, (5-4),0, (4-3),0	1	1
Right buccal occlusion		2	2	Less than half unit discrepancy	1	1
Overjet	Between 5.1 - 7mm	2	12	Between 5.1 - 7mm	2	12
Overbite	Greater than 1/3 but less than 2/3 of lower incisor	1	2	Greater than 2/3 of lower incisor	2	4
Centreline	Within the normal range	0	0	Within the normal range	0	0
Left buccal occlusion		2	2	Cusp to cusp	2	2
Total		12	23		12	24

Comparisons based on gender in nonextraction and extraction groups

In the nonextraction group, there was no statistically significant difference between the initial and final age and treatment time of boys and girls (Table 4.12). Cephalometric measurements did not differ between boys and girls ($p>0.05$) (Table 4.13). The initial PAR scores were greater than the final PAR scores for both gender ($p<0.001$). There was no statistically significant difference in initial and final PAR scores between boys and girls whereas PAR differences and percentage of PAR differences were significantly greater in girls ($p<0.05$, $p<0.01$ respectively). There was no statistically significant difference in TEI between boys and girls ($p>0.05$) (Table 4.14).

Table 4.12. Comparison of initial and final ages and treatment time of males and females in the nonextraction group (independent t test)

	Nonextraction (n=81)				
	Male (n=39)		Female (n=42)		
Variable	Mean	SD	Mean	SD	p
iAge (years)	12.87	2.83	12.19	2.05	0.302
fAge (years)	16.09	2.86	15.47	2.50	0.228
TT (months)	38.72	11.85	39.29	15.21	0.853

SD: Standard deviation, iAge: initial age, fAge: final age, TT: treatment time

p: probability values

Table 4.13. Comparison of cephalometric variables of the males and females in the nonextraction group (independent t test)

	Nonextraction (n=81)				
	Male (n=39)		Female (n=42)		
Variable	Mean	SD	Mean	SD	p
SNA	79.33	3.03	79.35	3.61	0.977
SNB	73.91	3.39	74.19	3.49	0.718
ANB	5.47	1.30	5.28	1.41	0.541
FMA	26.26	3.56	25.85	3.66	0.61
GoGN-SN	35.51	4.83	34.83	3.81	0.483

SD: Standard deviation, p: probability values

Table 4.14. Comparison of PAR scores of males and females in nonextraction group

(independent t test, ‡ dependent t test)

	Nonextraction (n=81)	
	Male (n=39)	Female (n=42)

Variable	Mean	SD	Mean	SD	p
iPAR	37.36	13.80	40.52	13.79	0.305
fPAR	15.13	5.03	12.86	5.62	0.059
p‡	0.007**		0.008**		
DifPAR	22.23	11.11	27.67	12.07	0.039*
PcPAR	56.58	16.23	66.70	13.21	0.003**
TEI	1.62	1.18	1.80	0.96	0.699

SD: Standard deviation, iPAR: initial PAR, fPAR:final PAR, DifPAR: PAR difference, PcPAR: Percentage PAR, TEI: treatment efficiency index.

p: probability values

***** p< 0.05, ******p<0.001

In the extraction group, there was no statistically significant difference in initial and final ages between girls and boys. However, the treatment duration of boys in the extraction group was significantly higher than that of the girls (p<0.05) (Table 4.15). The cephalometric measurements did not show difference between boys and girls (p>0.05) (Table 4.16). The initial PAR scores were greater than the final PAR scores for both gender (p<0.001). The initial PAR score was greater for boys (p<0.05); whereas, no significant differences were observed in final PAR scores between genders. PAR differences and percentage of PAR differences were significantly greater in the boys compared to the girls (p<0.01, p<0.05 respectively). There was no statistically significant difference in the TEI between boys and girls (p>0.05) (Table 4.17).

Table 4.15. Comparison of initial and final ages and treatment time of the males and females in the extraction group (independent t test)

	Extraction (n=76)				
	Male (n=25)		Female (n=51)		
Variable	Mean	SD	Mean	SD	p
iAge (years)	14.07	3.33	14.75	3.36	0.427
fAge (years)	17.5	3.36	17.51	3.84	0.990
TT (months)	41.14	17.69	33.10	13.18	0.043*****

SD: Standard deviation, iAge: initial age, fAge: final age, TT: treatment time

p: probability values

***** $p < 0.05$

Table 4.16. Comparison of cephalometric variables of the males and females in the extraction group (independent t test)

	Extraction (n=76)				
	Male (n=25)		Female (n=51)		
Variable	Mean	SD	Mean	SD	p
SNA	80.2	3.02	80.41	3.35	0.794

SNB	74.3	2.69	74.89	2.89	0.391
ANB	5.91	1.53	5.6	1.54	0.414
FMA	26.73	5.35	28.71	5.54	0.143
GoGN-SN	36.55	5.07	38.11	5.09	0.213

SD: Standard deviation, p: probability values

Table 4.17. Comparison of PAR scores of males and females in extraction group (independent t test, ‡ dependent t test)

	Extraction (n=76)				
	Male (n=25)		Female (n=51)		
Variable	Mean	SD	Mean	SD	p
iPAR	47.08	13.75	39.8	12.10	0.021*
fPAR	16.32	4.47	16.27	6.94	0.976
p‡	0.0001***		0.0001***		
DifPAR	30.76	12.71	23.53	9.96	0.008**
PcPAR	63.1	12.45	58.37	13.81	0.042*
TEI	1.90	1.29	2.13	1.25	0.447

SD: Standard deviation, iPAR:initial PAR, fPAR:final PAR, DifPAR: PAR difference, PcPAR: Percentage PAR, TEI: treatment efficiency index.

p: probability values

***** $p < 0.05$, ******$p<0.001$, *******$p<0.001$

4.3. Comparison of subgroups based on vertical growth pattern in nonextraction and extraction group

In the nonextraction group, the initial and final age, treatment time and sagittal cephalometric measurements of the patients did not differ among subgroups regarding vertical growth pattern ($p>0.05$) (Table 4.18 and Table 4.19). In each subgroup, the initial PAR scores were significantly greater than the final PAR scores ($p<0.01$) (Table 4.20). The initial PAR score, DifPAR, PcPAR and TEI did not differ among the subgroups, however the final PAR score was significantly different ($p<0.01$), which was greater in the low angle group compared to the normal group ($p<0.01$).

Table 4.18. Comparison of initial and final age and treatment time of subgroups based on vertical growth pattern in nonextraction group (one way ANOVA test)

	Nonextraction (n=81)						
	Normal (n=30)		Low (n=19)		High (n=32)		
Variable	Mean	SD	Mean	SD	Mean	SD	p
iAge	12.91	2.75	11.82	1.96	12.60	2.54	0.333
fAge	16.65	3.14	14.78	1.77	15.97	2.70	0.173
TT	40.23	15.80	35.52	10.86	40.33	13.59	0.448

SD: Standard deviation, iAge: initial age, fAge: final age, TT: treatment time

p: probability values

Table 4.19. Comparison of cephalometric measurements of subgroups based on vertical growth pattern in nonextraction group (one way ANOVA test)

	Nonextraction (n=81)						
	Normal (n=30)		Low (n=19)		High (n=32)		
Variable	Mean	SD	Mean	SD	Mean	SD	p
SNA	79.82	3.31	79.81	3.84	78.61	2.96	0.282
SNB	74.59	3.26	74.4	4.35	73.35	2.91	0.325
ANB	5.37	1.60	5.52	1.40	5.29	1.08	0.847

SD: Standard deviation, p: probability values

Table 4.20. Comparison of PAR scores of subgroups based on vertical growth pattern in extraction group (one way ANOVA, post Hoc test, ‡dependent t test)

	Nonextraction (n=81)						
	Normal (n=30)		Low (n=19)		High (n=32)		
Variable	Mean	SD	Mean	SD	Mean	SD	p
iPAR	37.1	13.71	39.37	12.59	40.56	14.74	0.614
fPAR	12.17[a]	5.48	16.95[b]	5.43	13.84[a,b]	4.72	0.009**
p‡	0.009**		0.002**		0.0001***		
DifPAR	24.93	12.17	22.42	10.90	26.72	12.20	0.462

PcPAR	64.53	16.35	54.85	15.84	63.44	13.60	0.077
TEI	2.04	1.23	1.61	0.86	1.73	0.68	0.216

SD: Standard deviation, iPAR: initial PAR, fPAR:final PAR, DifPAR: PAR difference, PcPAR: Percentage PAR.

Same superscript letters indicate no statistically significant difference.

***** $p< 0.05$ ******$p<0.01$ *******$p<0.001$

In the extraction group, the initial and final age, treatment time and sagittal cephalometric measurements of the patients did not differ among subgroups regarding vertical growth pattern ($p>0.05$) (Table 4.21 and Table 4.22). In each subgroup, the initial PAR scores were significantly greater than the final PAR scores ($p<0.01$) The initial and final PAR scores, DifPAR, PcPAR and TEI did not differ among the subgroups ($p>0.05$) (Table 4.23).

Table 4.21. Comparison of initial and final age and treatment time of subgroups based on vertical growth pattern in extraction group (one way ANOVA test)

	Extraction (n:76)						
	Normal (n=29)		Low (n=14)		High (n=33)		
Variable	Mean	SD	Mean	SD	Mean	SD	p
iAge	15.08	4.05	15.81	3.33	13.55	3.25	0.163
fAge	17.85	4.19	18.71	3.25	16.81	3.15	0.249
TT	33.28	15.71	34.84	10.64	39.01	16.33	0.333

SD: Standard deviation, iAge: initial age, fAge: final age, TT: treatment time
p: probability values

Table 4.22. Comparison of cephalometric measurements of subgroups based on vertical growth pattern in extraction group (ANOVA)

	Extraction (n=76)						
	Normal (n=29)		Low (n=14)		High (n=33)		
Variable	Mean	SD	Mean	SD	Mean	SD	p
SNA	80.46	2.65	80.25	3.17	80.28	3.73	0.969
SNB	75.03	2.70	74.83	2.72	74.37	3.00	0.644
ANB	5.57	1.21	5.42	1.10	5.91	1.87	0.537

SD: Standard deviation, p: probability values

Table 4.23. Comparison of PAR scores of subgroups based on vertical growth pattern in extraction group (one way ANOVA, ‡dependent t test)

	Extraction (n=76)						
	Normal (n=29)		Low Angle (n=14)		High Angle (n=33)		
Variable	Mean	SD	Mean	SD	Mean	SD	p
iPAR	41.76	12.82	42.17	9.63	42.57	14.46	0.970
fPAR	15.45	4.56	17.92	8.46	16.43	6.57	0.509
p‡	0.002**		0.002**		0.0001***		
DifPAR	26.31	11.47	24.25	10.10	26.14	11.97	0.861

PcPAR	61.3	12.23	57.33	16.44	59.68	13.64	0.691
TEI	2.48	1.73	1.73	0.73	1.79	0.80	0.058

SD: Standard deviation, iPAR: initial PAR, fPAR:final PAR, DifPAR: PAR difference, PcPAR: Percentage PAR, TEI: Treatment effeciency index.

******p<0.01 *******p<0.001

4.4. Results of compliant versus noncompliant appliances in nonextraction group

There was no statistically significant difference between the noncompliant and compliant appliance groups regarding the initial age (p>0.05). However, the final age and the duration of the treatment were significantly higher in the compliant appliance group (p<0.01) (Table 4.24). The cephalometric measurements of the patients did not differ between subgroups (p>0.05) (Table 4.25). In both subgroups, the initial PAR scores were significantly greater than the final PAR scores (p<0.001) (Table 4.26). When the initial PAR, final PAR scores, PAR difference and percentage of PAR difference were compared, there was no significant difference between subgroups (p>0.05). When the TEI was compared, it was significantly lower in the subgroup 1B (compliant appliance group) (p<0.05).

Table 4.24. Comparison of initial and final age and treatment time of the subgroups 1A (noncompliant appliance) and 1B (compliant appliance) in the nonextraction group (independent t test)

	Subgroup 1A (n=20) (noncompliant appliance)	Subgroup 1B (n=61) (compliant appliance)

Variable	Mean	SD	Mean	SD	p
iAge (years)	12.10	2.34	12.66	2.59	0.3703
fAge (years)	14.97	2.75	16.32	2.74	0.0038**
TT (months)	34.46	15.80	44.00	13.74	0.0021**

SD: Standard deviation iAge:initial age, fAge:final age,TT: treatment time p: probability values

**p<0.01

Table 4.25. Comparison of cephalometric measurements of the subgroups 1A (noncompliant appliance) and 1B (compliant appliance) in the nonextraction group (independent t test)

	Subgroup 1A (n=20) (noncompliant appliance)		Subgroup 1B (n=61) (compliant appliance)		
Variable	Mean	SD	Mean	SD	p
SNA	79.87	4.48	79.11	2.85	0.782
SNB	73.75	4.39	74.08	3.05	0.402
ANB	6.11	1.75	5.10	1.11	0.137
FMA	25.4	2.85	26.23	3.83	0.128
GoGN-SN	34.25	3.20	35.46	4.61	0.215

SD: Standard deviation. p: probability values

Table 4.26. Comparison of PAR scores of the subgroups 1A (noncompliant appliance) and 1B (compliant appliance) in the nonextraction group (independent t test, ‡ dependent t test)

	Subgroup 1A (n=20) (noncompliant appliance)		Subgroup 1B (n=61) (compliant appliance)		
Variable	Mean	SD	Mean	SD	p
iPAR	39.95	11.89	38.64	14.49	0.688
fPAR	13.55	5.28	14.13	5.58	0.676
p‡	0.0001***		0.0001***		
DifPAR	24.67	12.12	26.4	10.84	0.552
PcPAR%	63.05	12.68	60.33	17.88	0.201
TEI	1.94	1.02	1.52	0.98	0.047*

SD: Standard deviation, iPAR: initial PAR, fPAR:final PAR, DifPAR: PAR difference, PcPAR: Percentage PAR.

***** $p< 0.05$ *******$p<0.001$

4.5. Results of two versus four premolar extraction in extraction group

There was no statistically significant difference in the initial and final age and the treatment duration of the 2-premolar and 4-premolar extraction groups ($p>0.05$) (Table 4.27). There was no statistically significant difference between 2-premolar and 4-

premolar extraction groups regarding cephalometric measurements; whereas, FMA angle was significantly higher in the 4-premolar extraction group ($p<0.05$). There was no statistically significant difference between 2-premolar and 4-premolar extraction groups regarding PAR scores and TEI (Table 4.28 and Table 4.29). In both groups, the initial PAR was significantly reduced at the end of treatment ($p<0.01$).

Table 4.27. Comparison of initial and final age and treatment time of the subgroups 2A (2 premolar extraction) and 2B (4 premolar extraction) (independent t test).

	Subgroup 2A (2 premolar extraction) (n=34)		Subgroup 2B (4 premolar extraction) (n=42)		
Variable	Mean	SD	Mean	SD	p
iAge (years)	14.29	3.53	14.54	3.84	0.382
fAge (years)	17.42	3.64	17.54	3.68	0.287
TT (months)	37.64	15.17	36.01	15.90	0.671

SD: Standard deviation, iAge: initial age, fAge: final age, TT: treatment time

p: probability values

Table 4.28. Comparison of cephalometric measurements of the subgroups 2A (2 premolar extraction) and 2B (4 premolar extraction) (independent t test).

	Subgroup 2A (2 premolar extraction) (n=34)	Subgroup 2B (4 premolar extraction) (n=42)

Variable	Mean	SD	Mean	SD	p
SNA	79.92	3.35	80.58	2.96	0.367
SNB	74.33	2.84	74.89	2.66	0.384
ANB	5.59	1.62	5.8	1.48	0.563
FMA	26.65	5.70	29.51	5.09	0.025*
GoGN-SN	36.95	5.17	38.39	4.95	0.220

SD: Standard deviation. p: probability values

***** $p < 0.05$

Table 4.29. Comparison of PAR scores of the subgroups 2A (2 premolar extraction) and 2B (4 premolar extraction) (independent t test, ‡ dependent t test)

	Subgroup 2A (2 premolar extraction) (n=34)		Subgroup 2B (4 premolar extraction) (n=42)		
Variable	Mean	SD	Mean	SD	p
iPAR	43.62	13.60	41.16	12.52	0.417
fPAR	16.73	6.37	16	6.13	0.615
p‡	0.008**		0.001**		
DifPAR	26.89	12.28	25.16	10.6	0.515

PcPAR	60.29	13.66	59.51	13.65	0.806
TEI	2.05	1.42	1.88	0.785	0.562

SD: Standard deviation, iPAR: initial PAR, fPAR:final PAR, DifPAR: PAR difference, PcPAR: Percentage PAR.

**p<0.01

SD: Standard deviation p: probability values

Correlations

In the nonextraction group, there was a significant and positive correlation between initial PAR score and final PAR score (r=0.527, p=0.0001) as well as PcPAR (r=0.443, p=0.0001) (Table 4.30). None of the cephalometric measurements, initial age nor treatment duration showed significant correlations with the PAR values.

Table 4.30. Correlations in nonextraction group (Pearson Correlation test).

		Nonextraction (n=81)			
Variable		iPAR	fPAR	PcPAR	iAge
	r	-0.072	0.085	-0.132	
SNA	p	0.524	0.453	0.240	
	r	-0.068	0.119	-0.167	
SNB	p	0.549	0.290	0.137	
ANB	r	0.032	-0.126	0.114	

	p	0.780	0.264	0.309	
	r	0.527			
fPAR	p	0.0001***			
	r	0.443			
PcPAR	p	0.0001***			
	r		-0.088	0.096	
iAge	p		0.434	0.393	
	r	-0.181	-0.047	-0.133	-0.040
TT	p	0.105	0.676	0.236	0.723

r: correlation coefficient, p: probability values

***p<0.001

In the extraction group, there was a significant and positive correlation between initial PAR score and final PAR score (r=0.488, p=0.0001) as well as PcPAR (r=0.358, p=0.002) (Table 4.31). None of the cephalometric measurements showed significant correlations with the PAR values. There was a significant and positive correlation between the initial age and final PAR score (r=0.256, p=0.025), as well as significant and negative correlation between initial age and PcPAR (r= -0.296, p=0.009).

Table 4.31. Correlations in extraction group (Pearson Correlation test)

	Extraction (n=76)		
Variable	iPAR	fPAR	iAge

				PcPAR	
SNA	r	-0.035	0.067	-0.172	
	p	0.764	0.568	0.137	
SNB	r	-0.150	0.035	-0.235	
	p	0.195	0.767	0.051	
ANB	r	0.174	0.063	0.059	
	p	0.134	0.590	0.610	
fPAR	r	0.488			
	p	0.0001***			
PcPAR	r	0.358			
	p	0.002**			
iAge	r		0.256	-0.296	
	p		0.025*	0.009**	
TT	r	0.136	0.041	-0.134	-0.201
	p	0.241	0.725	0.067	0.081

r: correlation coefficient p: probability values

***** p< 0.05 ******p<0.01 *******p<0.001

5. DISCUSSION

Treatment alternatives for Class II malocclusion include growth modification, camouflage and orthognathic surgery. To control the growth of maxillomandibular complex in the early years of the 20th century, the pioneer American orthodontists preferred to use extraoral forces and they found that extraoral force to restrain the growth of the maxilla could change the way it grew. Angle and his contemporaries thought that Class II elastics could generate forward mandibular growth. By the 1980s, clinical success with functional appliances that hold the mandible forward had been clearly demonstrated on both sides of Atlantic. In theory, functional appliances stimulate and enhance mandibular growth. Additional growth is supposed to occur in response to movement of the mandibular condyle out of fossa, mediated by reduced pressure on the condylar tissues or the altered muscle tension on the condyle (3, 33). Functional appliances for Class II treatment cover a range of removable and fixed appliances that alter the position of the mandible both sagitally and vertically (4-6). In moderate Class II cases when growth modification is not possible, camouflage is the treatment option. The possibilities of treatment are therefore displacement of the teeth to their supporting bone, to compensate for underlying jaw discrepancy or surgical repositioning of the jaws. For Class II correction the extraction of upper first premolars alone or upper first and lower second premolars often is the choice (7). The objective of the treatment protocol with 2 maxillary premolar extractions is to mantain the existing Class II molar relatioship, reduce the overjet and correct the canine relationship. Whereas extraction of 4 premolars is indicated primarily for crowding in the mandibular arch, a skeletal discrepancy, or a combination of both, in growing patients (1, 7, 9). However, the decision of extraction or non-extraction treatment in a Class II malocclusion is not only based on patient’s skeletal characteristics, but also patient’s developmental stage as well as patient’s characteristics, cooperation and age (7).

It is known that treatment protocol and malocclusion severity can influence the results, the duration and consequently the efficiency of orthodontic treatment (12, 26, 46, 47, 159). However, the findings of studies investigating effectiveness of occlusal results of the nonextraction and extraction treatment protocol seem controversial. Several studies support that there are no significant differences (10, 58, 63, 64); whereas, others claim that extraction method leads to better occlusal outcomes at the end of the treatment (11-13). The purpose of this study was to investigate and compare the treatment duration and occlusal effectiveness of the nonextraction and extraction treatment protocol in Class II malocclusion patients.

Occlusal indices are helpful tools for the clinicians in diagnosis, research, decision-making, evaluation of the orthodontic treatment need and outcomes. In 1992, Richmond et al. (131) developed an occlusal index to record the measurements of a malocclusion and orthodontic treatment success (104, 140). After assessing 320 models by 74 orthodontists and dentists by the British Orthodontist Standards Working Party the index took its final form (132). The Peer Assessment Rating (PAR) Index was designed specifically to provide a more objective assessment of treatment success. It has been shown to have a good intra- and interexaminer reliability, with intraclass correlation coefficients of 0.95 and 0.91 respectively (131). The validation and reliability of PAR index were confirmed. The PAR index provides a method for objective assessment of the outcome and achievement of orthodontic treatment. (131, 132, 134, 156, 161). It has been extensively used as a method of audit in Europe (143-145, 151, 158) and this is the main reason we used the PAR in our study for occlusal measurement of Turkish population. The PAR ruler has been used in several studies to assess the quality of treatment measuring study pretreatment and posttreatment casts (146, 147). With the PAR, we can assess the treatment standards and determine the success of the treatment (148-150). It is simple, valid, objective and reliable for evaluating not only the quality of treatment outcome but also the stability of occlusion after orthodontic treatment (151, 152). Several studies used the method for assessing the stability after orthodontic treatment (144, 145, 154-156). The PAR assigns scores to occlusal traits and for every occlusal component there is a weighting (Table 2.9). The scores are applied to the dental features of a certain malocclusion and the sum of these scores ranks the malocclusion to which a weighting is added (134). The opinion of a panel of 74 dentists in Great Britain was used for the first validation exercise (131). The second used the opinion of a panel of 11 orthodontists in private practice in western Pennsylvania (135).

In the US-based weighting system the lower labial segment is not included and it is weighted 0. However, the British-based weighting system takes into account the lower labial segment (133) and this was the main reason we used the PAR for the measurements in this study.

There are several limitations of occlusal indices. In this study we used PAR index to evaluate the results of the treatments. It is used to evaluate the extent to which a dentition deviates from an ideally formed dental arch and occlusion (159). However, it does not consider important factors for the total quality of the treatment, such as facial profile, cephalometric measurements, periodontal health, root resorption, tooth angulations, patient compliance and treatment duration (133, 161). Iatrogenic damage such as decalcification, root resorption, gingival recession, periodontal breakdown and facial aesthetics are obviously not measured in any way although they undoubtedly contribute to the 'quality' of treatment. The PAR index also fails to evaluate treatment suitability/motivation, the functional occlusion, the temporomandibular joint and patient satisfaction. However, the PAR index is an epidemiological tool and was validated against a cross-section of dental opinion over a wide selection of cases and if used as intended, to assess samples from caseloads rather than individual cases, it is a reliable tool in assessing performance of practitioners or services (131-133, 155, 161).

In this study, the treatment duration was similar for both groups. In the nonextraction group, it was approximately 39 months and in the extraction group, it was 36 months. Similar to our findings, Janson et al. (10) who evaluated the treatment time of Class II Division 1 malocclusion treated by 4 premolar extraction and nonextraction, came to the conclusion that the treatment duration was similar in both groups. According to their results, the treatment time was 2.36 years for the 4 premolar extractions and 2.47 years for the nonextraction group. The difference was 1.3 months, which was meaningless clinically. Later on, Janson et al. (11) in another study compared the efficiency of nonextraction and 2 maxillary premolar extraction protocols in Class II malocclusion. They found no statistically significant difference in treatment time between the two groups with 30.14 months and 26.99 months, respectively. Supporting these findings, Vig et al. (172) who made a study to compare the treatment duration between the extraction and nonextraction treatment found that the treatment time was 31.2 and 31.3 months, respectively. On the other hand, Holman et al. (52) compared a group of 100 patients treated with extraction with a group of 100 patients treated with nonextraction treatment protocol. They found that the average treatment time for the extraction group was 29.7 months whereas for nonextraction group it was 26 months. According to their statements, extraction treatment protocol lasts longer and takes 3.3 months additional time. Several researchers stated that every extraction increases the treatment duration (15, 49, 51, 52, 159, 171). However, these studies lack of homogeneity in type of malocclusion and severity. It is speculated that the shorter treatment time of the nonextraction in the above studies might reflect more simple treatment for localized problems. In contrast, extractions tend to be associated with the treatment of more marked discrepancies (49, 51, 52, 159). Consequently with this rationale, it is reasonable to assume that the nonextraction treatment in Class I malocclusion is faster and takes shorter treatment time because in the extraction treatment more time is required to close the spaces after initial alignment (52). But the treatment objectives of Class I and Class II treatments differ greatly. In Class II treatment, the extractions are performed not only to solve arch size discrepancies but also to correct dental relationships. Therefore it seems that there is a mechanical similarity between the non-extraction protocol with the extraction protocol, when correcting the Class II molar relationship. In the nonextraction group the correction of molar relationship can be a factor that can prolong the treatment duration. On the other hand, in the extraction group if extraoral appliances or Class II elastics are used to reinforce anchorage, the compliance level is important in the treatment outcome. If the necessary compliance level is not achieved the occlusal results are compromised and treatment time can be prolonged. As a consequence in this aspect, both treatment protocols may result in similar treatment time (9, 29, 83-85, 89).

In both groups, the initial PAR scores were significantly reduced at the end of treatment and the percentages of PAR reductions showed various degree of improvement. The mean percentage of improvement was approximately 60% in our nonextraction and extraction sample. Our improvement ratio is slightly lower than the reported ratios ranging between 68-69 % (149, 159). The difference may be due to the orthodontist’s experience. In our study, the samples were composed of the cases treated by orthodontic residents, whereas the cases evaluated by Al-Yami et al.(149) and O'Brien et al.(159) were treated by a mixture of senior and junior staff. Furthermore, as the level of experience increases the ratio of improvement also increases as shown in the study of Richmond and Andrews (151).

In our nonextraction group, 26% of the cases were "greatly improved", 70% of the cases were classified as improved whereas 4% of the cases were classified as 'worse or not improved'. In the extraction group, the ratio of "greatly improved" was 21%, "improved" was 76% and 'worse or not improved' was 3%. When compared to the literature, the ratio of "greatly improved" and "not improved" cases are lower in our postgraduate clinic (150). The distribution of the satisfactory and unsatisfactory cases as well as increased fPAR scores and treatment duration of our study can be attributed to the fact that the research took place in a postgraduate university clinic where the patients were treated by postgraduate students. It is speculated that the treatment efficiency may be higher in hands of more experienced clinicians.

In this study there was a significant and positive correlation between the initial PAR with the final PAR outcomes and the amount of PcPAR reduction scores in both groups. It seems that there is direct correlation between the initial occlusal severity with the amount of occlusal improvement. The higher the initial severity of malocclusion, the greater the improvement of the occlusion achieved with orthodontics (12, 18, 34, 68, 77, 78). Shaw et al. (156) and O'Brien et al. (159) showed that the higher the PAR at the pretreatment stage, the higher the chance of achieving more than 30% reduction in pcPAR. On the other hand, there are studies demonstrating that there is no association (75, 76). However, these studies included different types of malocclusion in their samples as their main objectives were to audit the quality of orthodontic treatment in private practice or university clinics. Different malocclusions corrected with different methodology of treatment prevent us from further comparison.

In this study, the extraction group had significantly higher final PAR score than the nonextraction group. The fPAR scores for nonextraction group was 13.95±5.43 whereas for the extraction group 16.29±6.21. This demonstrates that Class II malocclusion treatment with nonextraction treatment protocol allows more favorable occlusal outcomes. An explanation for the better occlusal outcome can be the growth potential since the nonextraction group starts treatment at an earlier age, thus greater growth potential favors correction of Class II malocclusion. Especially in patients with a growth pattern resulting in forward mandibular growth, the growth is likely to enhance occlusal outcomes by correcting anteroposterior skeletal and dental relationship and overjet. In addition, when orthopedic appliances are used during treatment, if the patient is still growing, the possibility of success is increased because these appliances redirect the maxillary growth by restricting the anterior displacement. Moreover, the mandibular growth with its anterior displacement will increase the possibility of correction of anterior-posterior discrepancy (5, 9, 11, 31). In our study, the comparison of vertical cephalometric measurements revealed that extraction group had higher vertical growth tendency, indicating more unfavorable mandibular forward growth potential. Our correlation findings also support this statement. In the extraction group, the initial age was positively correlated to the final PAR and negatively and strongly correlated to the improvement of the occlusal relationships. As the patient was older at the pretreatment stage, the final occlusal outcome and improvement was less satisfactory. This may be due to the fact that older pretreatment ages tend to make Class II treatment more difficult (71, 84.). The extraction group was composed of older patients (mean age: 14.5 years). According to the correlations, it is obvious that the initial age is an important factor which might influence the achievement of satisfactory outcomes. As the patient gets older, the mandibular growth potential is decreased and also the patient's cooperation might be decreased. Therefore one may suggest to start the treatment of Class II malocclusion earlier as the cooperation level is higher and growth potential is increased when the child is younger.

Our findings showing better final occlusal outcomes with nonextraction treatment modality are in accordance with Cansunar and Uysal's (44) study, which compared the clinical outcomes of 2 maxillary premolar extraction, 4 maxillary premolar extraction, and nonextraction treatment protocols using the American Board of Orthodontics objective grading system. The authors showed that the 4 premolar extraction group had the least satisfactory; whereas, the nonextraction group had the better sagittal dental relationship, with more teeth in occlusion and better root angulations. Furthermore, Janson et al. (10) who assessed treatment outcomes using treatment priority index which is very similar to PAR, showed statistically insignificant but slightly better occlusal outcomes in Class II nonextraction treatment group compared to 4 premolar extraction treatment group. However, Holman et al. (52) couldn't reveal any significant difference between extraction and nonextraction treatment. Similarly, Xu et al. (56) compared orthodontic treatment outcomes in Chinese patients with borderline problems treated with and without extractions with OGS system and found no statistically significant differences for tooth alignment, overbite, overjet, midline symmetry, or posterior occlusion. On the other hand, Janson et al. (11) compared a sample of subjects with complete Class II malocclusion (nonextraction and 2 maxillary premolar extraction) and noted that the extraction group ended with more favorable results. Our opposing results with the above study (11) may be due to the fact that their sample consisted of only 2 premolar extraction cases whereas in our sample, both 2 and 4 premolar extraction cases were evaluated. In another study by Janson et al, it was revealed that the 2 premolar extraction therapy resulted in better occlusal outcomes than 4 premolar extraction in Class II malocclusion. In addition, in this study we used the British weighting system compared to the previous ones which used the U.S weighting system. The British weighting takes into account the buccal segment and is heavily weighted for overjet (x6) and centerline (x4). An increased overjet at the end of the treatment can significantly change the total final score according to the British weighting system.

Final PAR score is an indicative of occlusal status at the end of the treatment. But percentage of PAR reduction (PcPAR) is a better estimate of occlusal improvement as stated by Holman et al. (52). Although the final PAR was slightly lower in the nonextraction group, PcPAR did not differ between groups. This may be explained by the initial PAR of the nonextraction group which was lower than that of extraction group, meaning that the nonextraction group started treatment with a milder malocclusion. But the occlusal improvement amount with orthodontic therapy is similar in both groups, which is supported by the statistical similarity in difPAR. In orthodontic treatment, the treatment duration is very important as well as achieving good results. A satisfactory treatment is defined as the best occlusal outcomes achieved within a short treatment time. Therefore, the treatment efficiency should also be considered when comparing treatment modalities. The treatment efficiency index (TEI) is evaluated by the relationship between the PcPAR score and TT in months. It is increased when a greater PcPAR is associated with a shorter TT. In this study, there is no difference in the efficiency of the two treatment modalities due to the fact that PcPAR and TT between the two groups are not statistically different. However in the literature, the studies assessing the treatment efficiency of different Class II treatment modalities are limited. Leon-Salazar et al. (77) evaluated the TEI in a group of patients having Class I malocclusion treated with extraction and nonextraction treatment protocol. They concluded that in both groups the TEI is statistically higher in the nonextraction group compared to the extraction. According to their results, there is a direct relationship between the number of extractions and the longer treatment time. This suggests that as the number of extractions increases the treatment duration increases as well resulting in a lower TEI. As mentioned above, the treatment duration of Class I and Class II malocclusion may differ due to the requirements of the treatment. The difference between the findings of the studies may be due to the type of the malocclusion. When the treatment efficiency of extraction and nonextraction Class II therapy was evaluated, the extraction with 2 maxillary premolars was shown to be more effective than nonextraction therapy (11). The authors stated that the better occlusal success rate in the extraction group was due to the greater PcPAR in association with the shorter TT.

The influence of gender on the treatment duration and treatment outcomes was also investigated in the literature. In our nonextraction group, the treatment time was approximately 39 months for boys and girls and there was no statistically significant difference in the treatment duration between genders. Therefore the sex seems to have no significant influence on the treatment duration for nonextraction therapy. Similar to our findings, Melo et al. (178) who evaluated the variables that could influence the orthodontic treatment length, found that treatment duration was independent of sex. On the other hand, in our extraction group, the treatment time for boys was approximately 41 months whereas for girls it was 33 months, showing a significant difference. Because the initial severity of the malocclusion and improvement of the occlusion of the boys were greater than that of the girls, we questioned the relationship between the treatment duration and the initial severity of the malocclusion and improvement of the occlusion but we couldn't reveal any significant correlation. Therefore, the difference in treatment duration of the boys and the girls may be partly explained by the poor cooperation of the boys (15, 66). But other factors should also be investigated. Because the treatment duration is multifactorial, factors such as broken appointments, the 'type of bracket' used, brackets repositioning or breakeage of the appliance, immediate or delayed extractions, initial severity of malocclusion, transfer to a second resident, poor oral hygiene, poor elastic wear, patient's behavioral factors etc. might play a role in prolonged treatment duration (10, 11, 15, 66, 178). However the purpose of this study was not to investigate the variables that influence the orthodontic treatment duriation, so further investigation should be done to reveal the determinants of the orthodontic treatment length in different treatment modalities.

In our nonextraction group, PAR differences and percentage of PAR reduction were significantly greater in females. This was due to slightly higher initial and lower final PAR scores of the girls, although the gender difference was statistically insignificant. An explanation of better difPAR and PcPAR of the girls can be the higher level of compliance. Girls might have greater esthetic concerns than the boys. Therefore, esthetics seems to be a a cause of motivation and a reason for higher cooperation during treatment which may contribute to better improvement (15, 48, 66, 88).

In the extraction group, the iPAR score was greater for boys; whereas, no significant differences were observed in fPAR scores between genders. There are few studies in the literature investigating the influence of sex on the quality of occlusal results. It is suggested that the treatment success and outcome is independent of the sex. The quality of treatment outcome was reported to be the same for both genders (69, 70). Willems et al. (65) showed that males had significantly higher PAR scores in the beginning compared to females, however at the end the PAR scores showed no significant difference. They concluded that the final occlusal outcomes were similar in both groups. Moreover, they found that there was no difference in percentage reduction of PAR in both sexes (75.9% for males and 74.2% for females). However, we found that boys had significantly higher percentage of improvement in the extraction group. This may be due to the fact that the greater the initial severity, the greater is the occlusal improvement which was supported by the positive and strong correlation between initial

PAR and pcPAR as mentioned before. Although male's pcPAR was greater than that of the females, the treatment efficiency index was similar because the extraction treatment lasted longer in boys.

In general, the appliances used for nonextraction correction of Class II malocclusion require patient cooperation. However, there are also compliance free ones such as fixed functional appliances. Our nonextraction group was composed of patients treated with both type of appliances. In order to investigate the influence of patient's cooperation on the duration as well as the quality of treatment result, we subdivided the nonextraction group into two subgroups according to nonextraction treatment modality. The patients treated with extraoral appliances, removable functional appliances and intermaxillary elastics composed the compliant appliance group whereas the patients treated with fixed functional appliances were allocated to noncompliant appliance group. There was statistically significant difference between both subgroups regarding the final age and the duration of the treatment, which were significantly higher in the compliant appliance group. The patients treated with fixed functional appliances finished the treatment approximately 5 months earlier and at a younger age. The amount of PcPAR reduction was not significantly different in both groups; which showed that the occlusal improvement was similar in both subgroups. However, the TEI was significantly different with the noncompliant appliance subgroup showing better rate of treatment effectiveness. Even though both groups produce similar PcPAR, the shorter treatment time affected the efficiency of the treatment. As a conclusion, we can suggest that the use of appliances which do not require patient cooperation increases the effectiveness of Class II nonextraction treatment. However, there are not enough data in the literature comparing the TEI between cooperation and noncooperation group. Compliance, age, and malocclusion severity are clinical variables that cannot be controlled by the operator; they are inherent to the patient. Popowitch et al. (14) tried to identify clinical factors that predict the treatment duration in Class II malocclusions. They concluded that the type of appliance used can prolong the treatment duration. According to their study the use of Herbst appliance, Class II elastic wear or the Class II functional appliance is positively correlated with treatment length. Several studies investigate the treatment duration in Class II therapy. Lima et al. (174) compared the dentoskeletal effects of a Jasper Jumper and Activator-Headgear combination. They found that the treatment duration was 2.15 years for the noncompliant Jusper-Jumper appliance and 3.21 years for Activator-Headgear combination although, both appliances had similar improvement of overjet and molar relationships. Concado et al. (166) found that the duration of functional treatment followed by fixed appliances was 3.49 years. However, Cancado et al. (166) compared the occlusal efficiency between 1-phase and 2-phase treatment protocols in Class II Division 1 malocclusion. For the 1-phase treatment group the TEI score was 39.54 whereas for the 2-phase treatment group 27.80. According to their findings, this was due to shorter treatment time of the phase 1 group. The score was higher compared to our study due to the fact that they were calculated in years.

Our study demonstrated that 2- and 4-premolar extraction modalities had similar treatment times. Popowitch et al. (14) investigated the factors that could influence the treatment duration in Class II malocclusions. According to their findings, extractions did not seem to influence treatment duration. On the other hand, several studies stated that the number of extractions was positively correlated to the treatment duration (47). Efforts have been made to quantify the influence of extractions to treatment time (159, 171, 172). According to Fink et al. (171) there was an additional 0.9 months of treatment for every premolar extraction. Janson et al. (64) compared the treatment times in Class II malocclusions treated with 2 and 4 premolar extraction protocols. Treatment time was significantly shorter for the 2 compared to 4 premolar extraction group with average 23.52 and 28.12 months respectively. The result of our study is opposing with the above findings. This may be due to the difference in investigated malocclusions. In some of the previous studies, it was not distinguished if the comparison of the treatment times were carried on subjects with Class I or Class II malocclusions. And some of them did not compare 2 and 4 premolar extraction protocols in complete Class II malocclusion correction. Furthermore, another explanation might be the fact that the time that is required for closing the maxillary extraction spaces in Class II treatment can correspond to the necessary time to close simultaneously the maxillary and the mandibular spaces.

In our study, the PAR scores did not differ between the 2 and 4 premolar extraction groups. Supporting our findings, Cansunar and Uysal (44) did not find any statistically significant difference between the 2 and 4 premolar extraction groups regarding the occlusal contacts, overjet, occlusal relationship and interproximal contact measurements. In the literature, there is a great number of studies comparing cephalometric and dental outcomes of nonextraction and 4 premolar extraction therapy of Class II malocclusion (1, 85, 90). However, there is an absence of studies comparing the effectiveness between the 2 maxillary premolar extractions with the 4 premolar extraction protocols. Janson et al. (46) found a greater occlusal success rate in 2 premolar extraction group compared to 4 premolar extraction group. We did not reveal any better occlusal outcome in 2 premolar extraction group compared to 4 premolar extraction group; although, Janson et al. found that 4 premolar extractions resulted in worse final occlusal relationships; because this treatment modality required twice as greater extraoral anchorage than 2 premolar extractions. However, maxillary 2 premolar extraction may also lead to a transversal constriction of the maxillary arch, or Bolton discrepancy; which, impedes the proper interdigitation and correction of overjet. Furthermore, if there is a mandibular dental midline shift, this can not be completely corrected without mandibular premolar extractions, which would otherwise result in increased final PAR scores.

In our study, none of the cephalometric measurements showed significant correlations with the PAR values in both groups. Similarly, Kim et al. (2) state that the cephalometric variables may explain the iPAR; however, it seems that they can not provide a useful tool for predicting the occlusal result. This may be due to the fact that the initial cephalogram provides the skeletal component; whereas, the PAR index primarily reflects the dental component. In accordance with our findings, Wheeler et al. (12) who investigated the influence of the initial plane angle on the success of treatment showed that there was no correlation between these factors. Also, Janson et al. (39) showed that the initial cephalometric characteristics did not influence the treatment success rate of the 2 treatment protocols. On the other hand, Kim et al. (92) tried to assess the influence of cephalometric characteristics in treatment severity and outcome in Class II malocclusions. They tried to assess the predictive value of 41 cephalometric parameters with regard to pretreatment severity and the posttreatment outcomes. The occlusal severity was evaluated by using the PAR. They concluded that the cephalometric parameters explained 39.2% of the pretreatment severity variance, 17.9% of posttreatment severity variance, 15.7% of relative treatment improvement variance, and 20.0% of treatment duration variance.

In our study, there was no correlation between treatment duration and treatment outcomes. The quality of outcome and effectiveness of orthodontic treatment is not correlated to duration (75, 180). However, previous studies suggested that prolonged treatment duration leads to poor compliance of patient and progressive decline of treatment outcomes (72, 73, 167). The result of our study contradicts the finding of Pinskaya et al. (72) as in their study the sample used was non homogenous, because they evaluated Class I, Class II and Class III patients with the use of ABO grading system.

6. CONCLUSION

1. Nonextraction and extraction treatment of Class II malocclusion showed similar occlusal improvement and treatment efficiency.
2. There was no difference of treatment duration between nonextraction and extraction Class II treatment modalities.
3. There was a positive association between the initial severity of the malocclusion and the occlusal improvement in both groups. In the extraction group, as the patient was older at the start of treatment, the final occlusal outcome and improvement was less satisfactory.
4. In the nonextraction group, girls showed a better occlusal improvement than the boys; however, the treatment efficiency were similar for both genders.
5. In the extraction group, boys had more severe initial malocclusion and higher occlusal improvement at the end of treatment than the girls. However, the treatment efficiency did not differ between genders due to the increased treatment duration in boys.
6. The vertical growth pattern did not influence the treatment duration and occlusal effectiveness.
7. Using noncompliant appliances significantly reduced the treatment time and improved treatment efficiency.
8. Extracting 2 or 4 premolars resulted in similar occlusal outcomes and treatment duration.

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