OCCLUSAL OUTCOME ASSESSMENT OF ORTHODONTIC TREATMENTS PERFORMED AT AN EDUCATIONAL INSTITUTE IN DUBAI

By

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ABSTRACT

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Aim:

To assess occlusal outcome of comprehensive orthodontic treatments performed by postgraduate students at an educational institute in Dubai.

Materials and Methods:

Consecutive patients' files, including dental casts, were selected from the archives of the Boston University – Dubai (BU-D) (2008-2012), which have been transferred to the Hamdan Bin Mohammed College of Dental Medicine. The final sample was formed following application of certain inclusion criteria and consisted of 30 patients with permanent dentition who received comprehensive orthodontic treatment by means of fixed appliances in both dental arches. All pre- and post-treatment dental casts were blindly assessed by the author using the Peer Assessment Rating (PAR) and Index of Complexity, and Need (ICON) indices. In order to test the intra-examiner reliability, the examiner re-assessed 15 cases, which were randomly selected from the original sample, one week after the initial examinations. Statistical analysis included descriptive statistics, paired t-test, Neymman Pearson correlation coefficient and linear regression. The level of significance was set at $p<0.05$. The intra-examiner reliability was assessed using paired t-test and found high.

Results:

Occlusal outcome related to orthodontic care provided was characterized by significant improvement. Mean PAR changed from 19.43 before treatment to 4.63 after ($p<0.001$). Mean ICON changed from 53.96 before treatment to 19.06 after ($p<0.001$). According to PAR 46.67% of patients “greatly improved” and 36.67% “improved”, respectively. According to ICON 23.33% of patients “greatly improved”, 20% “substantially improved” and 36.67% “moderately improved”, respectively.

Conclusions:

Patients treated at the Postgraduate Orthodontic Program of BU-D demonstrated significant improvement of their occlusion.

DEDICATION

To my dearest mother and the soul of my father, my success in life could not have been without your love, prayers and belief in me

To my beloved siblings thank you for your sincere wishes.

To my wife, your patience and understanding has lead me to achieve this momentous level

To my children Ahmad, Enaya, Hamza and Osama, accepting and winning this challenge at the age of forty-year-old was for you

To all my colleagues in the Department of Orthodontics, particularly my classmates Dr. Moza and Dr. Mahmoud thank you for your continuous support.

DECLARATION

I declare that all the content of the thesis is my own work. There is no conflict of interest with any other entity or organization.

Name: Fadi Iyad Elshafee

Signature:

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1. INTRODUCTION

Assessment of orthodontic treatment outcomes during clinical training has been used as one of the criteria for evaluating advanced orthodontic education. Assessing clinical training in advanced orthodontic specialty education programs is a useful and necessary process since it provides information regarding its effectiveness in qualitative and quantitative manners (Eliades and Athanasiou, 2005). Although many methods can be used to evaluate clinical training outcomes regarding orthodontic treatment, evaluation of improvement and correction of malocclusions by means of properly designed, validated and widely used indices constitutes a common method.

Among the many popular indices used, Peer Assessment Rating (PAR) index and Index of Complexity, Outcome and Need (ICON) constitute valid, reliable and user-friendly methods for assessing malocclusion severity and occlusal complexity in relation to the need and outcome, respectively.

1.a. LITERATURE REVIEW

1.a.1. FACTORS INFLUENCING OUTCOME OF ORTHODONTIC TREATMENT

Many factors contribute to the final outcome of orthodontic therapy. This explains why the results of treatment are superior in some cases as opposed to others.

Primary factors in this context are correct diagnosis, type of mechanotherapy, severity of malocclusion, treatment plan, presence of craniofacial anomalies, level of cooperation of the patient, expertise of the operator, etc. (Richmond et al., 1993; Richmond et al., 1992b; Fox et al., 1997). Great variability has been demonstrated from clinician to clinician and patient to patient even though some of the previously used parameters remained the same.

Since patients are the beneficiaries of orthodontic treatment, their satisfaction with the post-treatment result is of the outmost importance. Therefore, patients' perception towards the goal of orthodontic therapy as well as their chief complaint should be seriously taken into consideration during treatment planning and addressed as much as possible. At the end of orthodontic therapy, both patients' and clinicians' goals should have been fulfilled regarding facial esthetics, function of the stomatognathic system, and morphology of occlusion. Less than ideal treatment outcomes maybe be justified in cases in which the severity of initial malocclusion, patient's health compromising conditions, and biomechanical limitation could not be overcome.

Ishikawa (1985) described the factors influencing the treatment by a fish-bone diagram (Figure 1). He mentioned different factors. These factors could be related to

the orthodontic problem itself like treatment difficulty, type of malocclusion, treatment need, cooperation and residence (e.g., urban or rural). Factors related to working methods mentioned were operator (e.g., specialist or general practitioner), treatment (e.g., corrective or interceptive), investment (e.g., attendances, duration and chair-side time), and mechanotherapy (e.g., fixed or removable appliance). He also discussed under the title measurements evaluation of reliability and validity. On the right side of the fish-bone diagram he placed effect of these factors on reduction in treatment need, degree of success, treatment stability, treatment desire and amount of deviation from ideal tooth relationships.

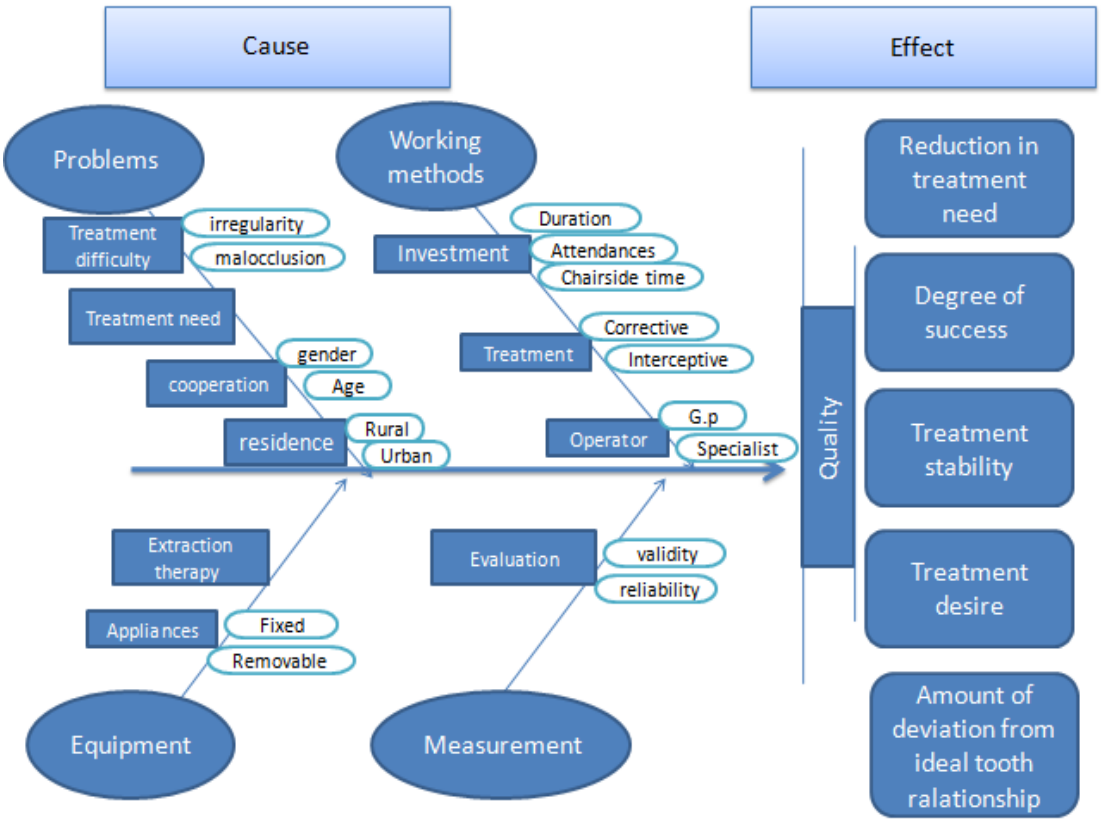

Figure 1. Factors influencing orthodontic treatment. (Modified from Ishikawa, 1985)

1.a.2. CRITERIA AND METHODS FOR ASSESSING ORTHODONTIC TREATMENT OUTCOME

Evaluation of orthodontic treatment outcome is important for justifying its necessity, its funding by private or third party providers, time invested by both patient and clinician, its effect on dentofacial esthetics, occlusal morphology and function as well as the long-term retention and stability of the results (Richmond 2008).

According to Berg (1991), orthodontic treatment can be assessed by means of the following criteria:

a. Occlusion

b. Function of the stomatognathic system

c. Facial esthetics and dental views of the patient and/or clinician

d. Short-term and long-term stability of the treatment occlusal outcome

e. Iatrogenic treatment effects.

Such, highly subjective criteria in many instances need to be objectively evaluated in order to assess treatment outcomes for the above mentioned aspects.

Following is a brief discussion about some of the criteria of assessment of orthodontic treatment outcome.

Function of the stomatognathic system

Based on epidemiological studies, people with malocclusion are more than people with functional disorder of the stomatognathic system. Few associations have been established between malocclusion or functional occlusion and signs and symptoms of temporomandibular disorders**.**

Helm et al. (1984) concluded that the untreated morphologic traits of malocclusion did not seem to predispose to tooth loss or functional disorders of the masticatory system as reported at the age of 30 years.

For the sake of evaluation and comparison, a list of criteria for orthodontic treatment results should include registration of the functional situation, with specific reference to functional disorders of the stomatognathic system (Helm et al., 1984; McLain et al., 1985; Berg, 1991, Gesch et al., 2004).

Esthetics

Evaluating esthetics from either orthodontist's or patient's point of view is subjective. Many factors could affect this judgment like social, cultural, geographical, psychological and racial backgrounds. Dentofacial characteristics have many variables to be taken in account. Keeping the score system as simple as possible appear to be more useful than a complex index evaluating a large number of variables. An example of occlusal indices that considers esthetics as a parameter in addition to occlusion is the Index of Complexity, Outcome and Need (Brook and Shaw 1989, Macgregor 1970).

Stability

In the end of orthodontic treatment, it is essential to have a stable result as the patient invested time, money, and effort during the treatment. Is it really enough to judge the retention factor after one year only? However, it is not easy to judge it after a very long time.

Berg (1991) recommended 10 years follow-up as a reasonable time for evaluating long term retention.

Iatrogenic treatment effects

The criteria of orthodontic treatment results should include the possibility of having iatrogenic effects that could happen as a result of the treatment. These may include root resorption, which may be generalized or mild. Enamel decalcification and white spots lesions are other important consequences that could be found. Iatrogenic enamel damage during bracket removal and alveolar bone changes should be also considered (Graber et al., 2004, Janiszewska-Olszowska et al., 2014; Nayak Krishna et al., 2013).

1.a.3. OCCLUSAL INDICES FOR ASSESSING ORTHODONTIC TREATMENT OUTCOME

Occlusal indices are tools developed in order to quantify occlusal traits in an objective way. According to Shaw et al. (1995) occlusal indices have many uses including the following:

- Classifying, planning and promoting treatment standards;
- Assisting general dentists and pediatric dentists to identify patients with orthodontic treatment need;
- Identifying patient prognoses and obtaining patients' informed consent, informing them of the risks and treatment stability in both severe and borderline cases;
- Assessing the difficulty of the treatment that a particular patient should follow
- Assessing the results of the treatment.

Occlusal indices could be also used for research, audit, practice management and quality assurance in orthodontics (Daniels and Richmond, 2000). A well-developed occlusal index should be reliable (indicate reproducibility) and valid. Validity means an index measures what it claims to measure (e.g., determination of treatment need) (Carlos, 1970) or outcome (Richmond et al., 1992a). Indices should be able to identify people not needing treatment (specificity) and those in need of treatment (sensitivity). An index should be quick and easy to use, acceptable to cultural norms, and finally be adaptable to available resources (McGuinness and McDonald, 1998; Borzabadi–Farahani, 2011). Occlusal indices may be divided and used as diagnostic, epidemiologic, orthodontic treatment need or treatment outcome, and orthodontic treatment complexity (Shaw et al., 1995) (Table 1).

Occlusal indices which may be used for assessing orthodontic treatment outcome are the following:

Dental Aesthetic Index (DAI)

Although this index is used mainly for measuring orthodontic treatment need (Jenny et al., 1980; Onyeaso and Begole 2006b; 2007; Baca- Garcia et al., 2004) it could be used indirectly to evaluate treatment outcome by measuring the difference in treatment need at the end of the treatment. The Dental Aesthetic Index (DAI) uses criteria to evaluate the esthetic aspects of occlusion. Despite it reflects mainly North American cultural, esthetic, and psychosocial values, it has been accepted by the World Health

Table 1. Different types of occlusal indices (Borzabadi-Farahani, 2011).

Diagnostic indices	Angle classification system (Angle,1899) Incisal categories (Ballard and Wayman, 1964) Five-point system (Ackerman and Proffit, 1969)
Epidemiologic indices	Index of tooth position (Massler and Frankel, 1951) Malalignment index (Van Kirk and Pennel, 1959) Occlusal feature index (Poulton and Aaronson, 1961) The Bjork method (Bjork et al., 1964) Summer's occlusal index (Summers, 1971) The FDI method (Baume et al., 1973) Little's irregularity index (Little, 1975)
Orthodontic treatment need indices	Handicapping Labio-lingual Deviation Index (HLD) (Draker, 1960; 1967) Swedish Medical Board Index (SMBI) (Swedish Medical Health Board, 1966; Linder-Aronson, 1974; 1976) Dental Aesthetic index (DAI) (Cons et al., 1986) Index of Orthodontic Treatment Need (IOTN) (Brook and Shaw, 1989) Index of Complexity, Outcome and Need (ICON) (Daniels and Richmond, 2000)
Orthodontic treatment outcome indices	Peer Assessment Rating index (PAR) (Richmond et al., 1992a) Index of Complexity, Outcome and Need (ICON) (Daniels and Richmond, 2000)
Orthodontic treatment complexity indices	Index of Orthodontic Treatment complexity (IOTC) (Llewellyn et al., 2007) Index of Complexity, Outcome and Need (ICON) (Daniels and Richmond, 2000)

Organization as a screening tool (Parker, 1998). DAI links clinical and esthetic components, mathematically, to produce a single score (Cons et al., 1986). DAI is based on a social acceptability scale of occlusal conditions, the scores can be rank ordered on a continuous scale and can differentiate cases within severity levels. The major limitation of DAI is the lack of assessment of occlusal anomalies such as buccal crossbite, impacted teeth, centre-line discrepancy, and deep overbite. It also does not account for missing molars (Borzabadi–Farahani, 2011).Therefore the esthetic assessment of DAI is limited (Onyeaso and Begole, 2007). DAI shows reliability and its validity has been confirmed (Beglin et al., 2001).

Peer Assessment Rating Index (PAR index)

The concept of Peer Assessment Rating index (PAR) is to assign a score to various occlusal traits which make up a malocclusion. It contains the scores of seven individual traits including alignment of upper and lower anterior segment, right and left buccal occlusion, overjet, overbite and centerline. The traits have been weighted to reflect opinions of a panel of 74 dentists in Great Britain according to the severity of malocclusion (Richmond et al., 1992b). The individual scores are summed to obtain an overall total, representing the degree a case deviates from normal alignment and occlusion. The difference in scores between the pre-treatment and post-treatment cases reflects the degree of improvement and, hence, the level of success of treatment (Richmond et al., 1992a).

PAR is a widely used occlusal index that is characterized by good validity and reproducibility (Richmond et al., 1992a; DeGuzman et al., 1995). It could be used for measuring treatment outcome in extraction and non-extraction cases (Holman et al.,

1998), fixed or removable or functional appliances cases (Kerr et al., 1993; Wijayaratne et al., 2000), and orthognathic surgery cases (Jeremiah et al., 2012; Templeton et al., 2006). Kindelan and Jenkins (2008) modified PAR index to produce an index of operator efficiency based on reduction in PAR score relative to treatment duration which could be important for clinical governance purposes. PAR index has limitations as it does not consider several malocclusion aspects such as angulation of upper anterior teeth, root parallelism, spacing and crowding of the buccal segment, facial esthetic, and iatrogenic effects of the orthodontic treatment (Mascarenhas and Vig, 2002; Richmond et al., 1993b). Moreover the potential for long-term relapse is not considered along with psycho-social attitudes, skeletal aspects, functional occlusion, periodontal health, root resorption, patient satisfaction or patient compliances (Dyken et al., 2001). The main problem related to the generic weighting system in this index (Hamdan and Rock 1999) encouraged DeGuzman et al. (1995) to adapt PAR index with improved weighting to be use with the North American context. Also PAR index may not be suitable to be utilized with mixed dentition and adjunctive orthodontic treatment modalities (Fox, 1993).

On the other hand PAR has many strength points. It is easily applied and used by non-specialized staff and also by dentists, following their calibration and training (Richmond et al., 1993; 1995). The use of PAR can set orthodontic treatment standards and facilitate self-evaluation. Its seven components are compound variables (assessment of buccal occlusion takes into consideration crossbite, lateral open bite and cuspal interdigitation, and reading overjet as positive and negative overjet) (Birkeland et al., 1997). A special PAR scale developed by Richmond et al., (1992a) makes it user friendly for application in most malocclusions (Figures 2 and 3).

Figure 2. The PAR ruler.(Richmond et al., 1992a; published with permission)

CASE NUMBER	Pre-treatment											
PAR COMPONENTS	RIGHT									LEFT	WEIGHTED TOTAL	
Upper anterior segments	3-2		2-1		1-1		1-2		2-3		X1	
Lower anterior segments	3-2		2-1		1-1		1-2		2-3		X1	
Buccal occlusion	Antero-posterior				Right			Left			X1	
	Transverse				Right			Left			X1	
	Vertical				Right			Left			X1	
Overjet	Positive						Negative				X6	
Overbite	Overbite						Openbite				X2	
Centre line											X4	
									TOTAL			

CASE NUMBER	Post-treatment											
PAR COMPONENTS	RIGHT									LEFT	WEIGHTED TOTAL	
Upper anterior segments	3-2		2-1		1-1		1-2		2-3		X1	
Lower anterior segments	3-2		2-1		1-1		1-2		2-3		X1	
Buccal occlusion	Antero-posterior				Right			Left			X1	
	Transverse				Right			Left			X1	
	Vertical				Right			Left			X1	
Overjet	Positive						Negative				X6	
Overbite	Overbite						Openbite				X2	
Centre line											X4	
									TOTAL			

PAR SCORE IMPROVEMENT			
Change in PAR Score		Greatly Improved	
% change in PAR score		Improved	
		Worse or No different	

Figure 3. PAR score matrix. (Richmond, 2008; published with permission)

Index of Complexity, Outcome and Need (ICON)

The Index of Complexity, Outcome and Need (ICON) was proposed using the judgment of an international panel of 97 orthodontists from nine countries (Italy, Spain, Germany, Norway, Hungary, Greece, Netherland, UK and USA) who provided subjective assessment on the need, complexity, improvement and acceptability by evaluating 338 study models (Daniels and Richmond, 2000). It has five highly predictive occlusal traits identified. They include esthetic component (Figure 4), crossbite, upper arch crowding/spacing, buccal segment antero-posterior relationship, and anterior vertical. ICON is a simple and quick index, takes about one minute to score each case without special tool except the esthetic component scale (Shaw et al., 1991a). ICON could be used for clinical governance, audit, research and decision making applications (Richmond et al., 2001).

ICON has been shown to be valid for assessing the complexity and outcome of orthodontic surgery cases (Savastano et al., 2003) as well as clinical outcomes and treatment improvement in orthognathic surgery cases (Templeton, 2006). It may be also used for measuring treatment need (Firestone et al., 2002) and even treatment failure (Fox and Chapple, 2004).

On the other hand, ICON has an important limitation as its esthetic component is heavily weighted (weighting of seven), which relies on the subjective opinion of the clinician (Borzabadi-Farahani 2011; Anthopoulou et al., 2014). This characteristic reduces the objectivity of the index and potentially affects the intra- or inter-examineragreements for different functions of the ICON (Figure 5) (Savastano et al., 2003; Koochek et al., 2001).

Figure 4. Aesthetic component, ten pictures ranking dental attractiveness. (Richmond, 2008; published with permission)

ICON	AC	Upper arch crowding	Upper arch spacing	Crossbite	Incisor overbite	Buccal segment	TOTAL
Pre-treatment	X7	X5	X5	X5	X4	X3	
Post-treatment	X7	X5	X5	X5	X4	X3	
Need		Complexity		Improvement		Acceptable	

Figure 5. ICON scoring matrix. (Richmond, 2008; published with permission)

American Board of Orthodontics Objective Grading System (ABO-OGS)

The American Board of Orthodontics (ABO) has been a main proponent of establishing an Objective Grading System (OGS) to evaluate post-treatment results. The American Board of Orthodontics Objective Grading System (ABO-OGS) index is an evaluation method of the final occlusion with eight criteria that contribute to ideal static occlusion and dental arches (Figure 6).

To make the measuring process more reliable, a measuring instrument was introduced and used for scoring each case (Figure 7) (The American Board of Orthodontics Objective Grading System for Dental Casts and Panoramic Radiographs revised June 2012). In addition, one of the ABO's objectives is to evaluate the knowledge and clinical competency of graduates of accredited orthodontic programs in North American (Nett and Huang, 2005). In 1999 the ABO initiated the official use of thisindex for orthodontists who want to take the ABO examination. This index has the advantage of being reliable and valid and it is able to discriminate between minor inadequacies of tooth position. On the other hand it is still necessary to evaluate the

	Criteria		Grading	Points lost
Model Analysis	Md	1st Order (alignment, rotations)	*	
		2nd Order (marginal ridges)	*	
		3rd Order (buccolingual inclination)	**	
	Mx	1st Order (alignment, rotations)	*	
		2nd Order (marginal ridges)	*	
		3rd Order (buccolingual inclination)	**	
	Occlusal Contacts	Buccal cusps Md	***	
		Lingual cusps Mx	***	
	Occlusal Relationships		****	
	Overjet		*/	
	Interproximal contacts		*//	
Pano	Root angulation		*///	
			TOTAL	

Criteria for Deducting Points

*	0 - 0.5 mm	0 pts.	*/	0 - 0.5 mm	0 pts.
	0.5 – 1 mm	1 pt.		0.5 – 1 mm	1 pt.
	>1 mm	2 pts.		>1 mm	2 pts.
**	0 – 1 mm	0 pts.	*//	0 - 0. 5 mm	0 pts.
	>1 – 2 mm	1 pt		0.5 – 1 mm	1 pt.
	>2 mm	2 pts.		>1 mm	2 pts.
***	0.1 – 1 mm	1 pt.	*///	0 – 1 mm	0 pts.
	>1 mm	2 pts.		>1 mm	1 pt.
****	1 - 2 mm	1 pt.		touching	2 pts.
	>2 mm	2 pts.			

Figure 6. American Board of Orthodontics Objective Grading System score sheet.(Pinskaya et al., 2004; published with permission)

panoramic radiograph for assessing the relative angulation of roots of maxillary and mandibular teeth (Casko et al., 1998). Another characteristic is that ABO-OGS index defines only the treatment outcome and does not consider the severity of malocclusion or difficulty of the treatment (Yang-Powers et al., 2002).

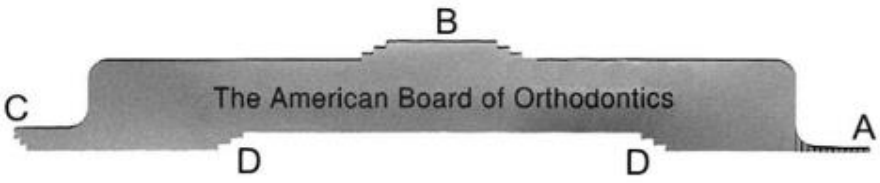

Figure 7. ABO measuring gauge. A, portion of gauge (0.5 mm thick, 1.0 mm wide) used to measure discrepancies in alignment, overjet, occlusal contacts, interproximal contacts, and occlusal relationships. When scoring overjet or interproximal spaces, 0 points are given if 0.5 mm dimension cannot be inserted, 1 point for inserting 0.5 mm dimention, and 2 points for the inserting 1.0 mm dimension. B, 1-mm steps on top of gauge used to measure mandibular posterior buccolingual inclination: <1.0 mm = 0 points, 1.0-2.0 mm = 1 point, >2.0 mm = 2 points. C, 1-mm steps on left side of gauge used to measure marginal ridge discrepancies: <0.5 mm = 0 points, 1.0-2.0 mm = 1 point, >2.0 mm = 2 points. D, 1-mm steps on bottom of gauge used to measure maxillary posterior buccolingual inclination: <1.0 mm = 0 points, 1.0-2.0 mm = 1 point, >2.0 mm = 2 points. (Pinskaya et al., 2004; published with permission)

1.a.4. SETTING STANDARDS IN ASSESSING ORTHODONTIC TREATMENT OUTCOME

Occlusal indices have a role in resource allocation and planning, identifying prospective patient, informed consent and promoting treatment standards (Shaw et al., 1995). These standards will help in evaluating the quality of treatment outcome and could be used for improving education, research work, audits, and self-evaluation for orthodontist. These standards may also highlight the practicing profile for individual practitioner and even a health care system within a country; some studies evaluated standards within different orthodontic clinics or hospitals in the United Kingdom (O'Brien, 1993; Richmond et al., 1993b; McMullan et al. 2003) or even

internationally, studies assessed the standards in Sweden (Richmond et al., 2001b), Norway (Richmond and Andrews 1993a), and Greece (Richmond et al., 2001c).

Regarding to the use of PAR in establishing benchmarks for practitioner to demonstrate high standards, the proportion of an individual's case load falling in the "worse/no different" category should be negligible, and the mean reduction should be as high as possible (e.g., greater than 70%). If the mean percentage reduction in PAR score is high and the proportion of cases that have "greatly improved" is also high (eg, greater than 40%), this indicates a practitioner is treating a great proportion of cases with a clear need for treatment to high standards (Richmond et al., 1992b; Richmond, 1993).

On the other hand using ICON to establish standards require the case to be acceptable in the end of the treatment if the score is less than 31 points (Richmond et al., 2001c), while in ABO-OGS the case with score less than 20 points will generally pass the ABO phase-3 clinical examination assessment and the case with score more than 30 will fail. With regard to the latter, a score of 26 is at borderline for passing (Abei et al., 2004).

1.a.5. PREVIOUS INVESTIGATIONS USING OCCLUSAL INDICES FOR ASSESSING ORTHODONTIC TREATMENT OUTCOMES IN ADVANCED ORTHODONTIC EDUCATION

In many postgraduate orthodontic programs, the treatment outcomes have been assessed by the use of occlusal indices like ICON, ABO-OGS and PAR.

Firestone et al. (1999) at the University of Bern used PAR index and found that there was no difference in treatment results between patient in the early treatment and late treatment groups who were treated with removable appliance.

Dyken et al. (2001) compared outcomes of cases treated by graduated students in Alabama University and cases treated by five local orthodontists which pass phase III of ABO examination. The results showed that the percent reduction in the mean PAR score for the ABO accepted cases was significantly more than that of graduated student-treated cases.

Mascarenhas and Vig (2002) used PAR index to measure malocclusion severity and post-treatment occlusal outcome in educational and private practice settings in Ohio. They also measured the quality of care depending on post-treatment PAR, percentage of PAR reduction, and treatment duration. It was found that there was no statistically significant differences regarding occlusal outcome between both groups, but treatment duration was significantly longer in private practice clinics.

Yang-Power et al. (2002) use the ABO-OGS assessment to study treatment outcome of orthodontic patients at the University of Illinois at Chicago and compared it with the outcome of cases treated at five private clinics of the city. The investigation provided suggestions on how university cases could be finished to a higher level of quality and how other samples could be evaluated to raise the level of orthodontic treatment outcome.

Pinskaya et al. (2004) established a multilayer baseline from Indiana University using a Comparative Clinical Assessment (CCA) method to assess facial form, dental esthetic, vertical dimension, arch form, periodontium preservation, root resorption and treatment duration. The sum of CCA and ABO-OGS scores were defined as the

clinical outcome. This study assessed the cases whose treatments started in 1998 and finished in 2000. Results indicated diminished quality of clinical outcome.

Cook et al. (2005) compared orthodontic treatment outcomes in educational and private practice settings in Tennessee by using ABO-OGS index and found that there were no significant differences between both groups regarding occlusal outcomes and duration of treatment.

Following the study of Pinskaya et al. (2004), specific changes in the clinical protocol were applied at Indiana University. A follow-up study was done by Knierim et al. (2006) to assess the clinical outcome for the following three years (2001-2003) and the results showed improvement of treatment outcomes.

Another study done in Indiana University utilized ABO-DI (discrepancy index), which quantifies the severity of malocclusion, together with the ABO-OGS and CCA (Campbell et al., 2007). This investigation demonstrated problems in treating complex malocclusions in a graduate orthodontic program and suggested methods for increasing the quality of clinical outcomes.

In Sweden, PAR index was used to compare treatment outcomes between specialist and postgraduate clinics (Tofeldt et al., 2007). It was found that the percentage reduction in weighted PAR scores after treatment and at a 5-year follow-up did not differ significantly between the two kinds of clinics.

Vu et al., (2008) found that there was no significant relationship between treatment duration and clinical outcome as measured by ABO-OGS and CCA in a graduate orthodontic clinic.

In the University of Puerto Rico treatments at the orthodontic graduate program clinic were assessed using the ABO-OGS. It was found that 53% of complete cases obtained a potentially passing score (ABO-OGS<30 points) (Santiago and Martinez, 2012).

A study at the Aristotle University of Thessaloniki, Greece (Pariskou, 2013) assessed the occlusal outcome of orthodontic treatment performed at the postgraduate orthodontic program clinic during the periods of 1998-2003 and 2004-2009 using PAR and ICON indices. The results showed that high standards of orthodontic care were provided in the clinic and these remained constant throughout the years. The outcome of orthodontic treatment was not correlated to gender and age of patients, the number of postgraduate students conducted the treatment, and the presence or absence of tooth extractions in the treatment plan. On the contrary the severity of initial malocclusion was found to be positively correlated with the treatment outcome. When the treatment plan included extractions and there were more than one postgraduate student involved in the therapy, there was a significant lengthening of treatment duration.

Mislik et al. (2016) compared treatment outcomes in university vs private practice settings with Class I patients using the ABO-OGS. They found that patients can receive similar quality of orthodontic treatment in a private practice and a university clinic. The orthodontists in the private practices were more successful in placing the roots properly, whereas the orthodontic residents accomplished better torque control of the posterior segments and better marginal ridges.

Postgraduate clinical training constitutes an important component of orthodontic specialty education. Assessment of occlusal treatment results of comprehensive orthodontic therapy performed at an educational institute will always provide

directions to future standards and improvement for postgraduate training in case of need. Such evaluations are also critical aspect of clinical audit.

1.b. AIM

The aim of the present investigation was to evaluate the outcome of comprehensive orthodontic treatment performed by means of fixed appliance at an educational institute in Dubai, United Arab Emirates.

2. MATERIALS AND METHODS

During the period of 2008 – 2012, Boston University - Dubai established and administrated a Master of Science in Orthodontics program. As part of this program, patients were treated in the Orthodontic Clinic by residents under faculty supervision. When Boston University – Dubai discontinued its function, Dubai School of Dental Medicine (presently Hamdan Bin Mohammed College of Dental Medicine) was founded in 2012 and became responsible for the retention follow-up as well as continuation of treatment of orthodontic patients of the former institution.

2.a. SAMPLE

The records of all patients who received comprehensive orthodontic treatment by means of fixed edgewise appliances in both dental arches at Boston University -Dubai were screened in order to identify those who fulfill the following inclusion criteria:

a. Healthy patients without a history of systemic diseases (which may have an impact on orthodontic treatment like diabetic mellitus and bone diseases), craniofacial anomalies, and cleft lip and/or palate.

b. Patients with permanent dentition at the beginning of their orthodontic therapy.

c. Patients with complete record files and study models of good quality.

Patients who had orthognathic surgery, patients with cleft lip and/or palate, and patients with previous orthodontic treatment were excluded. Finally thirty (30) consecutive cases (22 females and 8 males) were included in this study.

2.b. METHODS

PAR and ICON indices were calculated at the beginning and end of orthodontic therapy using the initial and final sets of models, respectively. The investigator (FIE) was blinded as to measurements of the indices and elaboration of the data.

The investigator was trained and calibrated in using the PAR and ICON indices by attending a relevant course held in December 2013 at Cardiff University, Wales, United Kingdom (Appendices 1-3).

All data were entered in an Excel file according to a specific format and patients' data confidentiality was ensured.

2.c. STATISTICAL ANALYSIS

Data were entered in computer using a special statistical program (Statistical Package for Social Science), Windows version 20.0 (SPSS Inc., Chicago, IL, USA). Measurements were tested for normality by using Shapiro-Wilk test which was validated for small sample size. A cross-tabulated test was used to examine the independency between categorical variables and statistics was performed using chi-square test for assessing of association. Where two or more continuous independent variables were examined, t-test and analysis of variance (ANOVA) were used if the data were normally distributed. Pearson coefficient correlation was used to test the relations between variables, paired t-test was used to assess the reliability and consistency of the investigator. P-value of less than 0.05 was considered significant in all statistical analyses.

Table 2. Reliability test of consistency of investigator's readings by using paired t-test.

Pairs	Mean difference	Std. Error Mean	95%CI		p-value
			Lower	Upper	
Initial PAR1 & Initial PAR2	-0.13	2.13	-1.26	1.0	0.817
Final PAR1 & Final PAR2	-0.07	1.07	-0.69	0.55	0.807
Initial ICON1 & Initial ICON2	-0.94	5.11	-3.66	1.78	0.474
Final ICON1 & Final ICON2	-0.71	1.86	-1.79	0.36	0.174

To test the assumption that the investigator read consistently the materials, a calibration test was done by using pair t-test after blindness and random selection were considered. As shown from the p-values of Table 2, the reliability of the investigator was confirmed.

3. RESULTS

The average age of the sample at the beginning of orthodontic treatment was 19.3 years (SD = 7.9 years). The average duration of orthodontic treatment (initial and final study models) was 17.7 months (SD = 5.8 months).

All variables, namely initial PAR, final PAR, initial ICON and final ICON were normally distributed.

Table 3 presents PAR and ICON values before and after orthodontic therapy. The mean value of initial PAR score was 19.4 (SD = 12.49), the mean value of final PAR score was 4.63 (SD = 2.47), the mean value of initial ICON was 53.96 (SD = 23.78) and the mean value of final ICON was 19.06 (SD = 6.19), respectively.

Table 3. PAR and ICON values before and after treatment.

Variable	**Mean**	**SD**
Initial PAR	**19.43**	**12.49**
Final PAR	**4.63**	**2.47**
Initial ICON	**53.96**	**23.78**
Final ICON	**19.06**	**6.19**

The rate value of PAR reduction (improvement) was 76.17% (Table 4).

Table 4. Calculation of rate of PAR reduction.

Calculation of rate of PAR reduction

$$\text{Reduction in PAR} = \text{Start PAR - Finish PAR} = 19.43 - 4.63 = 14.80$$

$$\text{Percentage reduction} = \frac{\text{Reduction in PAR}}{\text{Start PAR}} \times 100$$

$$= \frac{14.80}{19.43} \times 100 = 76.17\%$$

Based on PAR index interpretation (Appendix 4), PAR treatment acceptability descriptive analysis showed that 17 cases (56.7%) were treated to an ideal occlusion, 12 cases (40%) to an acceptable occlusion and only one case (3.3%) presented unacceptable treatment outcome (Figure 8).

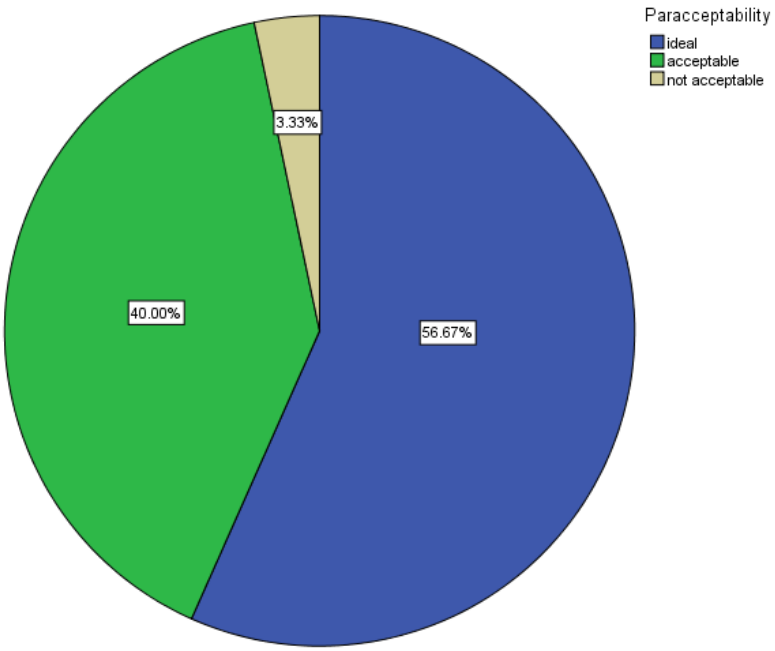

Figure 8. Treatment acceptability according to PAR Index.

Based on ICON index interpretation (Appendix No. 5), ICON treatment analysis shows 29 cases (96.7%) had acceptable treatment while only one case (3.3%) presented unacceptable treatment.

PAR and ICON changes were found statistically significant ($p<0.001$) (Table 5).

Table 5. Difference between initial PAR and final PAR as well as between initial ICON and final ICON evaluated by means of paired t-test.

	Paired difference					t	Sig. (2-tailed)
	Mean	SD	SE	95% Confidence Interval of the Difference			
				Lower	Upper		
Initial PAR- Final PAR	**14.8**	**12.81**	**2.33**	**10.01**	**19.58**	**6.32**	**.000**
Initial ICON- Final ICON	**34.9**	**24.22**	**4.42**	**25.85**	**43.94**	**7.89**	**.000**

ICON and PAR improvements showed a strong linear relation in correlation coefficient test ($r=0.874$ and $p<0.001$) indicating that whenever there is PAR improvement there will be ICON improvement as well (Figure 9).

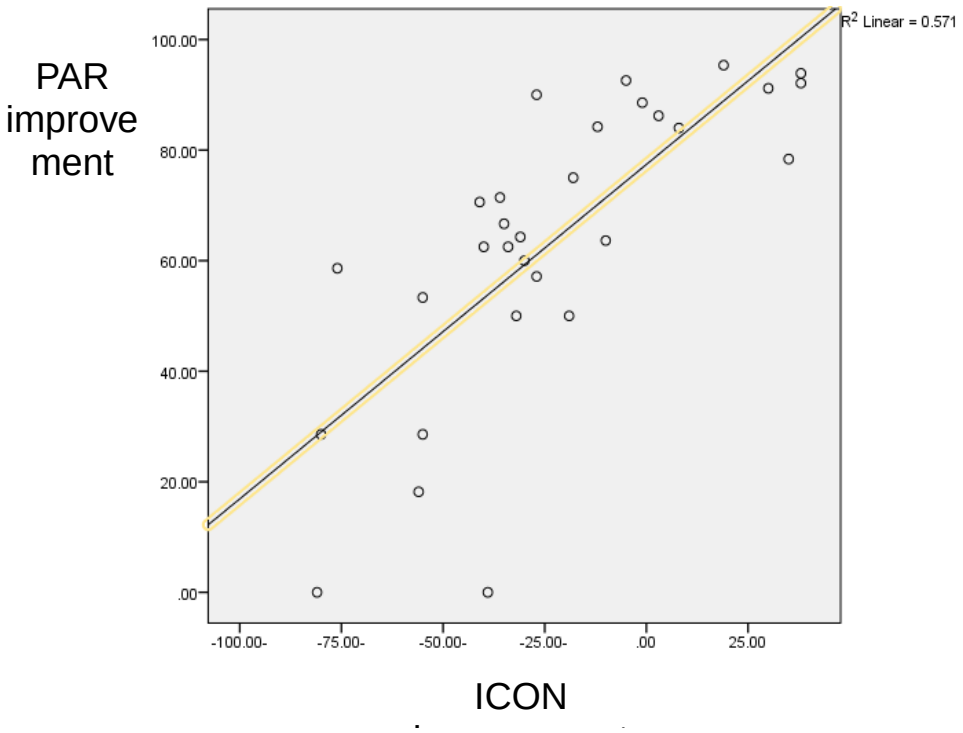

Figure 9. Correlations between PAR improvement and ICON improvement**.**

Based on PAR index interpretation (Appendix 4), Figure 10 shows that 46.67% of patients felt into the "greatly improved" category, 36.67% in the "improved" category, and 16.67% in "worse/no different" category.

Based on ICON index interpretation, Figure 11 shows that 23.33% of patients felt in the "greatly improve" category, 20% in "substantially improved" category, 36.67% in "moderately improved" category, and 20% in "minimally improved" category.

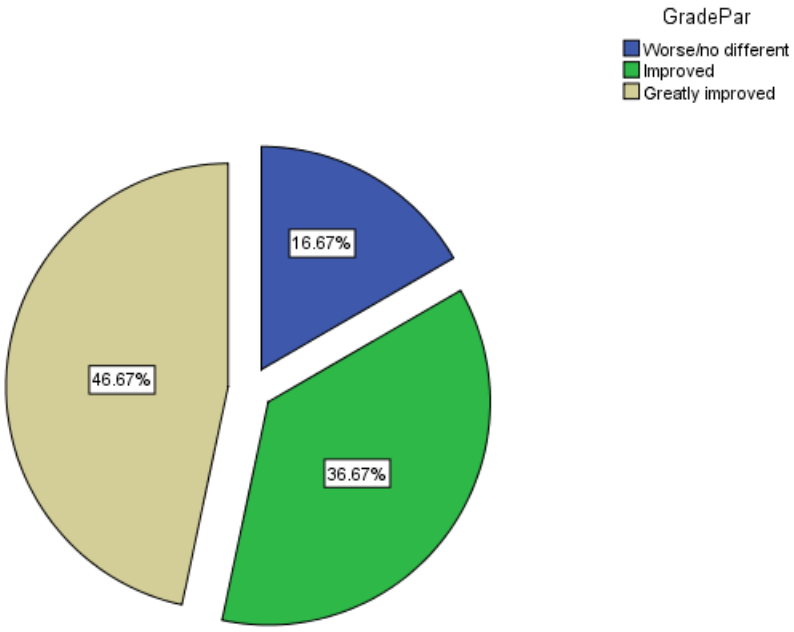

Figure 10. PAR index grades.

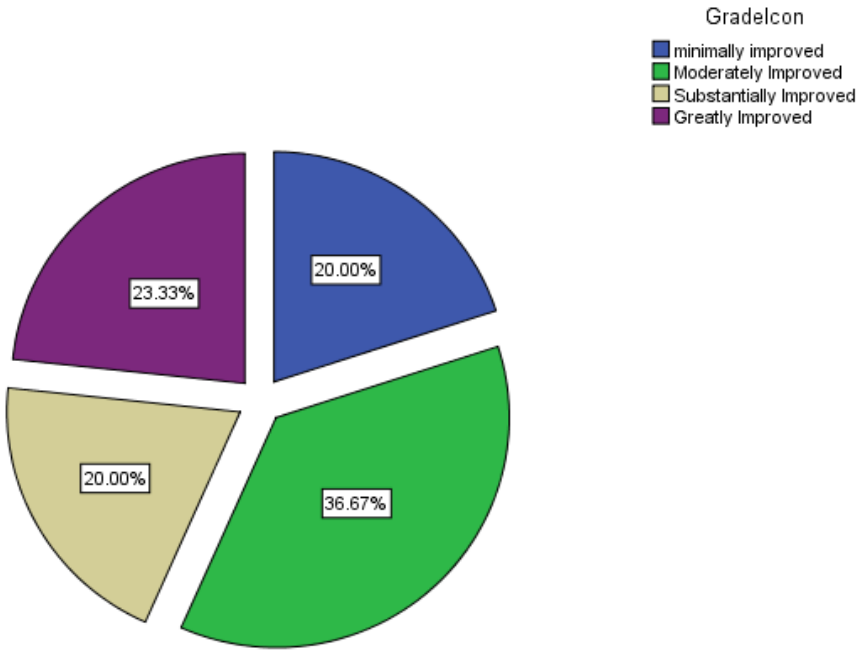

Figure 11. ICON index grades.

PAR and ICON improvements were not related to treatment duration (p=0.195 and p=0.264) (Tables 6 and 7).

Table 6. Correlation between PAR improvement and treatment duration.

		PAR Improvement	**Duration (months)**
PAR Improvement	**Pearson Correlation**	**1**	**0.243**
	Sig. (2-tailed)		**0.195**
Duration (months)	**Pearson Correlation**	**0.243**	**1**
	Sig. (2-tailed)	**0.195**	

Table 7. Correlation between ICON improvement and treatment duration.

		ICON Improvement	Duration (months)
ICON Improvement	**Pearson Correlation**	**1**	**0.211**
	Sig. (2-tailed)		**0.264**
Duration (months)	**Pearson Correlation**	**0.211**	**1**
	Sig. (2-tailed)	**0.264**	

PAR and ICON improvements were found to be significantly related to initial PAR ($r=0.738$ and $p<0.001$) and initial ICON ($r=0.772$ and $p<0.001$) (Figures 12 and 13).

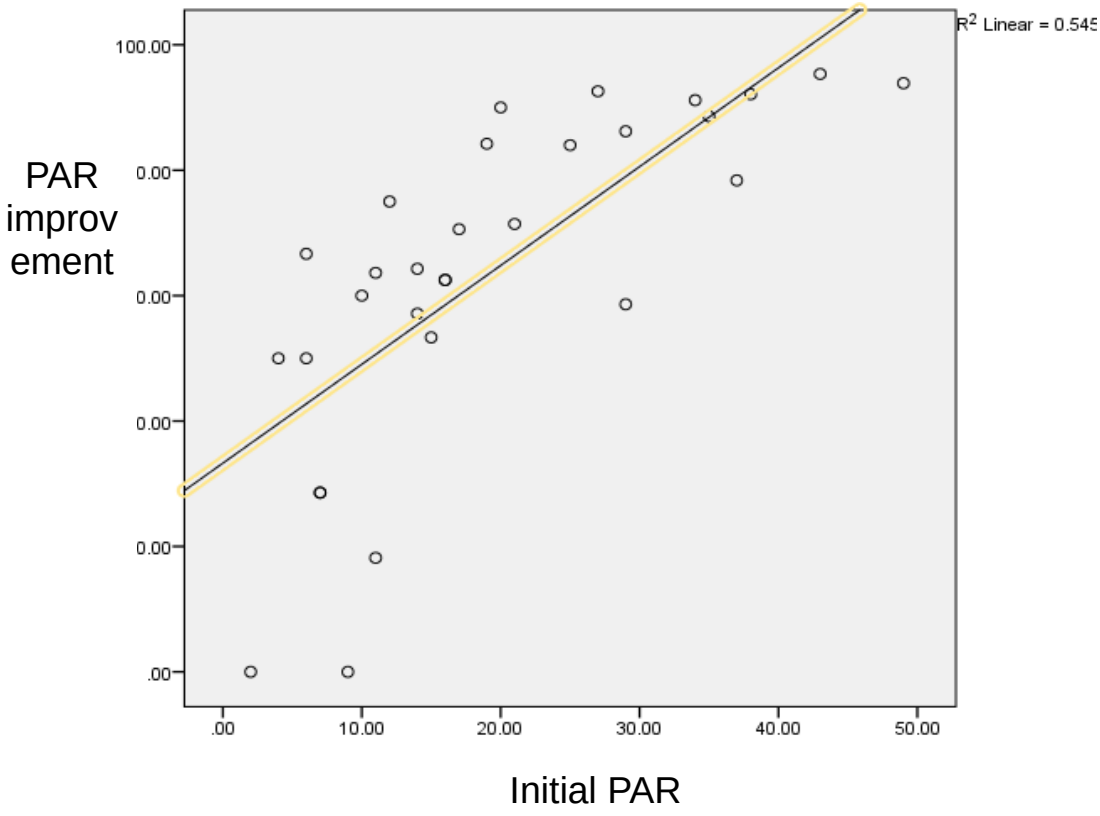

Figure 12. Correlation between PAR improvement and initial PAR score.

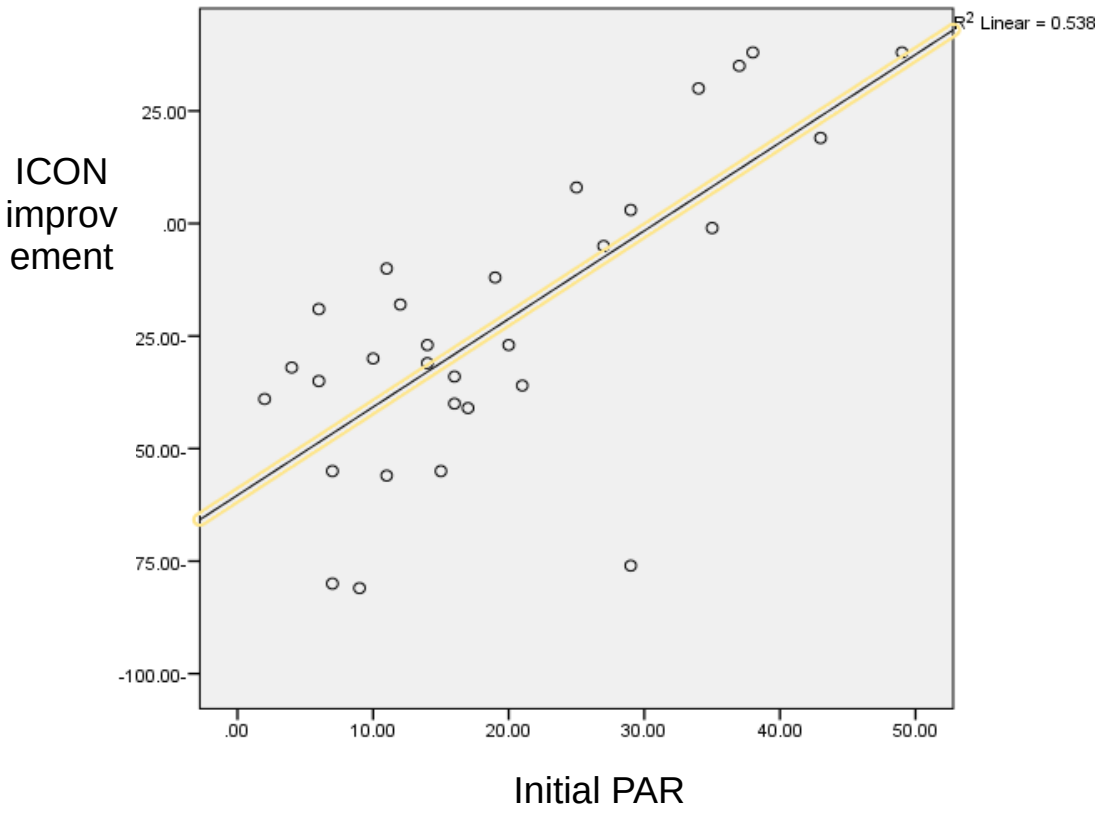

Figure 13. Correlation between ICON improvement and initial PAR score.

Initial PAR and ICON values were significantly related to treatment duration. Initial PAR (r= 0.415 and p=0.023), and initial ICON (r=0.408 and p=0.025) (Figures 14 and 15).

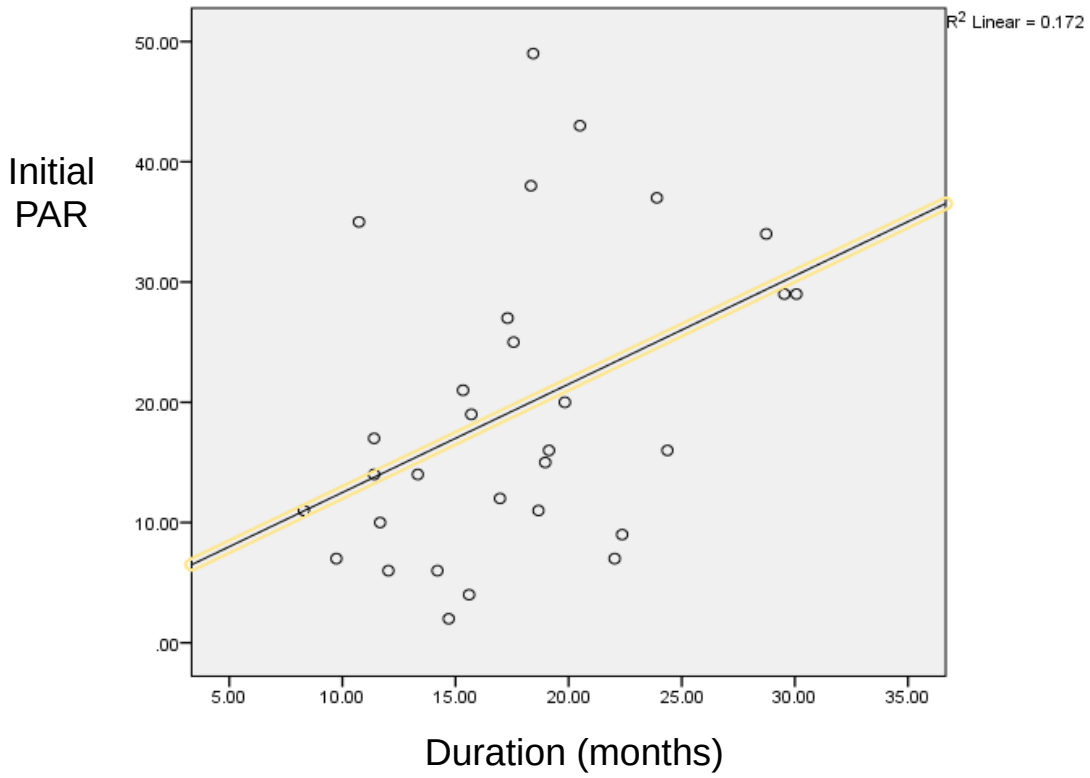

Figure 14. The relation between initial PAR and treatment duration.

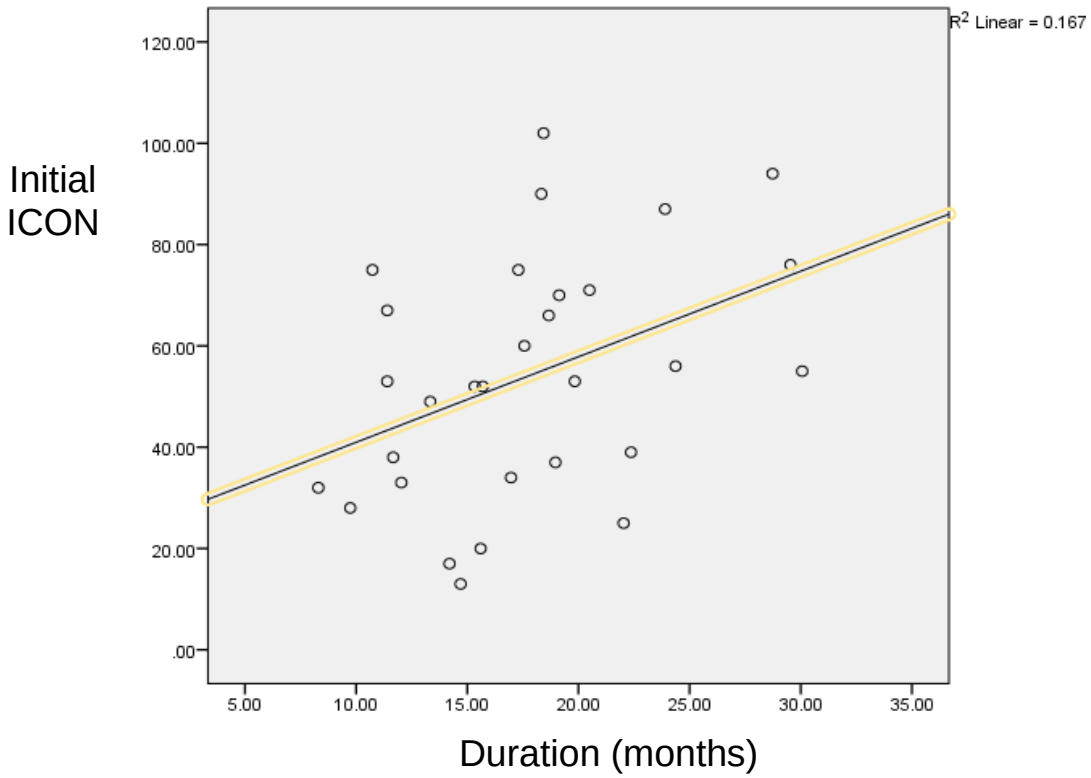

Figure 15. The relation between initial ICON and treatment duration.

Figure 16 shows that there is a statistically significant difference ($p<0.001$) between the three categories of PAR improvement in favor of the greatly improved group. It also shows a very low score of initial PAR in the "worse/no different" group.

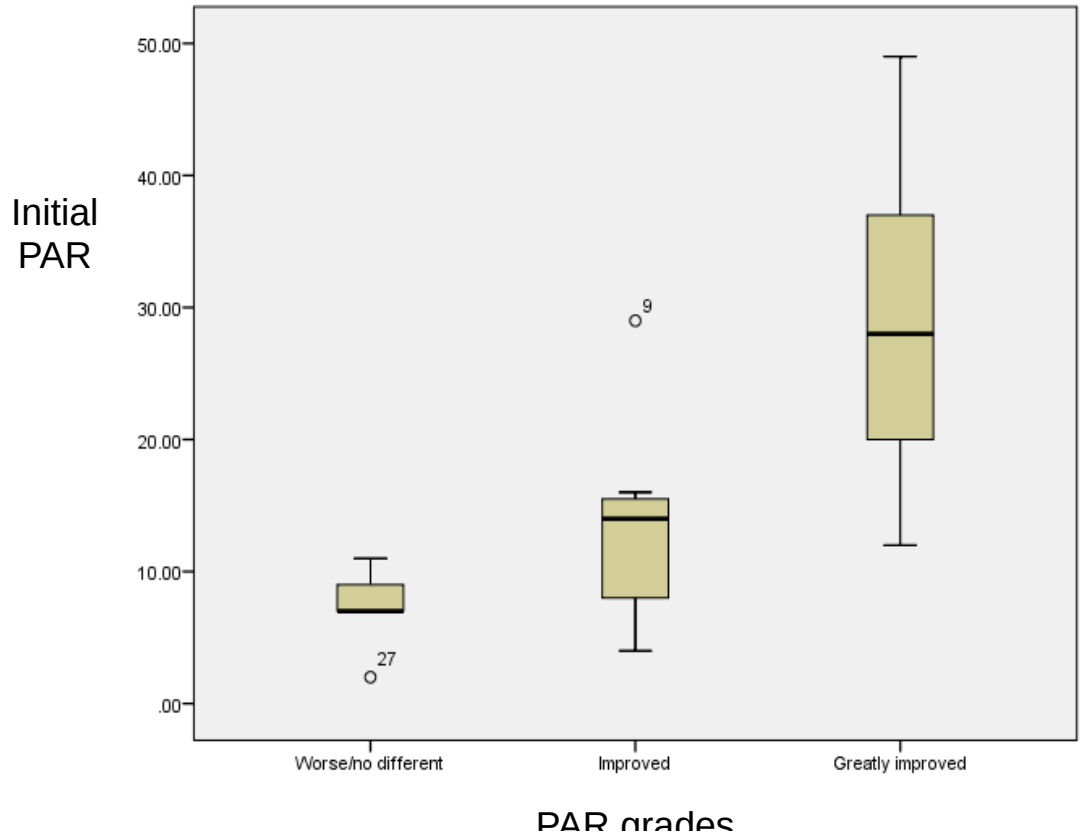

Figure 16. Simple Box plot between initial PAR and PAR grades.

4. DISCUSSION

Measuring the outcome of orthodontic therapy is an expanding field in orthodontics since it may contribute in justifying its need, cost and commitment of all parties involved. PAR and ICON indices are regarded as essential tools, not just as self-evaluation instruments, but also as means for evaluating large samples of patients. They could be used for quality control and setting standards as well as for educational improvement.

The present study assessed the occlusal outcomes in patients treated orthodontically by specializing dentists at a higher education institution in order to examine the quality of treatment delivered and for benchmarking standards.

Moreover, this study could serve as a baseline for comparing subsequent treatment results as part of internal clinical audit in the institution which is presently in the place of BU-D.

Assessment of occlusal treatment results of comprehensive orthodontic therapy performed at higher educational environment will always provide directions to future standards and improvement for postgraduate training**.**

The sample that has been used in this study consisted of patients who were treated with fixed appliances in both dental arches by means of the straight wire technique. After applying the inclusion criteria the total cases were 30, which are regarded as a relatively small size sample. This was due to the limited period that the orthodontic program existed in BU-D and the small number of orthodontic residents who attended it.

Scoring of the study casts was blinded by assigning a random number to each set of casts without the examiner being aware of patients' details and stage of therapy.

Also the computer program selected randomly 30 sets (16 initial and 14 final) to be re-examined for assessing method's error. The error of the method was assessed by measuring the models after one week for a washout period. The results showed significant correlation between the second and first reading thus indicating reliability of measurement reading.

The scoring investigator was calibrated in using the indices by attending a relevant course held in Wales in 2013 by one of the innovators of PAR and ICON indices, namely Professor Stephen Richmond.

These two indices are internationally acceptable and regarded as valid and reliable. PAR index has shown high validity and reliability (Richmond et al., 1992a). ICON validity was based on international opinion of 97 orthodontist from nine countries (Daniels and Richmond 2000). It shows validity in measuring outcome and complexity (Savastano et al., 2003) as well as treatment need (Firestone et al., 2002).

Many studies have used PAR index to assess occlusal outcome following orthodontic therapy (Dyken et.al., 2001; Birkeland et al., 1997; Firestone, 1999; Richmond and Andrews, 1993; Onyeaso and BeGole, 2006; Mascarenhas and Vig, 2002; Richmond, 1993). After its development, ICON has been also used for the same reason (Richmond et al., 2001c; King and Brudvik, 2010) and both indices used together have been similarly utilized (King et al., 2012a; King et al., 2012b; Mirabelli, 2005).

There are advantages in using both indices in a study like the present one. PAR assessed the cases from the aspect of how much these cases deviated from normal

occlusion before treatment and described the improvement that took place by means of percentage of PAR reduction and PAR acceptability thus assisting in setting and examining treatment standards. On the other hand, in addition to describing the outcome, ICON evaluated the degree of treatment need and complexity of the case before treatment. Therefore, to better describe the occlusal outcome of cases treated orthodontically by the residents at BU-D, both indices were used in order to examine it from different points of assessment. Furthermore, advantages in one index could compensate the disadvantages of the other index. For example PAR is not critical of final outcome because of its undue leniency on poor finishes and undue harshness on treatment with limited aims. ICON seem to require more stringent standard than PAR to attain "greatly improve" categorization (Fox et al., 2002). Also PAR can give more detailed view for single component, for example the overjet, while ICON addresses esthetics by including an esthetic component in addition to the occlusal component.

The mean initial PAR score in our study was 19.43, which is close to dental student groups in Firestone et al. (1999) study (21.0 and 21.3). And relatively smaller than other studies (Richmond and Andrews, 1993; Birkeland et al., 1997; Onyeaso and BeGole, 2006) (23.8, 28.7 and 23.83, respectively).The mean final PAR score was 4.63 which is smaller than PAR scores found in the studies of Birkeland et al. (1997) (6), Firestone et al. (1999) (8.3, 10.2 and 8.4, respectively).However, it was close to the findings of a postgraduate group of Firestone et al. (1993) study (5.3), similar to the one of Richmond and Andrews (1993) (4.4) and larger than the one of Onyeaso and BeGole (2006) (1.7).

The percentage of PAR reduction was 76.17%, which is very close to other similar investigations (Birkeland et al., 1997; Richmond and Andrews, 1993) (76.7 and 77.8, respectively). However, Onyeaso and BeGole (2006) presented a reduction of 86%.

Although the final PAR score indicated that 17 cases (56.7%) reached ideal occlusion and 12 cases (40%) reached acceptable occlusion, still this finding is not sufficient to show a high standard of treatment because the percentage of cases assigned to "worse/no different" was above 5%.

For more understanding of the results of PAR scores for this sample, differentiation should be made among three terms, categories of improvements, acceptability of occlusion and standards of treatment.

Categories of improvement depend on the percent of reduction from initial score to final score or the amount of points reduced due to orthodontic treatment. If the amount of PAR score reduction is 22 points or more, the case will classify as (greatly improved), and it will classify as (improved) if the percentage of PAR reduction is equal or greater than 30%. If the percentage of PAR reduction is less than 30% the case will lie under "worse or no difference".

In the present sample, and because of low initial PAR, the total reduction points were small leading to high number of cases (five cases) which were in worse or no different and resemble 16% of the cases.

The other manner by which PAR assesses treatment outcomes is by noting the acceptability of treatment. In this aspect there are three categories "ideal occlusion" if the final PAR score is less than 5, the second category is "acceptable" if the final PAR score is from 5 to 10, and "unacceptable occlusion" if the final PAR score is more

than 10 (Richmond et al., 1992a; b). Younis (1995) has proposed a value of 15 rather than 10 for the case to be “acceptable”.

These two ways of assessing the final results (i.e. categories of improvement and acceptability of occlusion) sometimes create confusion.

In the present study, it was interesting that five patients who ended with final PAR scores of2, 9, 9, 5 and 5, respectively, were actually from the improvement criteria and were categorized as “worse/ no different”. On the other hand from the acceptability criteria points of view, four of these cases are under “acceptable” occlusion, and the case with final PAR score 2 is under “ideal” occlusion. There is also a case with final PAR score 12 assigned the “improved category” from the improvement point of view, and “unacceptable” from the acceptability point of view.

The third way to interpret PAR scores is standards of treatment. Richmond et al. (1992a) proposed that to reach high standard orthodontic treatment, the mean PAR reduction should be greater than 70%, the number of cases allocated to the “worse/no different” category should be negligible (less than 5%) and the number of cases allocated to “greatly improved” should be high (for example greater than 40%).

In the present sample, the mean PAR reduction was 76.17%, cases allocated to the worse/no difference category was 16.67% and the cases allocated to “greatly improved” category was 46.67%.

Therefore, based on these criteria and because the number of cases allocated to “worse/no different” category is 16.67%,the treatment accomplished for this sample did not reach the high standard orthodontic treatment although PAR reduction was above 70% and cases felt in the “greatly improved” category was above 40%.

Considering the percentage of PAR reduction as the only criterion to reflect on the standards of treatment, the actual quality of orthodontic treatment that had been provided to these patients may not be evident, especially if the treated cases had low initial PAR score. It should be noted that the percentage of reduction depended on the initial PAR score, and whenever the initial PAR score was low (i.e. less than 22 points) the case could never be finished to the "greatly improve" category. This is demonstrated well in Figure 12 that shows by means of linear regression analysis between initial PAR and PAR improvement that 54.5% of PAR improvement explained by initial PAR measurement. It is also demonstrated in Figure 13 that shows from linear regression analysis between initial PAR and ICON improvement that 59.5% of ICON improvement explained by initial PAR.

It may be suggested that for more reliable standards of treatment, more emphasis should be given to the final PAR score in addition to the initial PAR score and amount of PAR reduction.

As both PAR and ICON indices show high validity and reliability as assessed by British and international panels of orthodontists, it is logic to show high correlation between both PAR improvement and ICON improvement scores as in Figure 9.

The mean value of initial ICON score for the present study was 53.96 which indicates moderate level of complexity (Appendix 5) similar to mixed dentition sample by King et al. (2010) in which it was 54.9 in comparison to Richmond et al. (2001) that was 69. Our score of 53.96 is above the ICON's cutoff for "treatment need" which means that these cases needed treatment, while the mean of final ICON score was 19.06, compared to Richmond (2001) that was 15.8 and with 33.6 in the mixed dentition sample of King et al. (2010).

This final ICON score places the sample under the “easy” group of complexity and “no need” group for treatment need (Appendix 5).

The outcome of orthodontic treatment of the present sample according to ICON shows that 20% “minimally improved”, 20% “substantially improved”, 23.33 “greatly improved” and 36.67 “moderately improved” thus verifying that all cases of this sample collectively presented different grades of improvement.

All the cases finished with acceptable occlusion except one which is the same case that shows unacceptable occlusion according to PAR index.

PAR and ICON improvements were not related to treatment duration and this means that whether the orthodontic treatment finished in a short or long duration it did not affect PAR or ICON improvement.

Finally, it should be taken into account the distinct limitation of ICON which is heavily weighted toward esthetic component, which is subjective because of absence of cutoff point and this leads to increased intra- and inter-examiner bias.

Regardless of the relatively small sample size that was examined in this investigation, there was a significant difference between the initial and final PAR and ICON scores indicating that the orthodontic residents of BU-D were able to improve the occlusion of their patients significantly.

5. CONCLUSIONS

Analysis and interpretation of the outcome of orthodontic therapy delivered by residents of the BU-D by means of the PAR and ICON indices concludes the following:

- According to PAR index scoring, 83.34% of patients were in the “improved” and “greatly improved” categories and only 16.67% were in the “worse or no different” category.

- According to ICON index scoring, all patients showed various degrees of improvement.

- There was a strong correlation between initial PAR score mean and PAR reduction that justifies the use of initial PAR as a good predictor factor for the final treatment acceptability.

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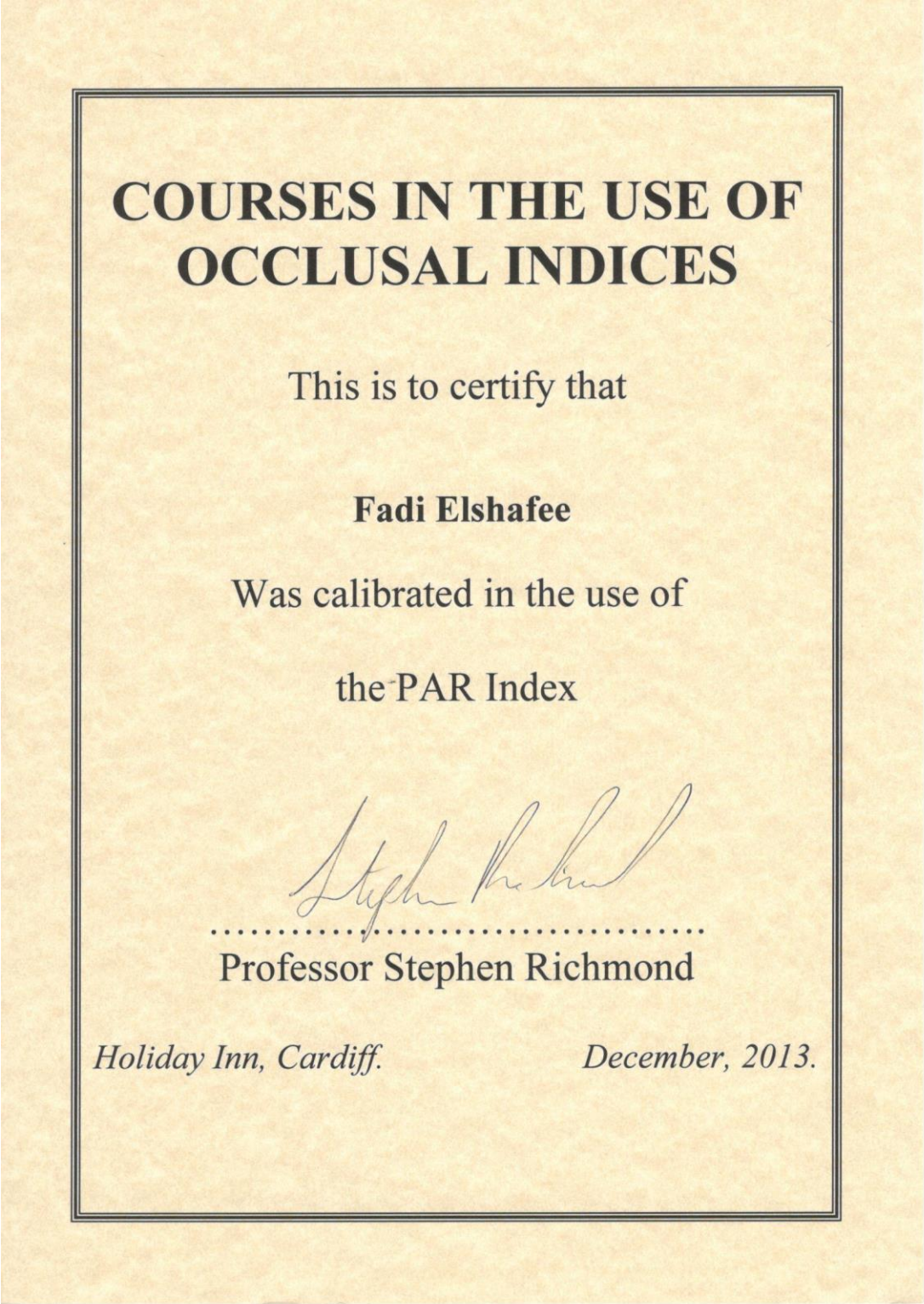
7. APPENDIX

Appendix I, II and III: Certificates of attending occlusal indices courses.

Appendix IV: Interpretation of PAR index.

Appendix V: Interpretation of ICON scores.

Appendix I



COURSES IN THE USE OF OCCLUSAL INDICES

This is to certify that

Fadi Elshafee

Was calibrated in the use of

the PAR Index

.....

Professor Stephen Richmond

Holiday Inn, Cardiff. *December, 2013.*

Appendix II

COURSES IN THE USE OF OCCLUSAL INDICES

This is to certify that

Fadi Elshafee

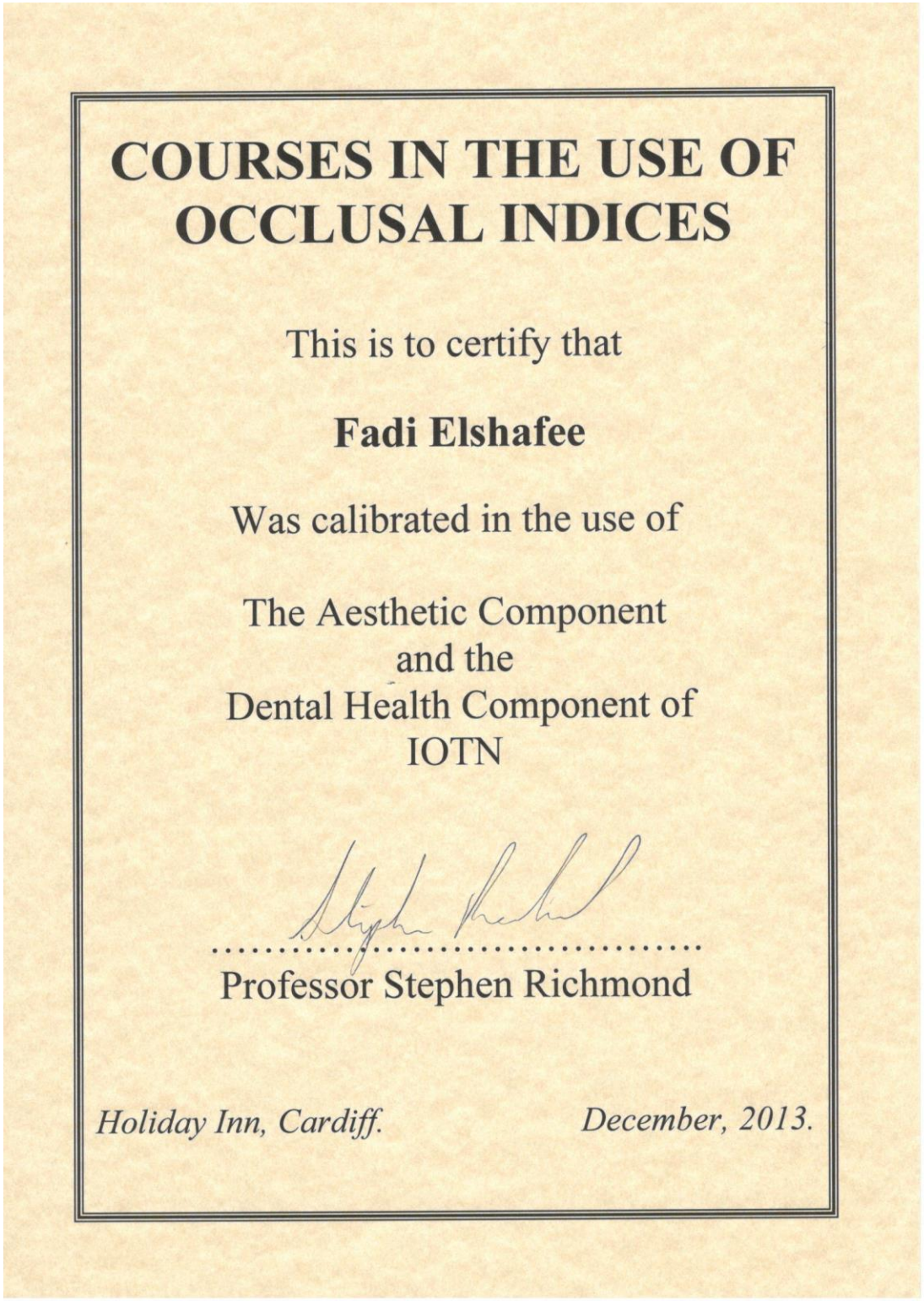
Was calibrated in the use of

The ICON index

Professor Stephen Richmond

Holiday Inn, Cardiff. *December, 2013*

Appendix III



COURSES IN THE USE OF OCCLUSAL INDICES

This is to certify that

Fadi Elshafee

Was calibrated in the use of

The Aesthetic Component
and the
Dental Health Component of
IOTN

.....

Professor Stephen Richmond

Holiday Inn, Cardiff. *December, 2013.*

Appendix IV. Interpretation of PAR index.

Need	**threshold**
Pretreatment need	**>32**
End treatment Acceptability	**threshold**
Ideal occlusion	**2 to 4**
Acceptable occlusion	**5 to 10**
Unacceptable	**>10**
Improvement Grade	**Score range**
Greatly improved	**>= 22 PAR point reduction**
Improved	**>= 30% PAR reduction**
Worse/No different	**<30% PAR reduction**

Appendix V. Interpretation of ICON scores.

Need and acceptability	**Threshold**
Pretreatment need	**>43 treatment need**
End treatment acceptability	**<31 acceptable**
Complexity grade (pretreatment)	**Score range**
Easy	**<29**
Mild	**29 to 50**
Moderate	**51 to 63**
Difficult	**64 to 77**
Very difficult	**>777**
Improvement grade **(pretreatment score – 4x post-treatment score)**	**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**