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President's Message

Sri Lanka Orthodontics Society

It is a great pleasure and privilege to write this message on the publication of the third edition of the Sri Lankan Journal of Orthodontics. I wish to thank the past presidents and the council members of the Sri Lanka Orthodontic Society for initiating and continuing the Journal.

I am very happy about the current professional development in the evidenced based practice while engaging research activities by clinicians in the field of orthodontics in Sri Lanka. This is evidenced with the marked improvement in the contribution of local research articles for the current edition of Sri Lankan Journal of Orthodontics when compare with the past editions. This highlights the current development in clinical practice in orthodontics seeking evidenced based approaches.

Further, I would like to express our pride and gratitude on the development and contribution of research work done by postgraduate students for the Sri Lankan Journal of Orthodontics.

I hope that this journal provides a great platform to share our Sri Lankan research findings with the clinicians universally.

I would like to express my gratitude to the chief editor of the Sri Lankan Journal of Orthodontics Prof. Mithran Goonewardene for his immense contribution towards this Journal and his generous contribution for the uplifting of professional activities of the Sri Lanka Orthodontic Society.

Also I am thankful to the members of the editorial board of this journal for fulfilling their tasks to produce successesful this 3rd edition of Sri Lankan Journal of Orthodontics. I am also grateful to local and international reviewers who have performed their duty in spite of their busy commitments to standardize the journal as peer-reviewed.

Dr. Rathnakumara Dissananyaka
President
Sri Lanka Orthodontic Society

Sri Lankan Journal of Orthodontics

Two years ago, the Sri Lankan Orthodontic Society held its scientific session in Colombo in somewhat strained circumstances. A number of local and international attendees presented excellent material and the collegiality and exchange of ideas was appreciated by all. The Sri Lankan Orthodontic Journal celebrated the publication of the second edition. Although there was some uncertainty of the immediate overall impact of Covid-19 transmission, little did we appreciate the global impact of the pandemic.

We have never seen such events as we have experienced over the past two years. The professional orthodontic community has been forced into lockdown and travel restricted. The professional meetings have been an essential component of our teaching and learning activities and the networking opportunities were most engaging, and an important element of our professional lives.

What has developed as a consequence of the pandemic is a radical change in the way we engage teaching and learning, modifications of our work habits, such as increases in application of telehealth activities.

We have seen individual lectures and total congresses delivered on- line and an extensive repertoire of speakers that historically were never readily accessible to smaller more isolated professional groups.

The international journals have continued to publish and there is an abundance of resources available to the entire international community. The Sri Lankan Orthodontic Journal has a small, enthusiastic group in their editorial team of Dr. Sheevani Wijeratne, Prof. Nishanthi Vithanaarachchi and Dr Ajith Premaratne and a number of national and international reviewers including Drs Sumithra Hewage, Crofton Daniels, Robert Hamilton, Nilantha Rathnayake and Prof. DYD Samarwickrama. They must all be congratulated for their excellent work and thanked for completing the Third Edition of the SLOJ which provides a broad range of topics of interest to local and international orthodontists. Moreover the publication of the articles on line ensure that this material is disseminated broadly.

In additional to the pandemic related issues, Sri Lanka is confronted with the most significant political and economic challenges that undoubtedly compromise all delivery of services including healthcare. We acknowledge the need for extraordinary efforts at this time and applaud all of those individuals providing service to the community under such stressful circumstances.

We eagerly await the progress towards resumption of normal activities and opportunities afforded to us to meet in person. After all, we value the interpersonal contact with the recipients of our care as healthcare providers and the also deeply appreciate meeting our colleagues and friends in person.

We look forward to the ongoing publications of the Sri Lankan Orthodontic Journal as it is one of the centre pieces of our Sri Lankan Orthodontic profession.

Mithran Goonewardene
Editor-in-Chief
SLJO

Clear Aligner Therapy - Overrated or overstated? A review

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INTRODUCTION

Tooth alignment using positioning appliances spurred the interests of orthodontists and general practitioners from the day it was introduced by Dr. Harold Kesling in 1946. He proposed the possibility of obtaining tooth alignment using a pliable rubber 'Tooth Positioning Appliance' which was formed on a model with desired tooth repositions (1). The original idea was explicitly reconnoitred over the years into the current day aligners employed in Clear Aligner Therapy (CAT).

There are two methods of performing CAT: analog or digital. In analog CAT, vacuum formed aligner trays are fabricated on a manually altered working models. This process is highly labour intensive and only recommended for very minor tooth movements but limitations in the manual technique have led to this method being almost obsolete. With recent application of digital CAT, more complex tooth movements can be planned using digital software platforms. This allows planning of an indefinite number of tooth positions and subsequent fabrication of aligner trays. Digital CAT could be fabricated either in-house or by commercial laboratories using digitized treatment planning. Most commercial CAT companies facilitate orthodontists' involvement in refining treatment plans through company-based technicians. While direct treatment planning by orthodontists is possible with some companies, this is subject to the orthodontist's geographical location, available facilities, technical literacy etc. As with any technical advancement this can turn into a double-edged sword, as direct-to-consumer CAT evades all levels of clinical surveillance as the process does not have a phase of face-to-face doctor patient consultation (2).

Orthodontics has advanced from achieving occlusal goals to improving patient's overall facial aesthetics. In contemporary orthodontics, diagnosis and treatment planning has progressed to firstly involve patient evaluation from the "outside in", rather than focussing on dental occlusal corrections. This process initially focusses on facial aesthetics (chin, midface, nose, lips and smile characteristics), function, gingival soft tissues and finally skeletal and dental hard tissues. Dental panoramic tomogram (DPT) and Lateral cephalograms (LC) are used to assess the root positions, pathology and cephalometric parameters which may outline a treatment outcome.

As with any appliance therapy, fundamental aspects of treatment are applicable to CAT. Therefore, the majority of CAT companies give allowance to upload patient pictures, intra and extra oral scans, LCs, DPTs and cone-beam computed tomography (CBCT) etc. Unfortunately, the majority of literature generated to emphasize various aspects of CAT fail to present a solid basis for case selection, scientifically assess treatment outcome or give evidence of post treatment stability.

It is prudent to investigate the literature that truly describe the scope of CAT based on the biomechanical viewpoint, so that the clinicians can better understand the biological aspects of CAT. Therefore, it is worth querying are these contemporary treatment planning and assessment methods constantly being employed in day-to-day CAT practice? And/or do they hold the same level of significance comparable to contemporary fixed appliance (FA) practice? Do the literature describing aspects of CAT studied based on sound methods? Are statements such as "at this point, there is no type of case that I would not consider treating with clear aligners" (3) or "I believe conventional braces will become obsolete over the next 10-15 years. We'll continue to follow the progress of aligner therapy and see if I'm right" (4) overstated?

In addition, this review will provide:

i. Aesthetic perception of CAT by adult patients
ii. Possible tooth movements with CAT,
iii. Forces and moments created with CAT,
iv. Efficiency, effectiveness, and treatment stability of CAT,
v. Adverse effects of CAT such as root resorption and enamel demineralization,
vi. Indications for specific patient populations where CAT could be employed and
vii. The popularity of CAT among orthodontists and general practitioners,
viii. Insight to the materials used in the construction of CAT.

Aesthetic perception of CAT by adult patients

Adult patients prefer less conspicuous orthodontic appliances only when it does not interfere with treatment outcome. Although the majority of adult patients request CAT for aesthetic reasons, CAT with multiple anterior or posterior attachments may not have aesthetic appeal over FA. Therefore, clear aligners without attachments and ceramic brackets are generally preferred over clear aligners with multiple attachments (23).

Predictability of tooth movement, effectiveness, and treatment stability of clear aligners

There are several systematic reviews (SR) and meta-analysis (MA) available that describes the treatment effectiveness of the CAT in comparison to FA (Table:1). In their latest SR Robertson et al (8) included studies that examined the predictability of achieving specific type of tooth movement with CAT by superimposing predicted and achieved models. Difficulty in identifying stable structures during superimposition of digital models was identified as a major drawback in this work. Extrusion and horizontal movement of incisors were found to be predictable with moderate levels of certainty while intrusion and rotation showed less predictability. Only one Randomized Control Clinical Trial (RCT) and one retrospective observational study have used pre and post treatment LCs to compare the treatment outcome in buccolingual inclination of upper and lower incisors. CAT produced clinically acceptable buccolingual inclination of upper and lower incisors compared to FA in mild to moderate cases. However, the studies included in this SR did not assess all potential clinical scenarios and had moderate risk of bias. Therefore, the authors concluded that despite the recent advances in CAT, they were not sufficient to accomplish most of the tooth movements with adequate predictability.

Table 1: Summary of SR on effectiveness of CAT		
SR	Observation	Conclusions
Lagravère *et al* 2005 (9)	Treatment effect of CAT	Inadequately designed studies. Generated low level of evidence. Cannot draw strong conclusions on treatment effects of CAT
Rossini *et al* 2015 (10)	Efficacy of CAT in controlling orthodontic tooth movement	CAT align and level arches. Effective in controlling posterior buccolingual movement and upper molar bodily movement. Not effective in anterior buccolingual inclination and rotation of rounded teeth
Zheng *et al* 2017 (11)	Efficiency effectiveness and treatment stability of CAT	Evidence is generally lacking about the effectiveness of CAT. Shortened treatment duration and chair time in mild-to-moderate cases are the only significant effectiveness of clear aligners over FA
Papadimitriou *et al* 2018 (12)	Clinical effectiveness of CAT	No clinical recommendations can be made except in non-extraction treatment of mild to moderate cases in non-growing patients
Ke *et al* 2019 (13)	Treatment effectiveness between CAT and FA	CAT and FA were effective in treating malocclusion. CAT was advantageous in segmental tooth movement and treatment time. CAT was not as effective as FA in producing occlusal contacts, torque, and retention
Robertson *et al* 2020	Effectiveness of CAT for orthodontic treatment	Despite the recent advances in CAT, they were not sufficient to accomplish most of the tooth movements with adequate predictability

A SR and MA by Zheng *et al* (11) reported clinically significant shorter treatment duration spent on mild to moderate cases with CAT compared to FA. Average treatment time in this meta-analysis was 1.7 years for FA and 1.4 years for CAT group but the complexity of the cases treated with CAT alone were less than the FA group. Patients with CAT spent less chair time and a smaller number of appointments due to longer appointment intervals (10 -12 weeks in patients with good compliance) compared to FA (6 weekly standard intervals). CAT needs less adjustment at each appointment compared to regular wire and bracket adjustments, shortening the chair time. Emergency appointments with CAT were reduced due to less breakages. However, after assessing treatment outcome with American Board of Orthodontics Objective Grading System (ABO OGS) (14) , CAT did not address the malocclusions as effectively as conventional FA. Moreover, it was difficult to treat complex malocclusions requiring extractions with CAT. Further, post treatment relapses were observed more frequently in patients treated with CAT compared to patients treated with FA when similar retention protocols were followed. Hence, there is insufficient evidence regarding the effectiveness and stability of treatment with clear aligners compared to conventional FA.

Forces and moments generated by CAT

A SR and MA reported on *in vitro* studies of CAT concluded that thickness of aligner material does not significantly influence initial moment to force ratios (15). Polyethylene terephthalate glycol (PETG) foils typically range between 0.5mm and 1 mm were used in fabrication of CAT. Tipping and rotation were frequently studied, and rotational forces were at much higher levels. However, *in vivo* studies to describe the effects of forces and moments generated by CAT to achieve various types of tooth movement were lacking. Therefore, a knowledge gap appears to exist in this area to summarize the optimum forces and moments generated by CAT to achieve specific tooth movement.

External Apical Root Resorption (EARR) with CAT

A SR and MA of prospective and retrospective radiometric cohort studies (16) with CBCTs and plain radiographs concluded that there is a clinically insignificant difference in EARR with CAT compared to conventional FA **(Table 2)**. However, when maxillary lateral incisors were considered separately, the difference in EARR was significantly less with CAT. The amount of EARR reported in CBCT was less than 1mm while it was higher in plain radiographs in both groups. The reason for over estimation of EARR in plain radiographs was suggested as an error in identifying root apices and incisal edges due to the overlying structures and magnification. Studies that were included in this SR did not consider case selection according to severity. Moreover, none of the studies included in this SR were RCTs.

Another SR and MA (17) with moderate to high risk of bias studies (none were RCTs) using CBCT concluded that CAT could not prevent EARR but reduced the incidence and severity compared to conventional fixed appliances. The reduced jiggling and intermittent force system from CAT was proposed to generate this outcome. However, firmer conclusions cannot be arrived at without having well planned RCTs to study the above prospect.

Table 2: external apical root resorption with CAT	
Occurrence of EARR	FA and CAT both cause EARR
Clinical significance	Not significant except in maxillary lateral incisors
Incidence	Less with CAT
severity	Less with CAT

White spot lesions (WSL) and CAT

An RCT (18) with two parallel arms consisting of CAT and conventional FA to study the development of WSL during treatment using quantitative light-induced fluorescence concluded that both CAT and FA cause WSL **(Table 3)**. More lesions occurred with conventional FA, and they were smaller in size but greater in demineralization. Larger lesion areas with less mineral loss occurred with CAT.

Table 3: white spot lesions in CAT	
Incidence	FA and CAT both increase the incidence of WSL
Number of lesions	More WLS occur in FA
Size of the lesion	Larger size lesions occur in patients with CAT
Level of enamel demineralization	Less mineral loss in CAT compared to FA

Periodontal health and CAT

A SR and MA of 10 RCTs reported better periodontal parameters with CAT **(Table 4)** compared to FA. However, the risk of bias of the included studies were high. Authors concluded that CAT could be recommended with caution for patients with higher periodontal disease risk (19). Prospective RCT with three parallel arms consisting of CAT, auto ligating FA, and conventional FA (which was not included in above SR), failed to find evidence for difference in oral hygiene levels or periodontal status measured by same indices as in above SR (20). However, none of the above studies reported radiological evidence of alveolar bone levels which would have given a better insight to the actual periodontal status.

Table 4: periodontal health and CAT	
Plaque index	Better in CAT compared to FA
Gingival index	Better in CAT compared to FA
Probing depth	Better in CAT compared to FA

Orthodontist vs general dentists using CAT

A parallel pair cross sectional survey to report case selection, treatment management and treatment expertise in CAT was conducted by Best *et al* (21) **(Table 5)**. General dentists tend to select more complex cases for CAT although their treatment objectives were non-equivalent to those of Orthodontists. During treatment management, general dentists were more likely to adhere to basic CAT technique than employing inter-arch mechanics with elastics or axillaries. Whereas Orthodontists tend to be more vigilant with case selection and employ more treatment mechanics to achieve more complex treatment objectives. They often feel that FA or combining CAT with FA will give superior results. Significant differences exist between orthodontists and general dentists in experience and case selection when using CAT and when reasoning for not using CAT in their cases (22).

Table 5: Difference between orthodontist and general dentist in using CAT		
Parameter	Orthodontists	General practitioners
Case selection	Often perceive that better outcomes could be achieved with FA than CAT(21). CAT thought to limit treatment outcome (22)	Willing to treat more complex malocclusions (21) Had limited experience (22)
Treatment management	Use inter-arch elastics more frequently Combine CAT with FA (21) Refine digital treatment plan more often (21)	Less likely to use Class II elastics or auxiliaries Have lower treatment objectives (21)
Expertise	Confident in treating mild crowding with CAT (21)	Confidant in treating deep bite, severe crowding, and Class II malocclusion with CAT (21)
Demographics	Had treated significantly higher number of total CAT patients (21,22)	Less number of total CAT patients (21)
	Increasing number of patients were selected for CAT in the past 12 months (21)	There is no increase in number of patients accepted for CAT in last 12 months (21)
	Receiving more CAT training (21,22)	Less training in CAT (21)

Materials used in construction of CAT

Thermoplastic polymers such as Polyurethane (PU), poly esters such as polyethylene terephthalate glycol (PETG) and combination of two are most often employed in manufacturing CAT (5) (**Table 6**). PU is higher in crystallinity, strength and glass transition temperature compared to PETG. Water absorption by PU is higher than PETG giving rise to more swelling and higher aptitude for degradation of mechanical properties. PETG is more transparent than PU producing higher aesthetics. But PETG based aligners acquire colour changes more than PU based aligners when exposed to food and beverages such as coffee and red wine (5). Although the above materials are being studied *in vitro*, there is an indication to study them *in vivo* to determine the best material that could serve the treatment needs (6).

Table 6: Mechanical and chemical properties of aligner materials

Property	PETG	PU
Modulus of Elasticity (MPa)	1933.03 +/-130	2489.43 +/- 74
Glass transition temperature ^{0}C	77.2	88.1
Water absorption µg/mm3 in 30^{0}C	10	16
Colour changes	Marked	Perceivable
Crystallinity	Lesser than PU	Higher than PETG
Transparency	Superior to PU	Less than PETG

Effect of composite attachment in CAT

Attachments are planned small protrusions from the tooth surface made from polymerized composite material. They offer additional retention and allow application of different farce modules either via elastics, auxiliaries or simply by increasing the pressure applied by the aligner tray onto the tooth at specific sites. They vary in the shape, size, number, and the position on the tooth depending on the specific task they were designed to achieve such as rotation of teeth, bucco-lingual or mesio-distal tipping, intrusion and or extrusion (**Table 7**). A recent SR (7) suggested further clinical studies to clarify the effects of attachments in achieving various types of tooth movements.

Table 7: Effectiveness of attachments in CAT

Root torque in anterior teeth	Can improve by adding attachments such as power ridges but insufficient to ensure right root control
Anchorage	Can be improved by adding attachments on greater number of teeth
Intrusion	Can be improved by adding attachments. But evidence is low
Extrusion	Evidence lacking on the effect of attachments on extrusion
De rotation	Conflicting evidence on the effectiveness of attachment for rotational correction. Sharper attachments seem to have better outcomes. Two attachments on buccal and lingual surfaces showed no effect
Posterior teeth expansion	No evidence

Conclusions

Each year an overwhelming volume of literature and boastful quarterly published proprietary reports appear discussing the CAT market. These reports often include information such as percentage share of orthodontic market for each CAT company which misrepresent their self-perceived expanding image. Literature generated by companies provide information regarding technicalities of CAT provision, material, finance, clinicians and patient affability etc. these articles, although appearing in leading peer reviewed journals, may solely convey commercial interests in order to appeal to readers. However, unavoidable conflicts of interest and lack of clinical judgement may cause bias in the reported information.

Therefore, the present review delved into the major queries regarding CAT and attempted to reflect answers but did not give an exhaustive account on CAT. Authors tried to indicate available SRs and MAs deliberately excluding studies done on specific CAT brands, on the sub topics which were often stated in CAT literature. In the absence of such work, prospective RCTs and good quality prospective and retrospective cohort studies were referred. Level of evidence (24) for most aspects of CAT were either low or lacking **(Table 8)**. Regardless of having a large number of expert opinions and case reports on CAT, evidence-based knowledge gaps exist on guidance for proper case selection, overall patients' level treatment outcomes, force levels generated by CAT and treatment related quality of life etc. More and more well designed RCTs are essential to overcome the current dispute. It is in the readers hands to decide if CAT truly delivers what is claimed or is overrated?

Table 8: level of evidence

Predictability of tooth movement, effectiveness, and treatment stability of CAT	Level I
Forces and moments generated by CAT	Evidence is lacking
Effects of attachment s in CAT	Level II
External apical root resorption with CAT	Level III
White spot lesions	Level II
Periodontal health	Level II
Orthodontist vs general dentist using CAT	Level IV
Aesthetic perception of CAT by adult patient	Level IV

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A review of the effects of disinfectants on Microbial contamination in orthodontic materials

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ABSTRACT

The main objective of this review is on contamination of orthodontic appliances and effective sterilization methods to remove biofilm on the orthodontic appliances. Sterilization of orthodontics appliances is important. It requires a special attention as both the patients and the practitioners have a substantial risk of spreading both oral and systemic infections. A literature search of PubMed and EBSCO was performed. The literature was searched using a combination of keywords, e.g., Sterilization; Orthodontics; Disinfection; Infection Control. The present review article reviews and assesses various recent methods of sterilization of orthodontic appliances. Based on the previous studies we concluded that all the sterilization methods were effective to prevent the contamination of orthodontic appliances.

Key words: Sterilization; Orthodontics; Disinfection; Infection Control.

INTRODUCTION

Orthodontics is a branch of dentistry concerned with the diagnosis, prevention, interception, guidance, and treatment of malocclusion [1]. According to the American Association of Orthodontics (AAO), an estimated 4.5 million Americans undergo fixed orthodontic treatment. In US the annual amount spent on orthodontic care is estimated to be around $6 billion. There have been significant advances in materials technology and development that has enhanced efficiency and outcome in clinical orthodontics. However, adherence of microorganism and contamination of these materials remain a concern. Studies indicate the need for sterilization of orthodontic materials before placement into the oral cavity. Although dental instruments are sterilized before use, orthodontic materials like brackets, archwire, bands and elastomeric ligatures are used 'as received' from the manufacturers for clinical use. While various-sterilization and disinfection methods have been shown to be efficacious, alterations in the physical and mechanical properties after treatment makes them unsuitable for use in routine clinical practice.

Orthodontic Appliances Cross Contamination

Irfan et al. (2019) conducted an *invitro* study to assess bacterial contamination of orthodontic bands after different pre-cleaning methods like manual scrubbing, enzymatic solution, a combination of both and steam autoclaving. The results of the study revealed that no growth in the pretreated groups, although the enzymatic group showed growth on 5% of the sample. Further investigation

also showed the presence of Staphylococcus non-aureus bacterial species in contaminated bands. The study concluded that all pre-cleaning methods were equally effective in band decontamination and that the tried-in bands were safe to reuse after sterilization [2]. Saad et al (2017) conducted a study to evaluate the microbial contamination of different orthodontic arch wires. The results of the study showed more microbial growth, mainly Staphylococci species on the stainless-steel wires when compared to nitinol. The study concluded that arch wires received from manufacturer are often contaminated and that there is need for sterilization before use [3]. Harikrishnan et al. (2013) conducted an *in vitro* study. Results revealed that stainless steel wires were less prone to microbial adhesion and growth when compared to Teflon coated wires and elastic ligatures[4]. Barker et al. (2011) conducted a pilot molecular study to evaluate microbial contamination of orthodontic appliances as received from manufacturers and after exposure to clinical environment. The results of the study showed low levels of bacterial contamination on 'as received' archwire, bands and impression trays. The identified bacterial species were *Staphylococcus epidermis, Kocuria, Maraxella and Micrococcus species*[5]. Brackets from manufacturers (Morelli and Abzil-3M Unitek) were found to be contaminated by bacteria in the original packages [6]. Microbial adherence (*S. mutans* and Candida) to brackets varied according to its materials. Composite brackets showed the most microbial adherence followed by ceramic brackets and lastly metallic brackets [7].

Rastogi et al. (2017) conducted an *invitro* study to assess the sterility of packed orthodontic materials 'as received' from the manufacturer and 'bench top exposed'. Out of the materials tested (elastomeric chains, molar bands, buccal tubes, and lingual sheaths), the buccal tube and molar bands showed highest levels of contamination. Bench top exposed materials showed more contamination than as received and the bacterial species identified were *Klebsiella, Streptococci, Citrobacter* and *E. coli* [8].Purmal et al. (2010) conducted an invitro study to test the sterility of orthodontic buccal tubes as received from the manufacturer. The results demonstrated the contamination of bands from all four manufacturers with opportunistic pathogens namely *Micrococcus luteus*, *Staphylococcus haemolyticus* and *Acinetobacter calcoaceticus* [9].

The orthodontic treatment and cross contamination

Jing et al. (2019) conducted a prospective comparative cohort study to analyze the effect of fixed orthodontic treatment on oral microbiota and salivary proteins. There was increased levels of *S. mutans* during the late period of treatment but no significant change in the levels of *Lactobacillus*. The study concluded that *S. mutans* might become a potential therapeutic target to maintain a healthy oral environment [10], [11]. Candida species, *S. mutans* and *Lactobacilli* levels increased during orthodontic treatment [12]. Following placement of fixed orthodontic appliances, the levels of *S. mutans* and *Lactobacilli* increased [13]. Mavani et al. (2016) conducted an in vivo study to determine the microbial colonization on elastomeric modules during orthodontic treatment and found presence of *S. mutans* and *Lactobacillus*. There was a significant rise in the microbial colonization with increased duration of time. [14] Sun et al. (2018) conducted a study to compare the oral microbiota in orthodontic patients and healthy individuals. The results revealed a greater number of *Pseudomonas* species in the orthodontic group, but no significant difference in *Streptococcus* species [15]. Sawhney et al. (2018) conducted a review to study the microbial colonization on elastomeric ligatures during orthodontic treatment. Orthodontic ligatures showed more bacterial plaque formation (*Porphyromonas gingivalis, Tannerella forsythia, Actinobacillus actinomycetemcomitans, Prevotella intermedia, and Prevotella nigresce*) when compared to steel ligature wires. The Super Slick type of ligature showed statistically significant higher *S. mutans* levels when compared to conventional elastomeric rings [16], [17], [18]. Guo et al. (2017) studied the microbial changes in subgingival plaques of orthodontic patients. The results of the study showed that *P. gingivalis* and *Aggregatibacter actinomycetemcomitans* levels showed no significant increase during short-term observation during orthodontic treatment, but

T. forsythia levels showed an increase. The levels of subgingival pathogens increased temporarily over time during orthodontic treatment but after orthodontic treatment the levels returned to pretreatment levels [19], [20], [21]. DP et al. (2015) conducted an in vivo study to evaluate the microbial colonization on orthodontic attachments. The study revealed minimal (Staphylococci) to no growth of aerobes and anaerobes within 24 hours. An increase in time duration showed progressive colonization of aerobes (*S. oralis, S. Sanguinis, S. parasanguinis* and *S. mitis*) and anaerobes (*L. acidophilus*, *L. casei* and *Peptostreptococci*) on orthodontic attachments. [17]. Leung et al. (2006) studied the oral bacteria in plaque and invading buccal cells of young orthodontic patients. He found that the buccal cells showed significant increase in *A. actinomycetemcomitans* levels suggesting the cause to be due to physical trauma or leaching of metals from the appliance [22] (Table 1). Therefore, in this review article we the effective sterilization methods for orthodontic appliances were presented.

Steam autoclave sterilization

Steam autoclave is the most common method of sterilization used in dentistry and considered the gold standard. Autoclaving is based on the principle that at a constant volume the boiling point of water is directly proportional to pressure.15 pressure per square inch (psi) at a temperature of 121 degree Celsius is used for 20 minutes. *Bacillus Stearothermophilus* is used to test the efficacy of the process. The steam that is produced in this process causes corrosion and rusting of orthodontic pliers [23]. Rapisarda et al., (1999)reported that the steam autoclave could be used with no damage to the orthodontic pliers if they are made of good quality stainless steel[24]. In contrast, Vendrell et al (2002) showed no difference on orthodontic ligature-cutting pliers with stainless steel inserts whether sterilized by steam autoclave or dry heat. Furthermore, some studies have focused on sterilization of both tried-in and new molar bands and advise they be sterilized separately[25] (Table 2).

Dry heat sterilization

Hot air that is free of moisture is used in this type of sterilization method. The main difference between dry and moist heat sterilization is that moist heat sterilization causes denaturation and coagulation of bacterial protein whereas dry heat sterilization causes oxidative damage to the cell of bacteria. A study by Kapila in 1992 conducted dry heat sterilization and recycling affects the properties of NiTi wires by reducing its pseudoplasticity and increasing its stiffness[26]. Cash (1990) proved that heat sterilization does not affect any property such as elastic moduli, surface topography or tensile strength of NiTi wire[27]. Study by Poosti et al (2009) showed no significant difference in the nickel ion concentration produced in saliva from NiTi wires which were either sterilized by dry or moist heat. A study was done to compare the wear of orthodontic pliers which were repeatedly sterilized by dry or moist heat. This study showed no significant difference in the mean wear at the tip of the pliers[28] (Table 2).

Table 1. orthodontic treatment and cross contamination		
In vivo studies	Summary	Ref
Effect on oral microbiota and salivary proteins	In the late period of treatment, there were increased levels of *S. mutans* but no significant change in the levels of *Lactobacillus*. The study concluded that *S. mutans* might become a potential therapeutic target to maintain a healthy oral environment.	[10], [11]
	S. mutans and *Lactobacilli* levels increased during orthodontic treatment.	[12]
	Levels of *S. mutans* and *Lactobacilli* increased following insertion of the fixed orthodontic appliance.	[13]
	During orthodontic treatment, there was a presence of *S. mutans* and *Lactobacillus* on elastomeric modules.	[14]
Comparing the oral microbiota in orthodontic patients and healthy individuals	There was a greater number of *Pseudomonas* species in the orthodontic group than the other group, but no significant differences in *Streptococcus* species.	[15]
Orthodontic ligatures vs. steel ligatures	Orthodontic ligatures showed more bacterial plaque formation when compared to steel ligature wires. The Super Slick type of ligature showed statistically significant higher *S. mutans* levels when compared to conventional elastomeric rings.	[16],[17],[18]
Microbial changes in subgingival plaques of orthodontic patients	*P. gingivalis* and *Aa* levels showed no significant increase in the short-term observation during orthodontic treatment, except for *T. forsythia*. The levels of subgingival pathogens increased temporarily during orthodontic treatment but after the treatment, the levels returned to pre-treatment levels.	[19], [20],[21]
Microbial colonization on orthodontic attachments	The study revealed minimal to no growth of aerobes and anaerobes within 24 hours. An increase in time duration showed progressive colonization of aerobes and anaerobes on orthodontic attachments.	[44],[17]
Oral bacteria in plaque and invading buccal cells of young orthodontic patients	The buccal cells showed significant increase in *A. actinomycetemcomitans* levels suggesting the cause to be due to physical trauma or leaching of metals from the appliance.	[22]

Table 2. Effect of Heat sterilization methods for orthodontic appliances.		
Autoclave type	Summary	Ref
Steam Autoclave	Autoclaving can cause blunting and corrosion of the sharp cutting edges of pliers.	[23]
	Orthodontic pliers with stainless steel inserts showed no difference whether sterilized with steam autoclave or dry heat.	[25]
	Orthodontic pliers made of stainless steel will not be affected if sterilized by steam autoclave.	[24]
Dry Heat	Dry heat reduces the pseudoplasticity and increases the stiffness of NiTi wires.	[26]
	Whether sterilized by dry heat or moist heat, there was no difference in nickel concentration in the saliva from NiTi wires.	[28]
	Heat does not affect the elastic moduli, surface topography or tensile strength of NiTi wires.	[27]

Chemical sterilization

Ethylene oxide gas sterilization

Ethylene oxide is a gas which has excellent penetration power, sporicidal, virocidal and is non-corrosive. However, this method is very slow, toxic, and explosive. Another drawback of this method is that materials retain varying amounts of ethylene oxide gas after removal from the sterilizer that must be allowed to dissipate before use. Ethylene oxide destroys microorganisms by alkylation and causes denaturation of nucleic acids of the microorganisms. Ethylene oxide is the only main sterilization method that does not require heat above room temperature hence it is mainly used for heat sensitive instruments such as rubber, plastic, and wood[29]. Ascencio et al. (1998) reported that although gas sterilization is effective in killing bacteria it is not recommended in orthodontic clinics because it is costly and technique sensitive[30].

Ethyl alcohol

Ethyl and isopropyl are the most frequent used alcohols with conc. of 50-70%. Both are widely used as skin antiseptics. Isopropyl is an effective bactericidal but ineffective with spores. It's also less effective in the presence of saliva and blood and causes metal corrosion. It has been used in orthodontic archwire sterilization. Elastomeric chains immersed in 70% GL alcohol for 1 minwas found to be 100% effective against *S. mutans* with no mechanical property's changes [31]. A chemical immersion method that should be limited to bands without prewelded attachments [23]. Seventy percent isopropyl 2X2 gauzes were used to wipe all chairside hand instruments.

Glutaraldehyde

Glutaraldehyde (2%) for 6-10 h is the most popular method in cold sterilization of metallic instruments, face masks, heat sensitive plastic rubbers, and fiber optics. It is used to inactivate bacteria and spores regardless of the pH and temperature. Elastomeric chains immersed in 2% glutaraldehyde solution for 30 min at room temperature was found to be 100% effective against *S. mutans* with no changes in mechanical properties [31],[32]. Studies revealed a pitting type of corrosion to the orthodontic instruments compared to surface corrosion type with other sterilizing methods. Also, a chemical immersion method that should be limited to bands

without prewelded attachments [23]. Chair side hand instruments were rinsed under tap water and then placed in GTA solution "Cidex" for 10 minutes. Cotton swaps were taken twice a day for 10 days from a random sample of the instruments. The results showed bacterial growth in 6/40 samples [33]. Elastics were disinfected by immersing them in 2% glutaraldehyde for 10 h. Neutral red analysis using a mouse L929 cell line was used to assess cytotoxicity of the sterilized elastics. Results show altered cell viability making the elastic more cytotoxic [34]

Chlorhexidine

Vivek et al. (2019) conducted an in vitro study to evaluate microbial contamination and the disinfecting efficacy of chlorhexidine on orthodontic brackets. All the brackets obtained from four different manufacturers (American Orthodontics, 3M Unitek, Ortho Organizers and China Dental Orthodontics) showed microbial contamination. The bacteria identified were *Staphylococcus aureus, S. epidermidis, Lactobacilli, Klebsiella pneumoniae, Bacillus licheniformis, and B. cereus*. On treating with 0.01% chlorhexidine 3M Unitek brackets were completely disinfected, whereas the brackets form the other manufacturers showed disinfection on treating with 2% chlorhexidine. The study suggested the use of 2% chlorhexidine for disinfection before placement of brackets in the oral cavity[35](Table 3).

Table 3. Effect of different chemical sterilization methods for orthodontic appliances

Chemicals	Summary	Ref
Ethylene Oxide Gas	Ethylene oxide stays in materials at varying amounts and so should not be used right away.	[29]
	Because ethylene oxide gas does not require additional heat, it is mainly used for heat sensitive heat instruments.	[23]
	This type of technique is not recommended for ortho clinics because it is technique sensitive and expensive.	[30]
Ethyl Alcohol	Elastomeric chains that were sterilized by ethyl alcohol did not display any mechanical property changes.	[31]
	NiTi wires that have been sterilized by formaldehyde alcohol vapor pressure of 20-25 psi for 30 minutes at 132 C showed no change in the elastic moduli, surface topography, or tensile properties.	[45]
Glutaraldehyde	Elastomeric chains sterilized by 2% glutaraldehyde for 30 minutes showed no change in mechanical properties.	[32]
	Altered cell viability was found in 2% glutaraldehyde sterilized elastics, which makes the elastics more cytotoxic.	[34]
Chlorohexidine	Prevent the growth of several bacteria	[35]

UV Light Sterilization

UV light works by destroying nucleic acids, thus damaging the DNA of the bacteria. The lack of heat and chemicals in the UV light keeps the properties the orthodontic appliances intact whilst the radiation of the light simply kills the bacteria. UV sterilization of elastomeric chains (for 30 minutes; 15 minutes on each side of the elastic) at room temperature was found to be the least effective methods (65%) against *S. mutans* when compared with the rest. No mechanical properties changes were found [31]. Neutral red analysis using a mouse L929 cell line was used to assess cytotoxicity of the sterilized elastics. Results showed that there is no changes in the cell viability or the elastic cytotoxicity [34]. Aeran et. al. (2015) conducted a study on the use of a dental UV chamber on dental impressions materials. Alginate and silicone were disinfected in 10 minutes whereas polyether took only 3 minutes[36]. Belanger-Giguere et. al. (2011) conducted a study of toothbrushes contaminated with *S. mutans*. UV light sterilization significantly decreased the number of bacteria compared to the control. However, the number of *S. mutans* CFUs was significantly higher when other treatments[37].

Larsen et. al. (2000) conducted an in vitro study examining the effect of UV radiation on the suspension media of silicone rubber and red wax, contaminated with 7 different strains of bacteria. Their results showed that the amount of UV radiation required differed with the bacterial species. However, the microbial count showed no significant reduction[38]. Contradictory results were observed by Al-Khafagy et. al. (2018) who conducted a study on dental impressions using UV light and blue light. Both UV and blue light sterilization gave positive results. Furthermore, there was a significant reduction of bacterial growth in the group exposed to UV light for 20 minutes. Walker et. al. (2017) conducted a study to compare the effectiveness of UV light versus dry heat sterilization on contaminated molar bands. Both sterilization methods were equally effective, but UV sterilization was 40% faster. On bands that were not effectively sterilized,dry heat sterilization had more virulent bacterial growth then with UV light sterilization. Brindha et. al. (2014)conducted a study to determine if the four different types of sterilization methods (autoclave, hot air oven, glutaraldehyde, and UV light disinfection) changed the tensile strength (TS) or the surface topography (ST) of three different types of orthodontic wires (stainless steel, TMA alloy, cobalt-chromium). For UV light, TS of stainless-steel wire was not affected, TS of TMA was increased compared to the control but still less than stainless steel, and the TS value for CoCr were inconclusive. UV light disinfection was shown to have the least effect on the surface topography of all the wire types when compared to the other three sterilization procedures[39]. Gujjari et. al. (2011) conducted a study to assess UV radiation and microwave sterilization for toothbrushes that had been contaminated by oral microorganisms. Both UV and microwave caused significant reduction in microorganisms. However, microwave irradiation was more effective than the UV radiation. Contradictory results were observed by Boylan et. al. (2008) whose study showed an 86% decrease in the total CFU count on bacterial contamination on toothbrushes by UV light sterilization.[40] (Table 4).

Table 4. Effect of UV light sterilization on orthodontic appliances

Summary of UV sterilization and its effect on orthodontic appliances	Ref
When elastomeric chains were UV sterilized, no mechanical property changes were found.	[31]
UV-sterilized elastics were analyzed to assess the cytotoxicity and no changes were found.	[34]
Alginate and addition silicone dental impressions were disinfected in ten minutes whereas polyether material took only three minutes when sterilized using a UV chamber.	[36]

Although UV light considerably reduced the amount of *S. mutans* on the contaminated toothbrush compared to the control, the amount of CFUs was still higher when compared to the other treatments.	[37]
Direct exposure to low doses of UV light killed all the oral bacterial strains that were tested but the dosage had to be adjusted to penetrate the innermost of the multilayer of bacteria.	[46]
UV sterilization of dental impressions made of silicon rubber and red wax did not show a significant reduction in microbial count.	[38]
There was a significant reduction in the bacteria growth on dental impressions when exposed to UV light for 20 minutes.	[47]
Both UV sterilization and dry heat sterilization were effective in disinfecting contaminated molar bands, but UV was 40% faster.	[48]
When compared to autoclave, hot air oven, and glutaraldehyde sterilization methods, UV light least affected the surface topography of all the wire types tested.	[39]
In toothbrushes contaminated with oral microorganisms, both UV and microwave radiation significantly reduced the number of bacteria compared to the control, but microwave was more effective than UV.	[40]
The UV sterilization method reduced the CFU count on contaminated toothbrushes by an average of 86%.	[49]

Studies comparing the efficacy of different sterilization methods

Ganavadiya et al. (2014) conducted a study to compare the efficiency of three different chemical disinfection methods on contaminated dental instruments. Results of the study revealed that none of the chemical methods completely eliminated the viable microbes growing on the instruments. Comparing the different methods, hydrogen peroxide produced the most reduction in bacterial growth, glutaraldehyde was second followed by ethyl alcohol which showed the least reduction (excluding the control) [41]. Staggers et. al. (1993) tested the effects of dry heat, autoclaving, and ethylene oxide gas on the tensile strength of orthodontic wires to see if reuse of ortho wires a viable possibility is still. Results showed that wires sterilized by dry heat had a significantly higher tensile strength after one cycle among the different sterilization methods. Autoclave and ethylene oxide gas did not show any statistical differences in tensile strength. Since tensile strength is not significantly affected by different sterilization methods and reuse, wire recycling is still plausible (except for stainless steel which is known to decrease tensile strength) [42]. Smith (1986) conducted a study to determine if glass bead sterilization is a viable option to sterilize orthodontic bands after inoculation with either *Staphylococcus albus* bacteria or *Bacillus subtilis*spores. In addition, Smith also compared this method to other sterilization methods used in a dental office. Results revealed that bacteria were sterilized in 15 seconds and spores were sterilized in 45 seconds. Out of all the methods used, only alcohol flame sterilization was able to prevent the growth of *Staphylococcus albus* on the bands[43] (Table 5).

Table 5. Effect of combination of different sterilization of orthodontic appliances		
Sterilization	Summary	Ref
Hydrogen peroxide vs. Glutaraldehyde vs. Ethyl alcohol	None of the methods completely removed the viable bacteria, but hydrogen peroxide showed the most reduction, with glutaraldehyde showing second-most reduction.	[41]
Dry Heat vs. Autoclaving vs. Ethylene oxide gas	There was a statistically higher tensile strength of the orthodontic wires after one cycle of dry heat compared to the other two methods.	[42]

Conclusion

Based on the previous studies we concluded that all the sterilization methods were effective to prevent the contamination of orthodontic appliances.

Acknowledgment

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors Contribution: Critical Review-KV, AA; Literature search-KV, KC, DA; manuscript writing KV, KC, DA, AA.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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Impact of Malocclusions and Orthodontic Treatment on Oral-Health-Related-Quality-of-Life of orthodontic patients: practical implications for patient care in resource constraints

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ABSTRACT

Objective

Oral-health-related-quality of life (OHRQoL), defined as individual's perceived impact of oral health issues on his/her physical, psychological and social well-being, denotes an integral component in general health and well-being. Therefore, explorations on OHRQoL has garnered recognition as an essential element in patient-centered health care provision and dental research underpinned by patient-reported outcomes. It is well known that not only severity of malocclusions manifested as orthodontic treatment need but orthodontic treatment as well could impact on OHRQoL of orthodontic patients embracing various aspects of their daily performances such as eating, speaking, smiling and much more. However, there is a remaining information gap in this regard in Sri Lankan context. Against this backdrop, present study aimed to explore and expound the impact of malocclusion and orthodontic treatment on OHRQoL of orthodontic patients in a public tertiary care dental hospital setting.

Materials & Method: A hospital based cross-sectional study was conducted among 492 orthodontic patients attended the Orthodontic Unit, National Dental Hospital (Teaching) Sri Lanka. Patients belonged to both pre-treatment and ongoing treatment categories. The data were collected by trained data collectors using a structured, interviewer administered questionnaire. OHRQoL was assessed by the previously validated modified version of Oral Impacts of Daily Performance (M-OIDP) index. The normative orthodontic treatment need was assessed by the dental component of the index of orthodontic treatment need (DC-IOTN) which was modified for Sri Lankan context by accounting for spacing. Data were entered and analysed using SPSS-21 statistical software package.

Results: The majority did not report frequent impacts and there was a mixed picture of affected aspects of OHRQoL as perceived by orthodontic patients. The worst affected aspects were *"Smiling/Showing teeth"* and *"Feeling Happy"* as 38.2% and 28.6% respectively reported to being affected frequently. Another 17.3% of orthodontic patients reported to be affected in *"speaking & pronouncing clearly"*. On the contrary, *"Sleeping and relaxing"* and *"Carrying out school and other activities"* were among the lesser affected aspects as only 9.6% and 11.2% of orthodontic patients reported more frequent impacts.

Furthermore, the age group, orthodontic treatment need, orthodontic treatment type and perceived oral health status were significantly associated with reporting of frequent impacts in some aspects of daily performance ($p<0.05$).

Conclusions: A heterogeneous pattern was evident in frequency of reporting impacts of daily performance by orthodontic patients that reflected their OHRQoL attended the tertiary care public dental hospital setting. However, it was influenced by their age, perceived oral health status, orthodontic treatment need and orthodontic treatment type. Therefore, it could be suggested to compliment normative clinician-centered assessments of malocclusions and treatment outcomes by assessments of OHRQoL of orthodontic patients. This may facilitate efficient use of limited resources in public sector for orthodontic treatment services whilst ensuring better patient compliance.

INTRODUCTION

Orthodontics denotes the unique specialty of Dentistry concerned with the position of teeth and the relationship between the maxilla and the mandible (1). Furthermore, orthodontic treatment accomplishes appropriate tooth movements thus making orthopaedic change and alterations to soft tissue envelope. Those are aimed at functional efficiency, structural balance, aesthetic harmony and stability of treatment outcomes (2). To accomplish those, clinicians use various treatment modalities in the management of malocclusions. They include extractions of teeth, use of removable, fixed and functional appliances depending on the patients' clinical findings and treatment objectives. There is consensus among many researchers on the need for complex orthodontic treatment conditional to severity of malocclusions. Therefore, patients with more severe malocclusions may require more complicated treatment procedures with more extractions, more appointments, longer overall treatment duration and importantly better patient compliance (3-5). Nevertheless, the demand for orthodontic treatment is ever increasing across the globe despite not being qualified to be considered as a disease in its own or posing a life threatening condition (6). Thus, considering the crucial importance of a well-aligned set of teeth for facial aesthetics not only the demand but the need for orthodontic treatment would not get plateaued (6). Therefore, appearance and position of teeth become major factors that have greater psychological and social impact on children, adolescents and young adults (7). Hence, one of the major drivers of seeking orthodontic treatment is improving facial aesthetics and appearance which are fundamental to self-esteem and social acceptance (8). Due to the inherent attributes of orthodontic treatment which is technique intense and long-term with frequent and multiple visits, malocclusions pose a cause for concern to health care systems in all countries, especially funded by public means (9). Sri Lanka as a lower-middle-income developing country holds a unique public health care delivery model in which oral health care including orthodontic treatment provision is being provided (10). However, it is well-known that not only the waiting lists for orthodontic patients are lengthening in the public sector but grappling with many resource constraints. Within the context of ever increasing economic constraints and competing priorities of health care provision, sustainability of public funding is becoming an important cause for concern. Therefore, triaging of orthodontic patients for prioritizing treatment has become an emerging need determined by normative assessments of severity of malocclusions and their consequences on oral health status of a given individual.

Patient-centered-health care provision underpinned by paying consideration to patient-reported-outcome-measures has garnered recognition as an integral component of health care provision worldwide (11-12). Assessment of an orthodontic patient is fundamental to his/her overall management and the need for orthodontic treatment is assessed by many methods (13). Of them, one of the most common assessment methods used in orthodontic practice and research to classify malocclusion is the Index of Orthodontic Treatment Need (IOTN) which was originally proposed by Brook and Show (14). Indices

like IOTN are clinically based normative assessment tools of malocclusions. However, presently there is a growing tendency for complementing clinical indicators by patient reported outcomes. For this purpose, researches extensively use the indices based on Oral Health Related Quality of Life (OHRQoL) which is a multidimensional construct of patient reported outcome that makes an integral component in general health and well-being (15). It embraces the biopsychosocial model of oral health into which symptoms, physical functioning, emotional and social well-being are incorporated into (16). Accordingly, Orthodontics, similar to many specialties in health care has witnessed a paradigm shift from orthodontist driven treatment services to patient-centered care provision (17). In this context, assessing OHRQoL has become a crucial element in providing patient-centered-orthodontic treatment provision and there is proliferating research in this regard over past two decades (18-19) and also known as "socio-dental model" in managing orthodontic patients (20). This model combines clinical assessment, perceived impacts of malocclusion on quality-of- life and behavioural tendency when prioritizing orthodontic treatment (21), especially in resource constraints with ever increasing demand necessitating optimizing resource use (22). This has attributed to the fact that substantial reductions in orthodontic treatment need was evident by using socio-dental model (20-22). Moreover, condition specific assessment tools of OHRQoL such as Oral Impacts of Daily Performance (OIDP) have been recommended over generic tools of OHRQoL such as Oral Health Impact Profile-OHIP-14) to discriminate between adolescents with normative orthodontic treatment need (23). However, several studies and systematic reviews and meta-analyses have included OHIP-14 for assessment of OHRQoL among orthodontic patients of (24-29).

An attractive smile is not only one of the desired outcomes of orthodontic treatment provision but crucial in determining the facial attractiveness that influences individual well-being and OHRQoL (29) Therefore, it is well known that malocclusion as well as orthodontic treatment provision impact on OHRQoL of orthodontic patients (23-25). Therefore, not only malocclusion but its corrective treatment has become quality-of-life issues as demand for orthodontic treatment mostly attributed to personal concerns about appearance and other psycho-social factors (26). Hence, findings of studies on OHRQoL on orthodontic patients become useful in taking steps for enhancing patients' cooperation, expectation, adherence to orthodontic treatment and its effectiveness (26-28).

As evident from published research there is an array of explorations on the impact of malocclusion/ orthodontic treatment need on the quality of life and OHRQoL of orthodontic patients. A systematic review in this regard conducted in 2009, based on 23 studies that met inclusion criteria reported that, there was a modest association between malocclusions /orthodontic treatment need and quality of life, nevertheless, suggesting need for further research with methodological rigour (30). Furthermore, the majority of OHRQoL research conducted in the past among orthodontic patients included only adolescent patients which could be considered as a global trend as the great majority of orthodontic patients comprised of adolescents. This pattern prevails in Sri Lankan context as well especially in overcrowded public orthodontic clinics. Another more recent systematic review and meta-analysis on impact of malocclusion on OHRQol of children provided evidence for a clear inverse relationship of malocclusions with OHRQoL (18). Heterogeneity of studies with regard to age of children, cultural attributes, malocclusion assessment indices and OHRQol indices had influenced the findings of those systematic reviews. Furthermore, cross-sectional study designs and small convenient samples could be considered as methodological limitations in many studies. Moreover, Sun et al.,2017, conducted a systematic review and meta-analysis to investigate the impact of untreated malocclusion on different aspects of OHRQoL (31). In order to make the comparability across the studies in this endeavour, studies that used the dental aesthetic index (DAI), index of orthodontic treatment need (IOTN), or index of complexity, outcome and need (ICON) to measure malocclusion and Oral Health Impact Profile (OHIP) to measure OHRQoL were included. As emerged from the findings, untreated malocclusions were

significantly associated with OHRQoL and more severe the malocclusions worse was the impact on many physical domains and all psychosocial domains (31). Similar findings were reported by Sun et al.,2018 in their subsequent systematic review and meta-analysis that included studies used the Child Perceptions Questionnaire (CPQ) to measure OHRQoL, and the Dental Aesthetic Index, Index of Orthodontic Treatment Need, and Index of Complexity, Outcome and Need to measure malocclusion (32). As emerged from the findings, nearly all levels of malocclusion affected the domains of functional limitation and social well-being; only very severe malocclusion affected the domains of oral symptoms, emotional well-being and the overall OHRQoL ($p < 0.05$) (32). Nevertheless, the authors recommended confirmation of the findings with longitudinal population-based studies (32).

Consequently, recent research explored how conventional and contemporary orthodontic treatment modalities impact on OHRQoL of orthodontic patients (33-37). However, it is not clear how malocclusions and orthodontic treatment modalities affect OHRQoL of orthodontic patients in Sri Lankan context. Against this backdrop, we aim to explore and expound OHRQoL of orthodontic patients in a premier public tertiary care dental hospital setting with special emphasis on their practical implications.

Methodology

A hospital-based based cross-sectional study with comparative components was conducted among orthodontic patients attending the National Dental Hospital (Teaching) Sri Lanka. The study population was all patients attending the Orthodontic Unit National Dental Hospital (Teaching) Sri Lanka (NDHTSL). Adolescent patients were defined as orthodontic patients aged 10-19 years, young adult patients as those who were aged 20-24 years and adult patients as those who aged over 24 years at the time of data collection which took place from August to October 2018. Inclusion criteria were, orthodontic patients belonging to those age groups having their first visits (those who were on pre-treatment status) and those who in the same age groups having subsequent visits to the orthodontic clinic (those who were on ongoing orthodontic treatment from initial stages to near completion). Orthodontic patients aged lesser than 12-years, syndromic cases, those who had difficulties in opening mouth, those presented with complications of previous orthodontic treatment were excluded. The study settings were the Orthodontic Unit and the Preventive Oral Health Unit of National Dental Hospital (Teaching) Sri Lanka.

The sample size calculation for the study was done using formula method by Lwanga & Lameshow, 1991) (38) as $n=z^2p\ (1-p)/d^2$. n = required minimum sample size, p = estimated percentage of orthodontic patients in Sri Lankan context with affected oral health related quality of life in the absence of any published studies with regard to public dental hospital context was considered to be 50% with z: level of significance as1.96. and desired level of precision as 0.05. Therefore, $n = 1.96^2 (1-0.50)/0.05^2 = 384$. However, when adjusted for 5% non- response rate sample size deemed 403.2. Accordingly, the minimum sample size was calculated as 403. Nevertheless, the final sample size comprised of 492 adolescents, young adult and adult orthodontic patients representing three categories. The sample comprised of orthodontic patients at first visits (pre-treatment stage) and those who were currently on orthodontic treatment. Dental Health Component of Modified Index of Orthodontic Treatment Need (DHC-M-IOTN) was used to categorize the severity of malocclusion of participating orthodontic patients (14). Importantly, an operational classification for severity of spacing was not available in the original version of the Dental Health Component of IOTN. However, compared to the Western populations spacing of teeth is common among Sri Lankan orthodontic patients. Therefore, it was mandatory to include an assessment of spacing and an operational classification for severity of spacing was developed. Consensual validity for this modification was obtained by the expert opinion of Consultant Orthodontists. Spaces within the upper dental arch were considered and categorized as Grade 1= (No treatment need) No spaces, Grade 2= (Little treatment need) Spaces total of less than 2mm, Grade 3= (Borderline treatment need) Spaces total of less than 4mm: Grade 4= (Need treatment)

Results

Table 1: Frequency of reporting oral impacts of daily performance by orthodontic patients										
Impact item	*Never*		*Hardly ever*		*Occasionally*		*Fairly often*		*Very often*	
	N	%	N	%	N	%	N	%	N	%
1. Eating, chewing & enjoying food	311	(63.2)	33	(6.7)	79	(16.1)	40	(8.1)	29	(5.9)
2. Speaking & pronouncing clearly	266	(54.1)	22	(4.5)	119	(24.2)	50	(10.2)	35	(7.1)
3. Brushing teeth well	317	(64.4)	32	(6.5)	68	(13.8)	39	(7.9)	36	(7.3)
4. Sleeping & Relaxing	406	(82.5)	17	(3.5)	22	(4.5)	25	(5.1)	22	(4.5)
5. Smiling, laughing & showing teeth without embarrassment	184	(37.4)	31	(6.3)	89	(18.1)	98	(19.9)	90	(18.3)
6. To be happy without getting upset about teeth	179	(36.4)	59	(12.0)	114	(23.2)	60	(12.2)	80	(16.3)
7. Carrying out school & other activities	368	(74.8)	23	(4.7)	46	(9.3)	37	(7.5)	18	(3.7)
8. Enjoying contact with friends & other people	338	(68.7)	27	(5.5)	58	(11.8)	42	(8.5)	27	(5.5)

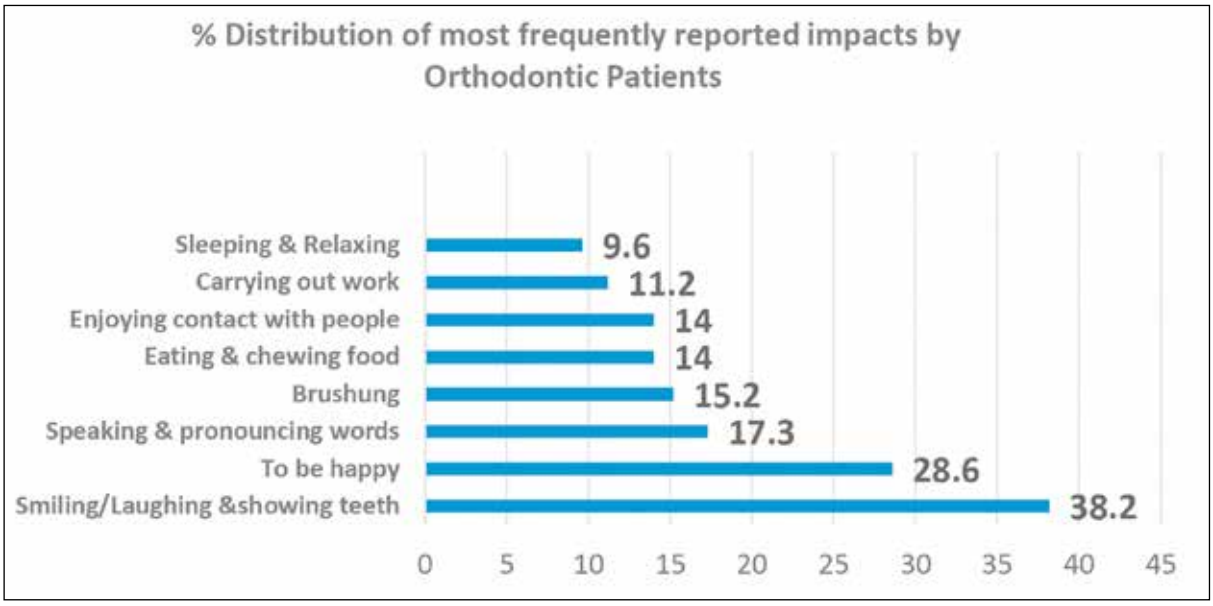

Figure 1: Distribution of patients by frequently reported impacts of daily performance

As shown in Table 1 and Figure 1, "smiling, laughing and showing teeth without embarrassment" was the most frequently affected aspect of daily life attributed to oral condition followed by "to be happy". "Speaking and pronouncing clearly", "brushing teeth well", "eating and chewing" and "enjoying contact with people" were among the occasionally affected daily activities reported by the orthodontic patients. In overall, less frequently reported impacts were related to "carrying out school and other activities" and "sleeping and relaxing".

Table 2: Comparison of frequency of reporting impacts on eating and speaking by socio-demographic and clinical indicators

Eating, chewing & enjoying food				
	Not frequently	Frequently	Chi-square value	p-value
Age group	N %	N %		
12-15 years	206 (48.8)	25 (35.7)	7.538	0.023
16-19 years	92 (21.8)	13 (18.6)		
≥20-years	124 (29.4)	32 (45.7)		
Total	422 (100.0)	70 (100.0)		
Gender				
Male	161 (38.2)	24 (34.3)	0.382	0.536
Female	261 (61.8)	46 (65.7)		
Total	422 (100.0)	70 (100.0)		
Perceived oral health status				
Below "good"	242 (57.3)	37 (52.9)	0.493	0.483
Good	180 (42.7)	33 (47.1)		
Total	422 (100.0)	70 (100.0)		
Orthodontic treatment need				
No/little/borderline	134 (31.8)	19 (27.1)	0.596	0.440
Definite	288 (68.2)	51 (72.9)		
Total	422 (100.0)	70 (100.0)		
Orthodontic treatment category				
Pre- treatment	242 (57.3)	27 (38.6)	12.439	0.002
Fixed appliances	132 (31.3)	37 (52.9)		
Removable appliances & other	48 (11.4)	6 (8.6)		
Total	422 (100.0)	70 (100.0)		
Speaking & pronouncing clearly				
	Not frequently	Frequently	Chi-square value	p-value
Age group	N%	N %		
12-15-years	200 (49.3)	31 (36.0)	9.122	0.010
16-19-years	89 (21.9)	16 (18.6)		
≥ 20-years	117 (28.8)	39 (45.4)		
Total	406 (100.0)	86 (100.0)		
Gender	N %	N %		
Male	146 (36.0)	39 (45.4)	2.666	0.103
Female	260 (64.0)	47 (54.6)		
Total	406 (100.0)	86 (100.0)		
Perceived oral health status	N %	N %	5.477	0.019
Below "good"	240 (59.1)	39 (45.3)		
Good	166 (40.9)	47 (54.7)		
Total	406 (100.0)	86 (100.0)		
Orthodontic treatment need	N %	N %	14.269	0.0001

No/little/borderline	141 (34.7)	12 (14.0)		
Definite	265 (65.3)	74 (86.0)		
Total	406 (100.0)	86 (100.0)		
Orthodontic treatment category	N %	N %	8.524	0.014
Pre- treatment	234 (57.6)	35 (40.7)		
Fixed appliances	129 (31.8)	40 (46.5)		
Removable appliances & other	43 (10.6)	11 (12.8)		
Total	406 (100.0)	86 (100.0)		

As illustrated in Table 2, age group, orthodontic treatment need and orthodontic treatment type were significantly associated with frequency of reporting impacts. Significantly higher proportions of orthodontic patients whom were aged ≥20-years and those who were on fixed orthodontic appliances reported frequent impacts in eating, chewing and enjoying food compared to adolescent age groups (p=0.023) and other treatment categories (p=0.002). Significantly high proportions of patients aged ≥20-years, had definite orthodontic treatment need, perceived their oral health status to be "good" and wore fixed appliances reported frequent impacts in pronouncing words compared to adolescent orthodontic patients (0.010), had no/little/borderline orthodontic treatment need (0.0001), perceived their oral health to be "below good" (0.019) and those who were on other treatment categories (0.014).

As demonstrated in Table 3, significantly higher proportions of 12-15-year- old adolescents and ≥ 20-year-olds reported frequent impacts in brushing teeth well compared to 16-19-year-olds (p=0.029). Gender, perceived oral health status, orthodontic treatment need and orthodontic treatment types were not significantly associated with frequency of impacts in brushing teeth well among the present cohort of orthodontic patients. As for the *sleeping and relaxing*, age group of the orthodontic patients were significantly associated with frequency of reporting issues. Compared to adolescent orthodontic patients, a significantly higher proportion of orthodontic patients whom were aged ≥ 20-years reported issues in this regard (p=0.006).

Table 3: Comparison of frequency of reporting impact on 'Brushing teeth well' and Sleeping/ Relaxing by socio-demographic and clinical indicators

Brushing teeth well				
	Not frequently	Frequently	Chi-Square value	p-value
Age group	N %	N %		
12-15 years	202 (48.6)	29 (38.2)	7.049	0.029
16-19 years	92 (22.1)	13 (17.2)		
≥ 20-years	122 (29.3)	24 (31.6)		
Total	416 (100.0)	76 (100.0)		
Gender	N %	N %		
Male	154 (37.0)	31 (40.8)	0.389	0.533
Female	262 (63.0)	45 (59.2)		
Total	416 (100.0)	76 (100.0)		

Perceived oral health status	N %	N %		
"Below" Good	233 (56.0)	20 (26.3)	0.959	0.327
Good	183 (44.0)	56 (73.7)		
Total	416 (100.0)	76 (100.0)		
Orthodontic treatment need	N %	N %		
No/little/borderline	133 (32.0)	20 (26.3)	0.959	0.327
Definite	283 (68.0)	56 (73.7)		
Total	416 (100.0)	76 (100.0)		
Orthodontic treatment category	N %	N %		
Pre-treatment	229 (55.0)	40 (52.6)	2.737	0.254
Fixed appliances	138 (33.2)	31 (40.8)		
Removable appliances & other	49 (11.8)	5 (6.6)		
Total	416 (100.0)	76 (100.0)		
Sleeping and Relaxing				
Age group	N %	N %		
12-15-years	219 (49.3)	12 (25.0)	10.332	0.006
16-19-years	91 (20.5)	14 (29.2)		
≥20-years	134 (30.2)	22 (45.8)		
Total	444 (100.0)	48 (100.0)		
Gender	N %	N %		
Male	168 (37.8)	17 (35.4)	1.787	0.181
Female	276 (62.2)	31 (64.6)		
Total	444 (100.0)	48 (100.0)		
Perceived oral health status	N %	N %		
"Below" Good	251 (56.5)	28 (58.3)	0.057	0.811
Good	193 (43.5)	20 (41.7)		
Total	444 (100.0)	48 (100.0)		
Orthodontic treatment need	N %	N %		
No/little/borderline	134 (30.2)	19 (39.6)	1.787	0.181
Definite	310 (69.8)	29 (60.4)		
Total	444 (100.0)	48 (100.0)		
Orthodontic treatment type	N %	N %		
Pre-treatment	237 (53.4)	32 (66.7)	4.062	0.131
Fixed appliances	155 (34.9)	14 (29.2)		
Removable appliances & others	52 (11.7)	2 (4.1)		
Total	444 (100.0)	48 (100.0)		

Table 4: Comparison of frequency of reporting impact on Smiling, laughing and showing teeth without embarrassment and to be happy without getting upset about teeth by socio-demographic and clinical indicators				
Smiling, laughing and showing teeth without embarrassment				
	Not frequently	Frequently	Chi-Square value	p-value
Age group	N %	N %		
12-15 years	155 (51.2)	76 (40.2)	6.004	0.050
16-19 years	62 (20.5)	43 (22.8)		
≥ 20-years	86 (28.4)	70 (37.0)		
Total	303 (100.0)	189 (100.0)		
Gender	N %	N %		
Male	121 (39.9)	64 (33.9)	1.829	0.176
Female	182 (60.1)	125 (66.1)		
Total	303 (100.0)	189 (100.0)		
Perceived oral health status	N %	N %		
"Below" Good	160 (56.0)	119 (63.0)	4.892	0.027
Good	143 (44.0)	70 (37.0)		
Total	303 (100.0)	189 (100.0)		
Orthodontic treatment need	N %	N %		
No/little/borderline	91 (30.0)	62 (32.8)	0.417	0.518
Definite	212 (70.0)	127 (67.2)		
Total	303 (100.0)	189 (100.0)		
Orthodontic treatment category	N %	N %		
Pre-treatment	148 (48.9)	121 (64.0)	15.137	0.001
Fixed appliances	111 (36.6)	58 (30.7)		
Removable appliances & other	44 (14.5)	10 (6.3)		
Total	303 (100.0)	189 (100.0)		
To be happy without getting upset about teeth				
Age group	N %	N %		
12-15-years	178 (50.7)	76 (37.6)	7.155	0.028
16-19-years	68 (19.4)	43 (26.2)		
≥20-years	105 (29.9)	70 (36.2)		
Total	351 (100.0)	189 (100.0)		
Gender	N %	N %		
Male	138 (39.3)	47 (33.3)	1.535	0.215
Female	213 (60.7)	94 (66.7)		
Total	351 (100.0)	141 (100.0)		
Perceived oral health status	N %	N %		
"Below" Good	193 (55.0)	86 (61.0)	1.479	0.224
Good	158 (45.0)	55 (39.0)		
Total	351 (100.0)	141 (100.0)		

Orthodontic treatment need	N	%	N	%	
No/Little/ Borderline treatment need	113	(32.2)	40	(28.4)	0.687	0.407
Definite treatment need	238	(67.8)	101	(71.6)		
Total	351	(100.0)	141	(100.0)		
Orthodontic treatment type	N	%	N	%		
Pre-treatment	183	(52.2)	86	(61.0)	4.500	0.105
Fixed appliances	124	(35.3)	45	(31.9)		
Removable appliances & others	44	(12.5)	10	(7.1)		
Total	351	(100.0)	141	(100.0)		

Table 5: Comparison of frequency of reporting impact on 'carrying out school and other activities' and 'Enjoying contact with friends & other people" by socio-demographic and clinical indicators

Carrying out school and other activities					
	Not frequently		Frequently	Chi-Square value	p-value
Age group	N	%	N	%		
12-15 years	210	(48.2)	28	(37.5)	6.344	0.042
16-19 years	96	(22.0)	12	(16.1)		
≥ 20-years	130	(29.8)	31	(46.4)		
Total	436	(100.0)	71	(100.0)		
Gender	N	%	N	%		
Male	163	(37.8)	22	(35.7)	0.096	0.757
Female	258	(62.2)	49	(64.3)		
Total	436	(100.0)	71	(100.0)		
Perceived oral health status	N	%	N	%		
"Below" Good	247	(56.7)	32	(57.1)	0.005	0.944
Good	189	(43.3)	24	(42.9)		
Total	436	(100.0)	56	(100.0)		
Orthodontic treatment need	N	%	N	%		
No/little/borderline	141	(32.3)	12	(21.4)	2.757	0.097
Definite	295	(67.7)	44	(78.6)		
Total	436	(100.0)	56	(100.0)		
Orthodontic treatment category	N	%	N	%		
Pre-treatment	240	(55.1)	29	(51.8)	1.773	0.412
Fixed appliances	146	(33.4)	23	(41.1)		
Removable appliances & other	50	(11.5)	4	(7.1)		
Total	436	(100.0)	56	(100.0)		

Enjoying contact with friends & other people					
Age group	N	%	N	%	
12-15-years	203	(48.2)	28	(39.4)	5.504	0.064
16-19-years	93	(22.1)	12	(16.9)		
≥20-years	125	(29.7)	31	(43.7)		
Total	421	(100.0)	71	(100.0)		
Gender	N	%	N	%		
Male	163	(37.8)	22	(31.0)	1.548	0.213
Female	258	(62.2)	49	(69.0)		
Total	421	(100.0)	71	(100.0)		
Perceived oral health status	N	%	N	%		
"Below" Good	242	(56.5)	37	(58.3)	0.713	0.398
Good	179	(43.5)	34	(41.7)		
Total	421	(100.0)	71	(100.0)		
Orthodontic treatment need	N	%	N	%		
No/little/borderline	130	(30.9)	23	(32.4)	1.065	0.799
Definite	291	(69.1)	48	(67.6)		
Total	421	(100.0)	71	(100.0)		
Orthodontic treatment type	N	%	N	%		
Pre-treatment	224	(53.2)	45	(63.4)	2.870	0.238
Fixed appliances	148	(35.2)	21	(29.6)		
Removable appliances & others	49	(11.6)	5	(7.0)		
Total	421	(100.0)	71	(100.0)		

Spaces total of less than 6mm and Grade 5=(Need treatment) spaces ≥6mm.

Data was collected by the Principal Investigator and co-investigators using an interviewer administered, pre-tested structured questionnaire. Face-to-face interviews were conducted by the co-I-investigators in the discipline of Dental Public Health and two fourth year dental undergraduates from the Dental School of University of Malmö, Sweden. Clinical examinations excluding assessment of malocclusion was conducted by the same investigators trained and assessed by a Specialist in Dental Public Health. Assessment of malocclusion was accomplished by using M-IOTN by the Principal Investigator and a co-investigator who was a Senior Registrar in Orthodontics who was trained and supervised Consultant Orthodontist. This achieved 98% agreement which deemed highly satisfactory. M-IOTN classification was assigned to participants by referring to pre-treatment study models and clinical records supported by clinical examination for those who were not on orthodontic treatment. Moreover, the data collection was conducted at a separate room away from the main clinic area of the Preventive Oral Health Unit. This ensured conduct of the interviews unobtrusively while maintaining confidentiality of the respondent without disturbing interferences. During interviews, orthodontic patients provided information on their socio-demographic profile, perceived oral health status, type of the visit, impact of their oral condition and ongoing orthodontic treatment (for those who were on ongoing orthodontic treatment) on their daily lives. The Oral Impacts on daily Performance (OIDP) index was used to gather information on those socio-dental impacts which was previously translated, modified, validated and cross culturally

adopted for Sri Lankan context (36). It comprised 8-items of daily life (eating, speaking, brushing teeth, sleeping, smiling, being happy, carrying out daily activities and social contact) that inquired how frequently during preceding three months (from the day of data collection) the respondent had experienced issues in each item with regard to status of his or her teeth and mouth. The frequency was marked on a Likert-scale as 0=Never, 1=Hardly ever, 2=Occasionally, 3=Fairly Often and 4=Very Often.

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Discussion

A plethora of studies found that untreated malocclusions or unmet orthodontic treatment need have physical, psychological and social consequences on children, adolescents (17,37,38,41-49) and young adults (7,25,40,50-53), whilst severe the malocclusion status the worst was the impact (27,29,38,52,53). Against this backdrop, our findings presented the prevalence of impacts on physical, psychological and social dimensions of their daily lives perceived by orthodontic patients pertaining to their malocclusions and ongoing orthodontic treatments. As for the frequent impacts on daily performances were concerned, *"smiling/laughing & showing teeth without embarrassment"* and *"to be happy without getting upset about teeth"* emerged as most affected elements (Figure 1, Table 1). Not only adult patients aged ≥ 20-year, a higher proportion of 12-15-year old adolescent patients as well reported frequent impacts on being *"happy without getting upset about teeth"*. Fixed appliances orthodontic treatment was significantly associated with reporting impacts on daily lives with regard to functional aspects. Our findings corroborated with similar findings published in voluminous global research on OHRQoL of orthodontic patients (28,34-37).

As emerged from our findings, adult patients aged ≥20-years, reported significantly frequent impacts on all items of OIDP except for social contact (Table 2-5). This notion was evident with similar research conducted among young adults in Malaysia despite methodological variations in two studies (7). Our findings corroborated the findings of another study by Chen et al.,2015, among 190 Chinese young adult orthodontic patients aged 18-25 years (26).

As revealed by their findings, there was a significant impact on their OHRQoL with greatest impact on psychological discomfort and psychological disability domains (26). Somewhat comparable findings were reported by another study that explored impacts on daily performance by fixed orthodontic appliances and clear aligner therapy on adult orthodontic patients aged 25-35-years (50). Accordingly, those who had fixed orthodontic appliances reported significantly high impact scores for eating, cleaning teeth and smiling and there were no gender differences thus supporting our findings. However, in contrast to our findings, social contact was significantly affected among those who had fixed orthodontic appliances (50). Another study that explored OHRQoL among Finnish orthodontic patients with severe malocclusion at pre-treatment stage reported a high prevalence of perceived oral impacts (70.2%) (51). Other studies reported gender specific associations of malocclusion traits in OHRQoL among Finnish adult population with women reporting more impacts (52) and female preponderance in reporting more impacts by Lithuanian young adults (53). In contrast, our findings did not show gender differences in OHRQoL of orthodontic patients on contrary to aforementioned researches (7,51-53) however, agreed with young adults getting more affected than adolescent orthodontic patients with frequent impacts. This could be due to relatively low overall prevalence of impacts as well as both males and females experiencing similar status of impacts due to their malocclusion status and orthodontic treatment. Our findings were further supported by a similar study conducted among Turkish orthodontic patients that evaluated the relationship between orthodontic treatment complexity and OHRQoL (25). Similar to our findings, in the Turkish study adult orthodontic patients indicated a priority group of emerging importance of orthodontic care provision (25) as they demonstrated significant negative impact on the psychological domain prior to treatment compared to adolescent orthodontic patients (25).

However, on the contrary to Orthodontist's claims on considering all those who with definitive orthodontic treatment need for orthodontic care, research findings questioned whether all of them actually needed such care as the majority did not perceive an impact in performing their daily activities (23,27, 37,41). On the other hand, some research findings reported that IOTN index when in combination with an OHRQoL measure, explained significantly more perceived needs of children with malocclusions than used alone (28). This notion was supported by the fact that relatively high percentages of children and adults with definite orthodontic treatment need did not perceive impacts for their daily lives whilst some of the adolescents despite having little or no orthodontic treatment need becoming dissatisfied with the appearance of their teeth (27-28,41) A highly variable association between the perceived orthodontic treatment need and orthodontist's assessment was revealed by a systematic review (42). Our findings as well raised the same concerns as the majority of patients ranging from 71.8% to 90.4% did not report frequent impacts across 8-items of OIDP. The diagnosis of severity of a malocclusion and assessment of orthodontic treatment need by an orthodontist therefore should be complimented by perceived impact of those on lives of affected people (23,24). Findings of such assessments found substantial reductions in normative need estimates for orthodontic treatment when they were combined with the socio-dental approach (44-47).

Orthodontic treatments with both removable and fixed appliances demonstrate varying impacts on performance of daily activities as supported by our findings. Fixed orthodontic appliances become more cumbersome over removable appliances with regard to aesthetics, difficulties in having food and beverages, maintaining oral hygiene as well as pain and oral trauma etc (28). Therefore, within the context of contemporary global paradigm shifts of patient-centered orthodontic treatment provision, assessments of OHRQoL among orthodontic patients receiving treatment has become increasingly evident, in short and long terms (28,34).

As revealed by the findings, perceived oral health status of orthodontic patients were significantly associated with frequent impacts on *"speaking and pronouncing words clearly"* and *"smiling, laughing and showing teeth without embarrassment"* (Table 2 &4). Significance of such findings, indicate the

importance of the clinicians to understand and appraise the patient differences in perceived impact of malocclusions as well as ongoing orthodontic treatment. Orthodontic patients in pre-treatment stage reported significantly higher impact compared to those in ongoing treatment (Table 4). Hence, it could be plausibly argued that those who with malocclusions before treatment perceived their oral health status to be "less than good". This assumption was supported by our previous findings of a group of 100 orthodontic patients attended the same study setting, demonstrating significant association with perceived oral health status and orthodontic treatment need assessed by DHC-IOTN (54). In this study those who had definitive orthofontic treatment need for severe malocclusions perceived their oral health status to be poor. However, for speaking and pronouncing words, those who perceived good oral health status reported more frequent impacts than those who perceived their oral health to be less than good. This could be explained by having pre-treatment and ongoing treatment groups together in our study with various stages of treatment outcomes which in turn influenced their perceived oral health status.

Conclusions

The majority of orthodontic patients did not perceive frequent impacts in their daily lives. However, among those who reported frequent impacts, "smiling, laughing and showing teeth without embarrassment" and "feeling happy without being upset of appearance of teeth" were the most affected aspects whilst the age of patients, perceived oral health status, severity of the malocclusion reflected by definite orthodontic treatment need and orthodontic treatment type were significantly associated with reporting frequent impacts in some aspects of daily life. In overall, patients aged ≥20-years, had definite orthodontic treatment need and had fixed appliance therapy reported significantly more frequent impacts than other age groups,who had no/little/borderline treatment need and other treatment modalities or were in pre-treatment stage. Therefore, complimenting clinician based normative orthodontic treatment need assessment with patient-perceived outcomes underpinned by OHRQoL assessments could be a promising way forward for prioritizing patients for orthodontic treatment services in public sector aimed at efficient use of scarce resources. Young adults emerged as an important priority group for orthodontic treatment provision due to the significant impact of their unmet orthodontic treatment need on their OHRQoL. Further, indicated by our findings, assessment of OHRQoL among patients on ongoing orthodontic treatment such as fixed appliance therapy especially during initial stages could be useful in improving their compliance and adherence to treatment. Nevertheless, more research is warranted in this regard with methodological rigor for better conclusive evidence.

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EFFECTIVENESS OF TWIN BLOCK APPLIANCE THERAPY IN THE MANAGEMENT OF CLASS II DIVISION 1 MALOCCLUSIONS- A CEPHALOMETRIC ANALYSIS.

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ABSTRACT

Class II division 1 malocclusion is common among the Sri-Lankan population. In some cases, removable functional appliance treatment may be an alternative to fixed appliance therapy if the clinician can amongst other factors, start treatment at the appropriate time

Objectives

To assess the effectiveness of twin block appliance therapy in the management of class 11 division 1 malocclusions in a sample of Sri Lankan patients.

Methods

A retrospective cross-sectional study was performed on a sample of randomly selected patients (N=30) completing Twin Block treatment, and with follow-up, at the orthodontic unit, Sirimavo Bandaranayke Specialized Children Hospital. Pre and post-treatment cephalograms were compared. Measurement means were compared by using student's t test. 0.05 Cephalograms were taken under standard conditions (constant film-focus distance of 1.5m, object to film distance 0.15m. Both angular and linear–measurements were measured and recorded. All statistical analysis were facilitated by statistical package for the social sciences version 25.0

Results

After Twin block appliance treatment, it appears that the mean SNB angle (t=2.06: p=.04), mean ANB Angle (t=5.74: p=<0.001) mean Upper Incisor to mean Maxillary Plane angle (t=5.05: p=<0.001), mean Inter Incisor angle (t=5.01: p=<0.001) and mean WITSS Appraisal (t=4.59:p=<0.001) experienced significant change.

Conclusion

The present study confirms that removable functional appliance therapy with the twin block appliance is a successful treatment option for management of Class II Division 1 malocclusions. But there are many challenges in using twin block. Poor patient compliance can be observed as a result of changes in speech, morphological deviations of the face, and discomfort in use. Successful implementation of twin block treatment is a complex challenge, especially considering the psychosocial development of an adolescent child.

INTRODUCTION

The objective in treatment planning is to design a strategy that would address the problems, maximizing benefits to the patient, whilst minimizing the cost and risk (1). Class II Division 1 malocclusion is a common orthodontic problem and has numerous treatment options available depending upon clinical factors, including the age and growth potential of the patient, as determined by the treating clinician.

Functional appliances, (or growth modification appliances), can be defined as removable or fixed orthodontic appliances that aim to utilize, eliminate or modify the forces generated by the orofacial musculature, tooth eruption, and dento-facial growth in order to alter the skeletal and dental relationship.

Examples of these appliances include (2)

1. Tissue Borne - Frankel appliance
2. Tooth Borne - Twin block appliance
3. Tooth Borne - Andresen appliance
4. Myotonic - Harvold activator
5. Fixed - Herbst appliance

The Twin block appliance is a removable functional appliance which was originally developed by William J. Clerk in the 1980s(3). It is made of two components, and uses an upper bite plate and lower bite plate which both work together to posture the lower jaw forwards. Treatment with Twin Block appliance is typically in the range of 12 to 18 months, however will vary depending upon the growth rate of the patient, as well as the severity of the malocclusion. Therapy generally consists of two stages, when using a twin block. The active phase aims to reposition the mandible forwards in order to achieve over-jet reduction and over-bite correction. The second phase is a supportive phase, where an upper removable appliance is used with an anterior inclined bite plane with the goals of retaining the corrected incisor relationship until the posterior occlusion is fully interdigitated. It is a commonly used functional appliance, partly due to its acceptability by patients (4). Key indicators for use of the twin block appliance are: Class II Division 1 malocclusion; patients who are actively growing and exhibit a normal growth pattern; early permanent or late mixed dentition; well aligned dental arches; over-jet 10mm or less; normal or deep over bite; and improved facial profile once mandible is postured forward to a Class 1 dental relationship.

Twin Block functional appliance is relatively well tolerated by patients (5), robust and easy to repair, fairly easy to advance the mandible, and suitable to use in permanent or in mixed dentition. Patient compliance for the Twin Block appliance is relatively high due to its low cost, less treatment time, aesthetic and functional acceptability, and relatively less tissue irritation. Although Twin Block appliance therapy is practiced by Sri Lankan orthodontists, there is no reported data among our patients regarding the efficacy of this functional appliance. Therefore, a study to evaluate the outcomes of treatment in Sri Lanka is required, in order to support evidenced based practice. This is particularly relevant considering the increasing popularity of the Twin Block appliance in Sri Lanka, hospital clinics in view of its advantages in reducing treatment cost, and clearing long waiting lists, when compared to treatment with fixed orthodontic appliances. Various other types of functional appliances are also used such as the Herbst, Bionator, Andresen, etc., but again, there is no published data regarding the effectiveness of these appliances specific to the Sri Lankan population.

Materials and Methods

A descriptive cross sectional study design, with retrospective data collection was conducted using a sample of randomly selected patients (N=30) treated, and with follow-up, at the orthodontic unit, Sirimavo Bandaranayke Specialized Children Hospital Peradeniya; Sri Lanka. Patients included in the study period commenced treatment between 2009.01.01 to 2011.10.01. The study was performed on archived radiographs, and in particular lateral cephalograms. The cephalograms of pre and post treatment were taken under standard conditions (constant film-focus distance of 1.5m, object -film distance 0.15m). All cephalograms were hand traced by a single investigator and all angular and linear measurements were recorded, and reviewed twice

by independent investigators for accurate land mark identification in order to minimize the intra observer error. (Figure 1)

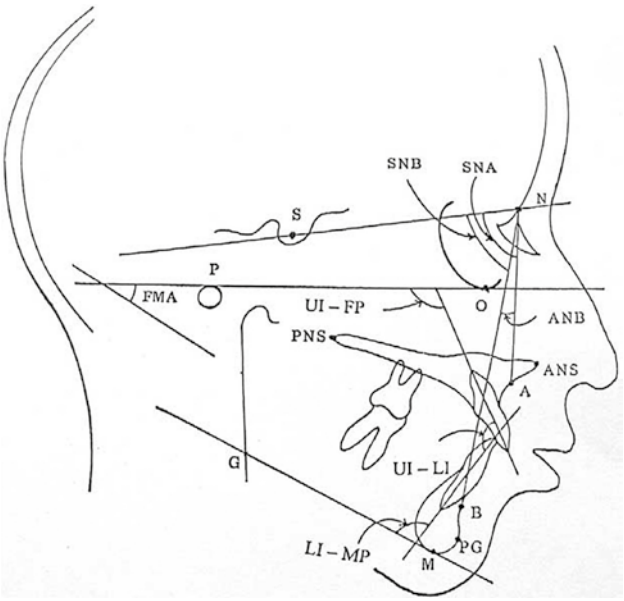

Figure 1 : Recorded Landmark with angular and Linear measurements.

The following landmarks were identified and marked:

1) Nasion (Most anterior point of the fronto-nasal suture)
2) Sella (The midpoint of sella turcica)
3) Anterior nasal spine (Tip of the anterior process of the maxilla)
4) Posterior nasal spine (Tip of the posterior nasal spine of the maxilla)
5) Gonion (The most posterior inferior point of the mandible)
6) Menton (Lowest point of the mandibular symphysis)
7) Porion (Upper most outer most point of the bony external auditory meatus)
8) Point A (The point of deepest concavity on anterior profile of maxilla)
9) Point B (The point of deepest concavity on anterior surface of mandibular symphysis)

Using those landmarks, the following parameters were measured.

Angular measurements:

1) Sella-nasion-A-point angle (SNA)
2) sella-nasion-B-point angle (SNB)
3) A-point-nasion-B-point angle (ANB)
4) Upper incisor axis to maxillary plane angle (UI-MAX)
5) Lower incisor axis to mandibular plane angle (LI-MAN)
6) Interincisal angle (IIA)
7) Maxillary mandibular plane angle (MMPA)
8) Frankfort mandibular plane angle (FMPA)

Linear measurements:

9) WITS.

All statistical analysis were undertaken on statistical package for the social sciences version 25.0. Mean values of pre and post treatment measurements were compared. Students t test was used for mean comparisons with 0.05 probability cut off to assess whether there was statistically significant difference between the pre and post cephalometric variables.

Results

Age of the study participants ranged from 9 years to 13 years (Mean=11.4 years: SD=1.2 years). Treatment follow up was reviewed between 15 and 22 months (Mean=18.3 months: SD=1.9 months). Using the Twin Block, it appears that the mean SNB angle (t=2.06: p=.04), mean ANB Angle (t=5.74: p=<0.001), mean Upper Incisor to mean Maxillary Plane angle (t=5.05: p=<0.001), mean Inter Incisor angle (t=5.01: p=<0.001) and mean WITS Appraisal (t=4.59:p=<0.001) change significantly (Table 2).

Table1: Distribution of age and Treatment duration of study participants		
	Frequency (N)	Percentage (%)
Age (Years)		
9.00	3	10.0
10.00	4	13.4
11.00	7	22.4
12.00	6	20.0
12.50	8	26.6
13.00	2	6.6
9.00	3	10.0
10.00	4	13.4
Treatment Duration (Months)		
15	2	6.7
16	5	16.7
17.00	5	16.7
18.00	1	3.3
19.00	8	26.7
20.00	7	23.3
22.00	2	6.7
15.00	2	6.7
16.00	5	16.7
Total	30	100.0

Table 2: Comparison of pre and post treatment angle measures				
	Pre-Treatment Mean(SD)	Post-Treatment Mean(SD)	t	P value
SNA Angle	81.8 (3.32)	81.26 (2.87)	.549	.664
SNB Angle	77.1 (3.3)	78.83 (3.2)	2.062	.044
ANB Angle	5.13 (1.35)	2.66 (1.91)	5.749	<0.001
Upper Incisor to Maxillary Plane angle	122.43 (6.61)	114.3 (5.8)	5.05	<0.001
Lower Incisor to Mandibular Plane Angle	100.46 (5.41)	101.96 (5.51)	-1.063	.292
Inter Incisor angle	114.16 (6.19)	122.56 (6.77)	-5.012	.000
FMPA	25.0 (4.01)	25.03 (3.81)	-.033	.974
MMPA	25.23 (3.8)	25.76 (3.72)	-.548	.585
WITS Appraisal	3.7 (1.86)	1.71 (1.44)	4.594	.000

An increase in the SNB, Inter incisor and lower incisor angulations was observed, whilst ANB, upper incisor angulation, WITS and SNA decreased after treatments (Figure 2).

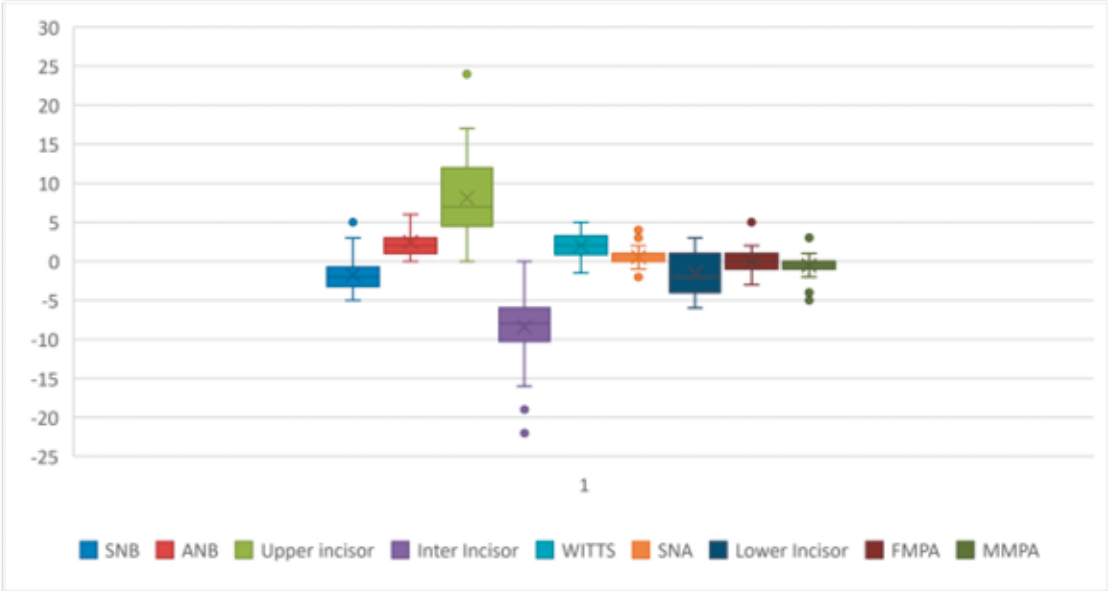

Figure 2: Distribution of differences in the parameters after the treatment

Sella-nasion-A-point angle (SNA), sella-nasion-B-point angle (SNB), A-point-nasion-B-point angle (ANB), Upper incisor axis to maxillary plane angle (UI-MAX), Lower incisor axis to mandibular plane angle (LI-MAN), Interincisal angle (IIA), Maxillary mandibular plane angle (MMPA), Frankfort mandibular plane angle (FMPA)

Discussion

Class II malocclusion can manifest in various combinations of skeletal and dental disharmony that affect the overlying soft tissue facial profile. However, the majority of patients exhibits some degree of Antero-posterior deficiency of mandible. In Sri Lanka, one of the popular growth modification treatments used for Class II Division 1 malocclusions is to use a twin block appliance. Although many studies have evaluated the dento alveolar and skeletal changes related to different types of functional appliances, only a relatively small proportion have analysed post treatment changes specifically related to the twin block appliance (5–7).

The present study was performed to analyse the effectiveness of twin block appliance in a group of Sri Lankan patients with Class II Division 1 malocclusion by analysing variables on pre and post treatment cephalograms. The results demonstrate significant changes in both dento alveolar and skeletal parameters after treatment.

In this study, skeletal effect on the maxilla seems to be minimal due to the less significant change in SNA value. This finding is similar to the studies by O'Brien et al 2003 and Illing et al 2016, who founded minimal restraining effect on maxillary growth with twin block appliance and demonstrated a small mean reduction in SNA angle respectively. Due to the viscoelastic stretch of the facial muscles and surrounding soft tissues, the anteriorly postured mandible tends has been reported to create a reciprocal restraining effect on the maxilla which is called the headgear effect (1). However, the present study would suggest in this group of patients this effect was minimal.

Skeletal effect of functional appliances on mandibular growth are controversial in orthodontics. Several studies have suggested that the twin block appliance can increase the SNB angle by anterior relocation of point b and pogonion (8–10). Baysal et al and Uysal et al found a significant increase in SNB angle after treatment with twin block appliance (11). Present study results are similar to the above-mentioned studies with significant increase in SNB angle following twin block appliance. In addition, no actual measurements of mandibular body length, mandibular fossa adaptation or relocation were made in this study and further studies are recommended to assess long term effects of mandibular skeletal growth after using the twin block appliance.

Maxillary-Mandibular relationship changes were assessed by the changes of ANB angle and the WITS appraisal. Many studies show a decrease in SNA angle or increase in SNB angle, or both, showing a significant change in ANB angle (11). Present study results are similar to previous findings with mean reduction in ANB angle following twin block appliance, which was found to be significant change (Table 2). Changes of the vertical relationship of the jaws after twin block appliance therapy seem to be vary. Some studies showed an increase in MMPA where as other studies demonstrated a small reduction of MMPA mean value. Possible cause for this decrease said to be the inhibition of molar eruption when using posterior bite planes. In present study , a significant increase in mean MMPA value could be observed (12).

The following dento alveolar changes were observed during twin block appliance therapy. A significant reduction in maxillary incisor inclination can be observed, in accord with findings by Illing et al (1998) and O'Brien et al (2003). This effect is greater by incorporating labial bow into the appliance (4,10). This contributes to the over jet reduction significantly (8). In present study significant retroclination of maxillary incisors was found following twin block appliance therapy.

The effect of twin block treatment upon mandibular incisor inclination has been found to vary in different studies (8,13,14). Lund and Sandler et al 1998 found a significant increase in mandibular incisor inclination whereas Illing et al found no significant changes (11,12). In this study, lower incisor inclination was increased less significantly. This contributes to the over-jet reduction by limiting the potential for further growth of mandible.

Conclusion

The present study supports the findings by prior studies, that twin block therapy is a successful treatment option for Class II Division I malocclusions. But it must be remembered that there are many challenges while using twin block appliances. Poor patient compliance can be observed due to changes in speech, morphological deviations of the face, and from discomfort in use. Successful implementation of twin block treatment is a complex challenge, especially considering the psychosocial development of an adolescent child.

In view of this, it is essential to educate the patient and family members adequately before commencing treatment with twin block appliances. It is essential that the child, parents, school and dentist work in close coordination throughout the treatment duration and provide a combined treatment approach.

Low cost, highly effective treatment modalities such as twin block therapy are very useful for a country with a free health care service such as Sri Lanka. The elimination of misconceptions about twin block applications and the deployment of trained health workers to better prepare the patient for treatment should be implemented in a planned manner.

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Translation and validation of the Sinhala version of Psychosocial Impact of Dental Aesthetic questionnaire (PIDAQ) among adolescents seeking orthodontic treatment.

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ABSTRACT

Psychosocial Impact of Dental Aesthetic Questionnaire (PIDAQ) originally developed for young adults seeking orthodontic treatment is a multi item psychometric instrument which investigates on four domains:Dental self confidence,social impact,psychological impact and aesthetic concern. PIDAQ comprises of 23 items.

Objective: The purpose of this study was to determine the construct validity and reliability of Sinhala version of PIDAQ to use among adolescents.

Methods: A cross sectional descriptive validation study was carried out with translation of the original English version of PIDAQ into Sinhala by a team of professionals adhering to translation and cross-cultural adaptation and validation guidelines. Inclusion and exclusion criteria were considered and in a convenient sampling method 11-16 year old adolescents were recruited from University Dental hospital,Peradeniya and Teaching Hospital Karapitiya. Data was analyzed using SPSS 21 and reliability and validity was evaluated.

Results: A total of 479 adolescents (Male: Female: 51:49) participated and mean age was 13.1 years. KMO Measure of Sampling Adequacy was 0. 870. A Principal component analysis was conducted on the 23 items with varimax rotation. Five domains with 57.88% variance were extracted. The internal consistency measured with Crohnbach's alpha value was 0.8($p<0.001$). The internal consistency for the five subdomains were 0.8,0.8,0.6,0.7 and 0.8.The mean PIDAQ total score and the score of the Dental Esthetic Component of the Index of the Orthodontic Treatment Need (IOTN) showed significant correlation.

Conclusion: PIDAQ Sinhala version has good internal consistency and construct validity.The Sinhala version of the PIDAQ is a reliable and valid tool to assess the psychological impact of the dental esthetics of the Sinhala speaking adolescent orthodontic patients.

Key Words: quality of life, adolescents, orthodontics, dental esthetics, Sinhala

INTRODUCTION

Oral health related quality of life is defined as 'the absence of negative impacts of oral conditions on social life and a positive sense of dentofacial self confidence'[1]. It is noticed that malocclusion affects an individual's self-satisfaction and the self-esteem and as a result the oral health related quality of life [2,3].

There has been an increased demand for orthodontic treatment in recent years and most of the patients seek orthodontic treatment to improve facial esthetics [4]. According to Jadbinder et al., dental irregularity can be subjected to bullying or peer victimization at a prevalence of 12.8% among children aged 10-14 years [5].

In order to objectify the treatment needs, several indices have been developed in orthodontics. At present, Index Of Orthodontic Treatment Need (IOTN index) proposed by Brook and Shaw is widely being used [6]. IOTN index considers the dental health condition as well as the esthetic appearance of the dentition. The disadvantage of this index is that it does not give much information about the perceived need and the impact of malocclusion on the psychological well being of a person [7].

Patient centered care is a concept that has been introduced recently in health care delivery system [8]. Orthodontic practice in Sri Lanka also need to adopt criteria to address patient's perceived need. Hence, in planning orthodontic treatment and prioritizing treatment, it is essential to adopt an oral health-related quality of life measurement as well. Health-related quality of life (HRQoL) is measured using questionnaires which provide information on the patient's perception of his or her welfare in relation to a particular medical condition[9].

Psychosocial Impact of Dental Esthetic questionnaire (PIDAQ) had been designed and developed by Klages et al., specifically for orthodontics and it is used to assess the psychosocial impact of dental esthetics in young adults[10]. Klages et al in 2015 used a partially reformulated version of PIDAQ questionnaire among adolescents and it was confirmed to have applicability across age-groups[11]. However,questionnaires written in another language need to be translated and adapted to the target language taking into account the cultural and social aspects while preserving the psychometric properties of the original instrument[12].

Therefore, the aim of the present study was to test the validity and reliability of the Sinhala version of PIDAQ questionnaire for use among adolescents in Sri Lanka.

Methods

Cross-cultural adaptation

The process of translation, cross cultural adaptation and validation of the PIDAQ consisted mainly of two parts viz preliminary study and main study. In the preliminary study the steps were, forward translation, back translation, committee review and construction of the final version.

Forward translation into Sinhala language was done by two experts in both English and Sinhala languages. These two included dental and non-dental professionals. Afterwards a commitee consisting of two orthodontists, two dental surgeons and two language experts were convened and a thorough discussion had been made with regard to semantics to create the first draft of the translation.

The first Sinhala draft had been back translated into English by two professionals independently who were English language experts attached to the University English Language Teaching Units. After back translation comparison and modifications were done and a second draft of the Sinhala version was formulated.

The second draft of the Sinhala version had been pretested among 20 children and with appropriate ammendments, final draft of the Sinhala version of PIDAQ was formulated.

The final version of the Sinhala PIDAQ questionnaire was self-administered among 479 adolecsent new orthodontic patients who were seeking orthodontic care from the University Dental Hospital, Peradeniya and Teaching Hospital Karapitiya respectively.

PIDAQ questionnaire

PIDAQ is a multi item psychometric instrument which investigates four domains that are orthodontic-specific: Dental self confidence (6 items),social impact (8 items), psychological impact (6 items) and aesthetic concern (3 items). The questionnaire consists of 23 items and it was self-administered. Response to each item was rated using a five-point Likert scale as in the original version: 0 = "not at all," 1 = "a little," 2 = "somewhat," 3 = "strongly,"and 4 = "very strongly" [3]. All items in the Dental Self Confidence domain which were positively worded were reverse scored to bring the direction of scoring in line with other subscales.

Index of Orthodontic treatment need

Index of Orthodontic Treatment Need (Brook and Shaw 1989) was used to assess the severity of the malocclusion [6]. It comprises of two elements: Dental Health Component (DHC) and Aesthetic component (AC).

The features considered in the dental health component are Missing teeth, Overjet, Crossbites, displacement of the contact points (crowding) and Overbite.

The worst trait of the malocclusion had been determined by the orthodontist and categorised into one of the five grades, which depicts the normative orthodontic treatment need of the patient. Grades 4 and 5 indicate great need for orthodontic treatment and the grade 3 indicate the borderline /moderate need. Grades 1 and 2 represent little need or no need for orthodontic treatment.

The Aesthetic Component of the Index of Orthodontic treatment need (IOTN-AC)

IOTN-AC had been used to rate the dental attractiveness by the patient as well as by the consultant orthodontist for professional rating of the dental arrangement. Ten color photographs with varying degrees of dental irregularity were presented to the patient and each of them was asked to point out the photograph which closely resembles his/her malocclusion.

Sample size and the population of the study

Sample size was calculated using the rule of thumb described by Herdman et al., for validation studies [9]

Questionnaire was administered to adolescent orthodontic patients attended to Orthodontic unit of the University Dental Hospital Peradeniya and Teaching Hospital, Karapitiya on their first visit. In 2018, using a convenience sampling method, 479 adolescents were recruited considering exclusion and inclusion criteria. Adolescents of Sinhalese ethnicity between 11 years to 16 years of age were included. Those children with a previous history of orthodontic treatment,compromised medical or psychological history, severe skeletal discrepancies,cleft lip palate patients, fractured or flourosed anterior teeth or restored anterior teeth and periodontal disease were excluded.

Ethical clearance was obtained for the study from the Ethics Review Committee of the Faculty of Dental Sciences, University of Peradeniya (ERC/FDS/UOP/1/2018/01). Consent from the parents and assent from the children was taken prior to conduction of the study.

Statistical analysis

The data was analysed using statistical package for social sciences.(Version 20.0, SPSS Inc, Chicago,Illinois,USA). Simple descriptive statistics were generated.

Reliability of the scale

Internal consistency was tested using Cronbach's alpha and coefficient of correlation between items and scale were analyzed.

Validity of the scale

Kaiser-Meyer-Olkin measure was used to check the Sampling Adequacy.

Construct validity was tested using principal component analysis on the 23 items with varimax rotation in exploratory factorial analysis.

Convergent construct validity was assessed by comparing PIDAQ scores and IOTN DHC and AC components using Pearson correlation. The level of significance was set at $p<0.05$.

Results

A total of 479 adolescents were included and aged between 11 to 16 years with the mean age of 13.1years (± 1.3).Male to female ratio was 1.04:1.

Reliability

The internal consistency of the questionnaire assessed by Cronbach´s alpha coefficient was 0.8 ($p<0.001$). Cronbach´s alpha for the subscales ranged from 0.6 to 0.8 indicating acceptable to excellent internal consistency (table 1).

Table 1: Cronbach's alpha if item deleted for all 23 items along with corrected item total correlation.

Item	Corrected Item-Total Correlation	Chronbach's Alpha if Item Deleted
Q1 I am proud of my teeth	.630	.805
Q2 I like to show my teeth when I smile	.534	.826
Q3 I am pleased when I see my teeth in the mirror	.659	.799
Q4 My teeth are attractive to others	.686	.795
Q5 I am satisfied with the appearance of my teeth	.597	.812
Q6 I find my tooth position to be very nice	.568	.817
Q7 I hold myself back when I smile so my teeth don't show so much	.480	.801
Q8 If I don't know people well, I am sometimes concerned what they might think about my teeth	.467	.805
Q9 I'm afraid other people could make offensive remarks about my teeth	.524	.796
Q10 I am somewhat inhibited in social contacts because of my teeth	.537	.795
Q11 I sometimes catch myself holding my hand in front of my mouth to hide my teeth	.578	.788
Q12 Sometimes I think people are staring at my teeth	.522	.795
Q13 Remarks about my teeth irritate me even when they are meant jokingly	.600	.783
Q14 I sometimes worry about what members of the opposite sex think about my teeth	.583	.787
Q15 I envy the nice teeth of other people	.317	.670
Q16.If I don't know people well, I am sometimes concerned what they might think about my teeth	.375	.656
Q17. Sometimes I am somewhat unhappy about the appearance of my teeth	.618	.565
Q18. I think most people I know have nicer teeth than I do.	.394	.649
Q19.I feel bad when I think about what my teeth look like	.631	.551
Q 20.I wish my teeth looked better	.209	.717
Q21.I don't like to see my teeth in the mirror	.558	.788

Q22.I don't like to see my teeth in photographs	.746	.589
Q23.I don't like to see my teeth when I look at a video of myself	.595	.752

Overall Cronbach's alpha is 0.795. Deleting item number 20 increases the overall internal consistency. Corrected inter-item correlation was greater than 0.3 for each item

Construct validity

Kaiser-Meyer-Olkin measure of Sampling Adequacy was 0.870. A Principal Component Analysis was conducted on the 23 items with varimax rotation and extracted 05 components with 57.88% variance. Common factor 1 contained the original Social Impact subscale items 7-14 (eigenvalue=5.70) and explained 25.015 % of the variance. Common factor 2 contained items 1-6, comprising the Dental Self Confidence subscale (eigenvalue=3.2), and explained 14.25% of the variance. Common factor 3 derived only two questions (15 and 16) which had 6 questions in the original questionnaire. This segment as the psychological impact subscale explained 7.4% of the variance(eigenvalue=1.71). Common factor 4 contained the items 21-23 of the Aesthetic concern (eigenvalue=1.51) and explained 6.58% of the variance. Finally, the newly extracted common factor 5 contained the items 17-20 of the Dental consciousness subscale (eigenvalue=1.048) and explained 4.55% of the variance. In total, these 5 components explained 57.88% of the total variance. (table 2)

Table 2.0: Principal factorial analysis with orthogonal rotation using the varimax procedure and Kaiser normalization. The five factors are shown along with salient factor loadings for all items.

	Factors				
Responses	Social Impact	Dental Self Confidence	Psychological Impact	Aesthetic Concern	Dental consciousness
Q1		.743			
Q2		.635			
Q3		.758			
Q4		.781			
Q5		.720			
Q6		.732			
Q7	.576				
Q8	.737				
Q9	.707				
Q10	.504				
Q11	.564				
Q12	.607				
Q13	.606				
Q14	.649				
Q15			.735		
Q16			.691		
Q17					.617
Q18					.705

Q19					.592
Q20					.679
Q21				.743	
Q22				.873	
Q23				.820	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Discriminant validity

The mean PIDAQ total score and the score of the IOTN-AC showed significant correlation.

Difference in the perception according to the gender

Effect of gender on the PIDAQ score was evaluated using Mann-Whitney U test, and it was it was significant (P=0.03). Boys had scored more in the PIDAQ scores than girls.

Discussion

The present validation study of the PIDAQ among Sinhalese adolescents revealed an internal consistency of Cronbach's alpha 0. 795.Generally,it is accepted that a Cronbach's alpha value in a range of 0.5-0.8 as satisfactory for comparisons between groups [12].In Brazilian and Spanish validation studies conducted among the adolescents, the internal consistency measured with Cronbach's alpha values were in the range of 0.59 to 0.86 and 0.76 to 0.9 respectively[14,15]. Therefore, the internal reliability of our study was in accordance with those studies among adolescents (Table 3)

Table 3.0: Comparison of the reliability scores with other validated adolescent versions of PIDAQ

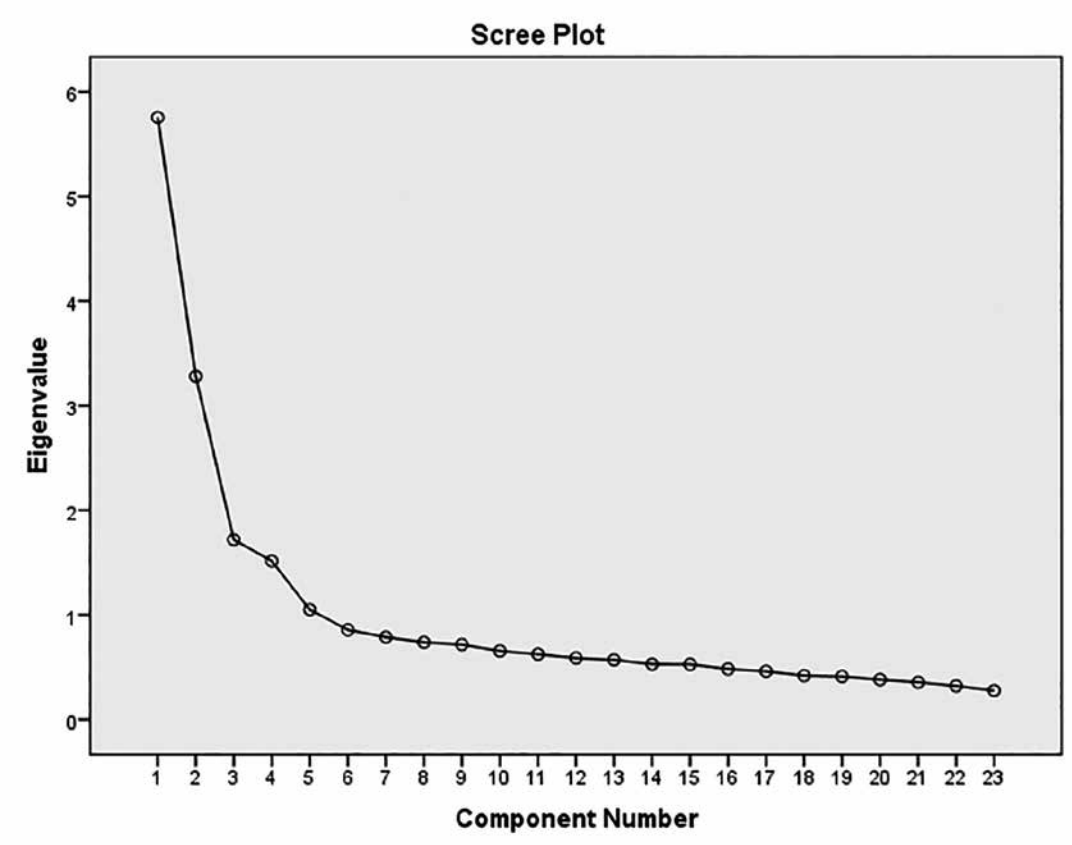
Author	Language	Chronbach's alpha values
Klages 2015	English	0.71-0.88
Santos PM,2015	Brazilian	0.59-0.86
Montiel-Company JM,2013	Spanish	0.76-0.9
Present study	Sinhala	0.6-0.838

In the present study, the factorial analysis extracted five factors in contrast to the four factors in the original study by Klages et al. However other validation studies of PIDAQ showed four domains as in the original study [14,15,16]. This finding is similar to the Nepalese version of the translation in which principal component analysis with orthogonal rotation, five factors had been extracted[17],[table 2]. In our study, the five components had an initial Eigen value greater than 1; furthermore, the Scree-plot confirmed the extraction of five components, and they could explain of 57.88% of the total variation [figure1]. Factor analysis with fixed number of four components had been attempted but there was a lot of mixing of items along the originally proposed domains and some items could not load sufficiently on the analysis. However, accepting five factors produced good item factor loadings and a new factor had to be formulated without mixing of items along sub-domains. This was in accordance

with the Nepalese study, in which a new domain was named as Self-consciousness. According to Decety and Sommerville, self-consciousness is defined as the awareness of his/her own body in a time-space continuum and its interactions with the environment including others [18]. The items 17 to 20 that comprise the fifth component were coinciding with emotions related to dental consciousness. The 5 subdomains of present study demonstrated good internal consistency when compared to the Nepalese version which had very high Crohnbach alpha values [table 4].

Table 4: Comparison of the reliability scores to assess socio-cultural differences in perception		
Subcategories	Chronbach's alpha values of translated questionnaire(Internal reliability)	Chronbach's alpha values of Nepali version
Dental Self confidence	0.838	0.986
Social Impact	0.826	0.978
Psychological Impact	0.610	0.965
Aesthetic Concern	0.680	0.976
Dental consciousness	0.795	0.988
Alpha value for the overall scale	0.8	0.944

Figure 1: Five components showing an initial Eigen value greater than 1



It is interesting that Sinhalese adolescents segregated the new domain from Psychological Impact (PI) whereas the Nepalese young adults segregated these items from both social and psychological impact domains of the original instrument. In Chinese version three factors had been extracted in factor analysis. The Chinese version joined PI and AC into a single subscale, essentially because of the cultural characteristics of the young Chinese population, as the authors explained [19]. Therefore, it is evident that the number of factors could vary according to the cultural background and the way of the expression of feelings and emotions.

The scale had good convergent construct validity as its' total score correlated well with the IOTN AC and DSC scales as adolescents having high scores for Sinhala PIDAQ exhibited higher statistically significant IOTN-AC and DSC values.

Interestingly, there was a significant difference in the PIDAQ scores between girls and boys and boys scored higher than the girls. However, the study done by Singh et al compared the male and female PIDAQ scores in young adults between 18 to 29 years and found no statistically significant difference [16]. Accordingly, during adolescence males have more concern about their outward appearance than during their early adulthood. This could explain a gender difference in the perceptions according to the age group.

Limitations

The discriminant construct validity could not be assessed as present investigation was hospital-based study among the orthodontic patients who had definite treatment need. The representation of normal occlusion was only 8%. As a result, group dichotomisation between no need and definite need for treatment could not be obtained.

Conclusion

Sinhala version of the PIDAQ for adolescents has good internal consistency,construct validity and psychometric properties. The Sinhala version of the PIDAQ is a reliable and valid tool to assess the psychosocial impact of the dental esthetics of the Sinhala speaking adolescent orthodontic patients.

Financial support and sponsorship

Self-funded

Conflict of interest

None

Acknowledgements

We would acknowledge Prof.T.M.S.U.B. Tennakoon for statistical support.

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Buccal alveolar bone effects after Conventional Hyrax and Hybrid Hyrax rapid palatal expansion in young adults - A CBCT study

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ABSTRACT

Objective: The undertaken research intends to assess the impact on buccal alveolar bone after conventional Hyrax expansion and hybrid Hyrax palatal expansion.

Materials and Methods: Twenty individuals with maxillary transverse deficiency were selected (mean age:21.5 years) and categorized into two groups. One group underwent maxillary expansion through traditional Hyrax device (n=10) and the second group through hybrid Hyraxdevice (n=10). CBCT was used to assess the buccal dehiscence and tooth angulation changes pre- and post-treatment. Statistical analysis was done using paired *t*-test.

Results: The hybrid Hyrax group exhibited insignificant difference from canine to second pre-molar. But the anchored first molar showed a mean difference of -4.54mm between pre and post alveolar bone width. In the traditional Hyrax group, the mean difference between pre and post alveolar bone width was significant in first premolar (-4.2mm) and first molar region (-4.84mm).

Conclusion: The conventional Hyrax induced buccal bone dehiscence and buccal tipping of first premolar and first molar region, whereas the hybrid Hyrax did not show any significant difference from canine till second premolar. However, there was tipping and buccal dehiscence in the first molar region.

Keywords: Adults, Buccaldehe science, Cone beam computed tomography, Hyax expander, Hybrid Hyrax expander

INTRODUCTION

The rapid palatal expansion protocols are related to the application of intermittent high forces. Previous studies have indicated that palatal expansion induces physiologic effects on the suture, alveolar bone bending, and tooth movement, and an orthopedic effect on maxilla[1].Several previous studies have investigated the skeletal as well as dental effects of rapid maxillary expansion(RME). While the main objective of this protocol is skeletal extension, it also leads to substantial dental expansion. RME has been shown to expand palatal shelves and rotate them upon opening, which leads to alteration in palatal process and alveolar process, and rotation of teeth about the mid palatal sutures[2,3,4].

Traditional tooth-borne expansion appliances have been successfully utilized to address transverse maxillary deficits for decades[5].However, these appliances accompany a number of drawbacks, such as limited skeletal movement, root resorption, unwanted tooth movement, dehiscence, reduction buccal cortical plate thickness, etc.[6].Since such

appliancesare linked to the teeth, it often impacts alveolar processes and leads to buccal mobility of posterior teeth, with the most prevalent side effect being buccal tilting [7].These issues have resulted in the development of alternative treatments, including implant-supported fast maxillary expander, [8,9].

Implant-supported palatal expanders facilitate direct anchoring of the screw with the palatal bone, obviating the need for tooth communication[10]. These appliances are divided into two categories: bone-borne and hybrid-Hyrax. Hyrax devices gain support from the palate through both anchor tooth and mini-implants. So, these hybrid expanders are partly tooth- and partially bone-anchored. Many studies have evaluated and recognised the skeletal and alveolar effects of hybrid expanders[11], but there's a scarcity of information on the periodontal effects of hybrid expanders.

The goal of this pilot study is to examine the difference in the three-dimensional alterations in the buccal alveolar bone between individuals who have undergone conventional Hyraxpalatal expansion and expansion via hybrid Hyrax expansion device.

Materials and Methods

In this pilot observational prospective study,20 individuals with maxillary transverse deficiency who presented to the Department of Orthodontics at **Ragas** Dental College & Hospital and Hospital were included. All patients were adults with age > 18 years (Range: 19 – 24 years; Mean: 21.5 years). Study protocol was ethically approved by the Institutional Review Board. Written informed consent was obtained by all patients.

Inclusion criteria: Adult individuals suffering from maxillary transverse discrepancy and skeletal Class 1 malocclusion, warranting non-extraction orthodontic treatment.

Exclusion criteria: Individuals with developmental deformity, cleft lip and palate, and history of orthodontic therapy.

At the onset of treatment and following maxillary expansion stabilization, the participants were subjected to pre-treatment study models, image analysis, and cone beam computed tomography (CBCT).

Appliance design

Maxillary Skeletal Expander (MSE), a skeletally anchored RPE device, was used in this study (Biomaterials, Korea; catalogue number 03). Palatal wall constriction was used to determine the optimum screw size. The device was made as per the manufacturer's instructions. Lateral arms of the device were contoured to palatal shelf curvature. The central jack screw expander was flush with the palate and the distance between the supporting arm and the lateral palate wall was 2 mm [12].

The Mini Handle Driver was used to place four orthodontic mini screws (Biomaterials, Korea; 1.8 mm × 11 mm). Prior to this, opposing screws were first put to prevent the movement or distortion of the devise [12].

In the patients who served as controls, a Hyrax expander was used (Leone, Italy). Again, palatal wall constriction was used to determine the optimum screw size. The expander was made as per the manufacturer's instructions. The lateral arms were soldered to the first molar and first premolar bands and molded to the curve of the palatal shelves.

Maxillary expansion began two days after the device was implanted. The appliance was turned twice a day until a midline diastema appeared, and then, once a day until the desired expansion was attained. The expansion screw was blocked after attainment of desired expansion and the appliance was left in place for four months.

Measurements

CBCT images were obtained pre- and post-treatment using a Kodak machine (Model CS 9300, Care stream Health, Inc, Rochester, NY, USA), with 0.18 mm thickness of axial slice and a current of 8.0 mA and 70 kV. The patients were oriented during image acquisition to obtain the Frankfort horizontal plane parallel to the floor.

Images were imported from the Digital Imaging and Communications in Medicine (DICOM) database

and the Dolphin imaging software (version 11.5, Dolphin Imaging and Management Solution, Chatsworth, CA, USA) was used to create the cross-sectional slices. The Frankfort horizontal plane, the transporionic plane, and midsagittal planerepresented the X-axis, the Y-axis, and the Z-axis in 3-D image reconstructions (Figure 1) [13,14].

Figure 1 : Cone beam computed tomography image orientation in all three planes

Nasal floor was used as a reference line to measurealteration in the thickness of buccal alveolar bone, from which a vertical line and three horizontal lines perpendicular to the nasal floor were traced. We were able to calculate the distance between outer wall of the buccalroot from the canine to the first molar area and the outer alveolar plate surface [15] (Figure 2).

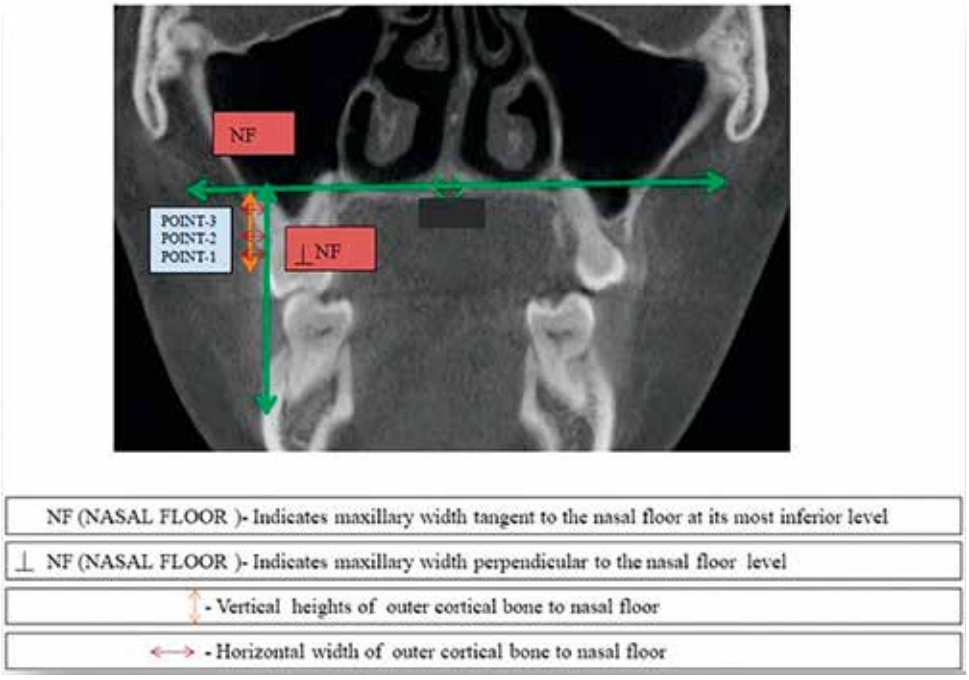

Figure 2 : Evaluation of Buccalalveolar Dehiscence

Outer angle between the nasal floor from canine to first molar region and the palatal root axis was calculated to determine tooth angulation (Figure 3).

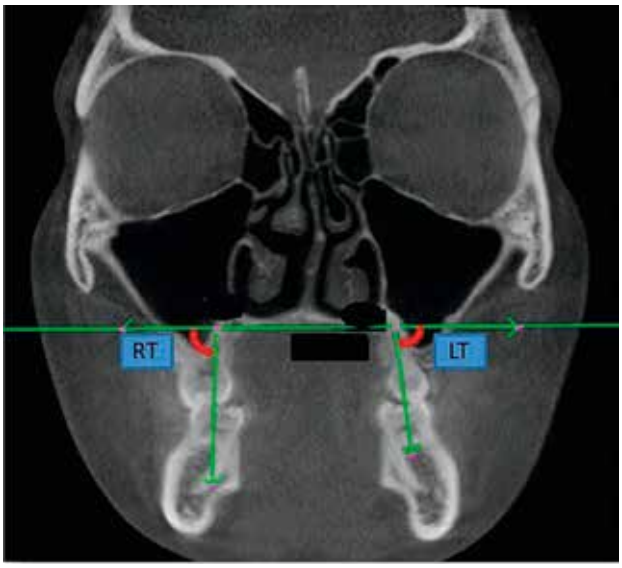

Figure 3 : Angulation of tooth (With nasal floor (NF) as base Inclination between the palatal root axis) RT-Right tooth angulation, LT-Left tooth angulation

Statistical Analysis

SPSS (SPSS, Inc., Chicago, IL) was used to perform statistical analysis. Pairedt-tests were employed to calculate differences in parameters pre- and post-therapy. P <0.05 indicated statistical significance. In addition, each pre- and post-treatment buccal alveolar bone and tooth angles were compared to assess any differences.

Results

We observed a significant decrease in the buccal alveolar bone and tooth angulation of the Hyrax RME group after the treatment (P <0.05). In addition, we observed a significant difference between pre- and post-treatment alveolar bone width and buccal tipping of teeth in the first premolar and first molar regions (Table 1).

Table -1 Change in the width of Buccal alveolar bone and tooth angulations of Conventional Hyrax expansion group.

Parameter	Pre-treatment (Mean ± SD)	Post-treatment (Mean ± SD)	Mean difference	P-value
Buccal Dehiscense (mm)				
Canine LT	2.166±0.20	2.083±0.20	-0.083±0.20	1.000
Canine RT	2.164±0.20	2.082±0.20	-0.081±0.20	1.000
I pre-molar LT	3.66±0.41	1.83±0.41	**-1.83±0.41**	0.000*
I pre-molar RT	4.17±0.2	2.0±0.01	**-2.17±0.41**	0.000*
II pre-molar LT	2.24±0.27	2.17±0.26	-0.17±0.26	1.000
II pre-molar RT	2.24±0.27	2.17±0.26	-0.17±0.26	1.000
Molar LT	3.83±0.41	2.0±0.41	**-1.83±0.41**	0.000*
Molar RT	4.0±0.2	2.0±0.01	**-2.0±0.01**	0.008*
Tooth angulation (°)				
Canine LT	89.16±1.47	88.06± .082	-.1.1±.408	0.3409
Canine RT	89.33±1.21	88.43± .032	-0.9±.41	0.0000
I pre-molar LT	88.66±1.21	84± .284	**-4.66±.816**	0.0000
I pre-molar RT	88.5±1.37	84.23± .04	**-4.27**±.516	0.3951

II pre-molar LT	89.16±1.47	88.3± 1.04	-0.86±.408	0.0432
II pre-molar RT	87.5 ± 2.25	86.729± 1.04	-0.771±.36	1.0000
Molar LT	82.83±2.99	77.33± 1.041	**-5.5±.836**	0.3951
Molar RT	83 ±2.36	77.5 ± 2.258	**-5.5±.547**	1.0000

There was no significant change in canine to second pre-molar bone width in the hybrid Hyrax RME group, but pre- and post-treatment alveolar bone width differed significantly in the anchored first molar. In addition, the first molar tipping was significantly higher than the premolars and canine (Tables 1 and 2).

Table - 2 Change in the width of Buccal alveolar bone and tooth angulations of Hybrid Hyrax expansion group

Parameter	Pre-treatment (Mean ± SD)	Post-treatment (Mean ± SD)	Mean difference	P-value
Buccal Dehiscense (mm)				
Canine LT	2.166±0.20	2.083±0.20	-0.083±0.20	1.000
Canine RT	2.164±0.20	2.082±0.20	-0.082±0.20	1.000
I pre-molar LT	3.05±0.23	3.0±0.23	-0.05±0.23	0.000*
I pre-molar RT	2.166±0.22	2.083±0.21	-0.083±0.21	0.000*
II pre-molar LT	2.24±0.27	2.17±0.26	-0.17±0.25	1.000
II pre-molar RT	2.24±0.27	2.17±0.26	-0.17±0.25	1.000
Molar LT	4.0±0.2	2.0±0.01	**-2.0±0.01**	0.008*
Molar RT	3.66±0.41	1.83±0.41	**-1.83±0.4**	0.000*
Tooth angulation (^{0})				
Canine LT	89.5± 1.04	88.7± .04	-0.8±.41	0.3409
Canine RT	89.66±.516	88.94± .064	-0.72±.21	0.0000
I pre-molar LT	90.16±.4082	89.35± .07	-0.81±.73	0.0000
I pre-molar RT	89.83±1.47	88.93± 1.04	-0.9±.83	0.3951
II pre-molar LT	88±1.78	86.98± .0314	-1.015±.65	0.0432
II pre-molar RT	88.16±3.81	87.25± .0404	-0.91±.83	1.0000
Molar LT	80.83±2.48	75.83±1 .161	**-5±1.09**	0.3951
Molar RT	81.16±.983	75.66±1.75	**-5.5±.836**	1.0000

Buccal Alveolar Bone

In the tooth-supported RME group, bone dehiscence was created on the buccal face of the anchor teeth (-4.84 mm,-4.2 mm,and -4.54 mm at the first molar,first premolar, and molar levels, respectively) in the implant-assisted RME group. The Hyrax group experienced significant buccal alveolar bone loss at the first premolar and molar area, which seemed to be connected to increased dental growth.

Tooth Angulations

In the tooth-borne Hyrax group, first premolar angulation and molar angulation rose by an average of -4.6˚ to -5˚ and -5.5˚ to -5.8˚, respectively. However, there were no statistically significant variations in second premolar and canine angulations. The Hyrax group exhibited significant alteration in the buccal inclination between fist premolar and molar regions. At the apex and crown

levels, the unbanded second premolar and canine showed no signs of buccal tipping and growth.

Molar angulation was slightly raised by -5˚ to -5.5˚ in the implant-supported RME group, but first premolar, second premolar, and canine angulations did not exhibit any significant variations.

Discussion

Several previous studies have been focused on the interaction between periodontics and orthodontics, with respect to impact of tooth movement on periodontium. The movement of buccal teeth and bone dehiscences are inextricably linked. Buccal tooth movement with mild stresses leads to an increase in the distance between the buccal alveolar crest and the cementoenamel junction[16-19].Other studies have found gingival recession subjected to either orthodontic or normal buccal movement [20-24].

Several studies have shown that RME application considerablyreduces buccal bone thickness, while other studies have reported minor alterations or none at all. After a 6-month retention period, Ballanti et al. reported a decreasein the buccalthickness of anchoring teeth following active extension and remodeling of palatal and buccalbones[25].

The traditional tooth-supported RME generated bone dehiscence in the first premolar and the first molars area (-4.2 mm and -4.84 mm, respectively) in this study. These results were in agreement with those of Garib et al, who observed that application of RME produced bone dehiscences on the buccal aspect of the anchorage teeth at first premolars and at mesiobuccal area of first molars (7.1± 4.6 mm and 3.8 ±4.4 mm, respectively).

In the tooth-borne Hyrax group, first premolar angulation and molar angulation rose by an average of -4.6˚ to -5˚ and -5.5˚ to -5.8˚, respectively, although there were no statistically significant variations in second premolar and canine angulations. A typical observation after RME was buccal tilt of the dentoalveolar structures [26-29]. This might be attributed to the placement of bands or direct anchors on the first molar and premolar regions.

In the implant-assisted RME group, bone dehiscence was observedon the buccal side of the anchor teeth, with a mean difference of around -4.54mm between pre- and post-treatment expansion. These findings were corroborated by the occurrence of substantial buccal alveolar bone loss at the first molar region of the hybrid Hyrax group.

In a recent study, MirayGunyuz et al. evaluated the periodontal effect of the hybrid Hyrax expander and reported a decrease in buccal bone thicknesses of the first molars. These results were in line with our observationsof a buccal bone dehiscence of 1.8 to 2mm in the implant assisted RME group[30].

Molar angulation was slightly raised (-5˚ to -5.5˚) in the implant-supported RME group, but first premolar, second premolar, and canine angulations showed no significant changes.

Tausche et al. also reported buccal crown tipping with application of both skeletally-anchored as well as tooth-borne expansion appliances. Ppreviously, G. Nelson reported a buccal tipping in the first molar and first premolar regions ranged from -3.4˚ to -6.94˚ and -2.4˚ to -5.36˚, respectively, [31]. Another study documented a buccal tipping of 5.30˚- 6.50˚ at the first teeth region [32].

When comparing the research on the periodontal effect of maxillary expansion, however, there are significant differences. Such variances could have been caused by differences in samples, techniques, types of computerized tomography, evaluated tomographic slices, and tomographic device settings [15].

The first molar and first premolar angulation were shown to be statistically different between the tooth-borne Hyraxand the implant-supported RME groups, with the former group displaying more substantial angulation changes post treatment.

Buccal bone dehiscence was observed in the teeth with buccal tipping, which was related to the placement of bands or direct anchorage on the first molar and first premolar in either group. Owing to their direct relationship to the expansion screw, the first molar and first premolar in the tooth-borne Hyrax RME group should have shown more

substantial angulation alterations and tipping.

Thoughin the hybrid Hyraxgroups, the implants were skeletally secured, a few cases still exhibited buccal tipping of the molars. This finding could be attributed to the stabilizing wire's incapacity to transmit expansion forces to the molars.

Conclusion

When compared to conventional RME, the hybrid Hyrax expansion group exhibited fewer periodontal sequelae.

The tooth-borne Hyrax RME group exhibited more buccal bone dehiscence and tooth angulation alterations post treatment compared to the implant-supported Hybrid Hyrax group, indicating that conventional maxillary expansion caused tipping and buccal dehiscence in the first molar and first premolar regions.

In the anchored molar tooth, the implant-assisted hybrid Hyrax group exhibited buccal tipping and bone dehiscence, which might be due to the rigid arm's ability to transmit force to the molar teeth that were anchored.

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Measurement of Force Decay in Orthodontic Elastomeric Power Chains

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ABSTRACT

Objective

To evaluate the magnitude of force degradation of short and closed clear elastomeric chains.

Materials and Method

The study was conducted at the Department of Orthodontics, Kantipur Dental College, Kathmandu. Ten commonly available samples of five-segment elastomeric chains (three short and three closed clearchains) were collected from the local suppliers and allotted a specific group. The elastic chains were stretched from a specified distance corresponding to 170 grams for every chain and the force was measured using a dynamometer of 450 grams capacity. The experimental set-up was immersed in saliva substitute at 37° to simulate oral environment and measured after 24 hours, 7 days and 14 days for the amount of force decay. Statistical analyses were performed using ANOVA followed by Tukey tests.

Result

There was a sharp decline in force level (50-60%) in all brands during the first 24 hours of stretching. A short clear chain group (Group B) showed lesser degradation among the three groups with 80.09±4.78grams after 24 hours, 75.13±6.85 grams after 7 days and 64.50±7.80 grams after 14 days. Among closed clear chains, Group D retained more force with 80.09±5.83 grams, after 24 hours. After 14 days, the force decay rate varied from 62% to 71% among all brands.

Conclusion

All groups of elastomeric chains showed decay in force level irrespective of the type and brand. There was significant decrease in force level after 24 hours in all brands. However, comparison of different brands at different time intervals revealed that significant differences in force decay were dependent upon type of clear elastomeric chains.

Keywords : Dynamometer, elastomeric chains, force decay.

INTRODUCTION

Elastomeric chains are synthetic thermoplastic polymers used in orthodontics.[1] These materials are made by vulcanization, three-dimensional cross linking with covalent bonds, hydrogen bonds and van der Waal forces to resist physical actions of heat, chemical, light and natural aging.[2,3] They possess the capacity to return to their original size after significant deformation.[4,5] During this process, they deliver certain amount of force which is used for tooth movement like canine distalization, space closure, rotation correction, etc.[6-8] Hence, these elastomeric power chains are used in orthodontic force delivery systems.

However, these physical properties are dependent upon the chemical composition of the material and is affected by the quality of raw materials, their processing, technology used for refining and storage.[2] Also, these chains are degraded with time in oral environment owing to the physical and chemical insults of mastication, light, saliva, food, chemicals, differences in pH, etc.[9-19] Hence, the force decay is inevitable and studies related to the efficiency of these chains are important.

Ash and Nikolai (1978) reported 50-85% loss of initial force after 4 weeks and showed greater force decay in vivo than in vitro.[20] Killiany et al. (1985)[21] and Eliades et al. (2004, 2005)[9,22] found that open chains showed greater residual extension than closed ones. Kuster et al (1986) concluded that force decay was greater in vivo than in air.[23] While comparing four different brands of elastomeric chains, Almeida et al. (1991) reported 35% force decay at the end of the first day and 75 % at the end of the experiment.[24] Nattrass et al. [1998]have reported greater force decay in elastomeric chains in cola and curcuma than in water.[15] Kochenborger et al. (2011) compared four different brands of elastomeric chains and found that some groups were more stable than others.[25]

In our context, studies related to force delivery of locally available elastomeric chains are insufficient. Therefore, the objective of this study was to evaluate the magnitude of force degradation of short clear & closed clear elastomeric chains, in vitro, as available in the local market.

Materials And Methods

An experimental in vitro study was carried out at the Department of Orthodontics, Kantipur Dental College Teaching Hospital and Research Center using short clear & closed clear elastomeric chains of the following brands: Rabbit force, Captain Ortho, Power chain, Dyna-link™ and United Dental Group respectively. The ethical approval was taken from the Institutional Review Committee of Kantipur Dental College.

Sample size was calculated referring the data from Kochenborger et al. (2011)[25] using the formula:

where,

$Z\alpha$ = z deviate corresponding to desired reliability level (at 95%, 1.96)

$Z\beta$ = 1.28 at 90% power

S.D: $\frac{(SD_1 + SD_2)}{2}$, $d = m_1 - m_2$

$$\text{Sample size } (n) = \frac{\{2\,(Z\alpha+Z\beta)^2 \times S.D^2\}}{d^2}$$

$$= \frac{\{2(1.96^2 + 1.28^2)^2 \times 6.29^2\}}{9.5^2}$$

$$= 9.20$$

Adding 10% of sample size for permissible error,

Number of samples = 9.2+0.92 **(~ 10)** for individual allotted group.

Six packets of elastomeric chains (three short clear and three closed clear) were purchased from five different local suppliers. Each packet of elastomeric chains had a valid expiration date and were stored in cold and dry environment. The elastomeric chains were cut by a single operator using same number of segments/links (five) to deliver initial force of 170.10 grams.

The stretching distance was variable in different brands while maintaining the same force level. Thus, a pilot study was conducted using five-segment elastomeric chain of each brand stretched to 170.10 grams, with five samples each. Every brand was thus stretched to maintain the same force level in this experiment.

To create a stretching environment for force calculation, six acrylic plates (three pink and three white) of 7 mm thickness, 15 cm length and 4 cm were fabricated with cold cure acrylic (DPI-RR acrylic), each representing one brand. The acrylic plates were marked 1 cm apart and holes were drilled at specified distances for 170.10 grams measured from a dynamometer (Captain Ortho, 450 grams).

Stainless steel pins of 22 gauge were cut into 10 mm length using hardwire cutter and inserted into holes (5 mm deep) and fixed with acrylic as well as hot glue. Ten samples of five-segment elastomeric chain were loaded (Figure 1) in their respective plates with a different operator. To avoid observer bias, each brand was allotted a group after loading. Two extra samples, PT1 and PT2 were made in each plate, to avoid probable attrition of the sample due to fabrication errors.

The experimental set-up was immersed in artificial saliva substitute (ICPA Wet Mouth) to simulate oral environment and measured after 24 hours, 7 days and 14 days for the measurement of force decay. To ensure consistent temperature of 37°C, the set-up was placed in an incubator and the liquid was measured with digital thermometer for two minutes every alternate day.

The elastomeric chains were checked at the intervals of 24 hours, 7 days and 14 days and the force levels were measured. The data were entered in Excel and statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) Version 21. After normality test, the data were subjected to Analysis of variance (ANOVA), followed by Tukey's multiple comparisons test. A 5% confidence interval was adopted ($p \leq 0.05$).

List of figures:

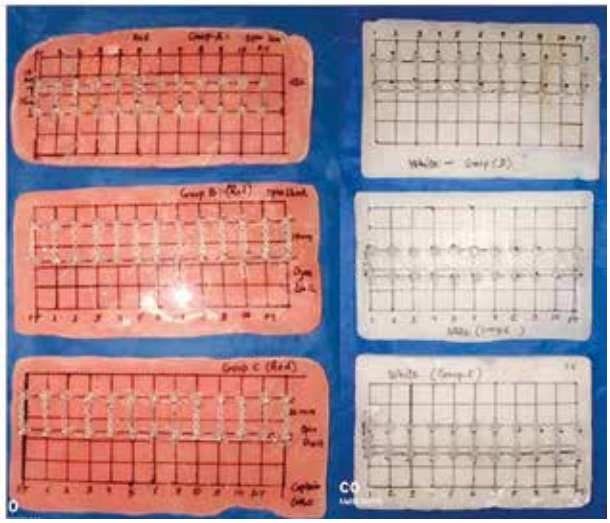

Figure 1: Elastomeric chains stretched in white and pink acrylic plates (Samples loading) with specific stretching distance: Group A:15 mm, Group B:17 mm, Group C:16 mm, Group D: 14.5 mm, Group E: 12.5 mm and Group F: 13.5 mm.

Results

The mean, standard deviation and decay percentage of force level of short and closed clear elastomeric chains, were calculated on different time periods. Table 1 shows the means and standard deviations of residual stretching forces (in grams) according to the elastomeric chain groups and stretching time. Table 2 shows the mean force degradation and their percentages at different time periods. Table 3, 4, 5 and 6 show the Analysis of Variance and Tukey's test for comparison of brands at different time-intervals.

Table 1: Descriptive statistics of residual stretching forces (in grams) according to elastomeric chain groups and stretching time

Type of elastomeric chain	Brand	Allotted Group	Stretching force level (in grams)		
			24 hours	7 days	14days
Short clear chains	United Dental Group	A	70.17±8.49	58.83±5.83	48.90±7.80
	Dyna-link ™	B	80.09±4.78	75.13±6.85	64.50±7.80
	Captain Ortho	C	75.84±8.22	61.66±5.83	55.99±5.23
Closed clear chains	Captain Ortho	D	80.09±5.83	69.46±5.59	53.82±6.07
	Rabbit force	E	68.04±6.85	60.95±6.85	50.98±4.58
	Power chain	F	66.62±6.85	55.99±5.23	48.82±4.18

There was a decrease in force level after 24 hours, 7 days and 14 days. In the short clear chains, Group A elastomeric chains had decreased from 70.17±8.49 grams to 58.83±5.83 and 48.90±7.80 grams after 24 hours, 7 days and 14 days respectively. Group C showed reduction from 170.10 grams to 75.84±8.22 grams after 24 hours to 61.66±5.83 grams after 7 days and 55.99±5.23 grams after the interval of fourteen days. Group B showed lesser degradation among the three groups with 80.09±4.78grams after 24 hours, 75.13±6.85 grams after 7 days and 64.50±7.80 grams after 14 days. Among closed clear chains, the Group D retained more force with 80.09±5.83 grams, than Group E (68.04±6.85 grams) and Group F brands (66.62±6.85 grams) after 24 hours. After 7 days and 14 days, the feature was similar with Group D having residual force of 53.82±6.07 grams, Group E with 50.98±4.58 grams and Group F Chains with 48.82±4.18 grams after 14 days.

Table 2: Mean force degradation (in grams) and their percentages at different time periods

Group	Force degradation after 24 hours in grams (in %)	Force degradation after 7 days in grams (in %)	Force degradation after 14 days in grams (in %)
A	99.93 (58.75)	111.27 (65.42)	121.20 (71.25)
B	90.01 (52.92)	94.97 (55.83)	105.60 (62.08)
C	94.26 (55.42)	108.43 (63.75)	114.10 (67.08)
D	90.01 (52.92)	100.64 (59.17)	116.18 (68.36)
E	102.06 (60)	109.14 (64.17)	119.11 (70.02)
F	103.48 (60.83)	114.11 (67.08)	121.29 (71.30)

Table 3: ANOVA for comparison of short clear chains							
Time	Group	N	Mean	Standard deviation	95% confidence interval		Sig.
					Upper bound	Lower bound	
24 hours	A	10	70.166250	8.4852897	64.096239	76.236261	0.019*
	B	10	80.088750	4.7836979	76.666699	83.510801	
	C	10	75.836250	8.2179691	69.957469	81.715031	
7 days	A	10	58.826250	5.8349446	54.652182	63.000318	0.000*
	B	10	75.127500	6.8471755	70.229326	80.025674	
	C	10	61.661250	5.8349446	57.487182	65.835318	
14 days	A	10	48.903750	7.7998287	43.324089	54.483411	0.000*
	B	10	64.496250	7.7998287	58.916589	70.075911	
	C	10	55.991250	5.2296167	52.250208	59.732292	

*Statistical significance at p<0.05.

Table 4: Post Hoc Tukey's test for comparison of short clear chains				
Time	Groups			Significance
24 hours	A	-	B	0.015*
	B	-	C	0.412
	C	-	A	0.215
7 days	A	-	B	0.000*
	B	-	C	0.000*
	C	-	A	0.568
14 days	A	-	B	0.000*
	B	-	C	0.031*
	C	-	A	0.081

*Statistical significance at p<0.05.

Analysis of variance and post hoc Tukey test revealed that there was statistically significant difference between Group A and Group B at all time periods. However, Group B and Group C showed statistically significant difference after 7 days and 14 days. Group A and Group C showed no difference at all time periods.

Table 5: ANOVA for comparison of closed clear chains							
Time	Group	N	Mean	Standard deviation	95% confidence interval		Sig.
					Upper bound	Lower bound	
24 hours	D	10	80.0888	5.83494	75.9147	84.2628	0.000*
	E	10	68.0400	6.84718	63.1418	72.9382	
	F	10	66.6225	6.84718	61.7243	71.5207	
7 days	D	10	69.4575	5.59070	65.4582	73.4568	0.000*
	E	10	60.9525	6.84718	56.0543	65.8507	
	F	10	55.9913	5.22962	52.2502	59.7323	
14 days	D	10	53.8213	6.06981	49.4792	58.1633	0.100
	E	10	50.9863	4.57592	47.7128	54.2597	
	F	10	48.8163	4.17857	45.8271	51.8054	

Table 6:Post Hoc Tukey's test for comparison of brands		
Time	Groups	Significance
24 hours	D - E	0.001*
	E - F	0.879
	F - D	0.000*
7 days	D - E	0.009*
	E - F	0.167*
	F - D	0.000*
14 days	D - E	0.426
	E - F	0.602
	F - D	0.083

Analysis of Variance and post hoc Tukey test revealed that among closed clear chains, there were statistically significant differences between Group D and Group E, Group D and Group F after 24 hours and 7 days. However, Group E and Group F showed statistically significant difference only after7 days. After 14 days, all three groups, Group D, Group E and Group F showed no difference.

Discussion:

Generally, elastomeric chains decay owing to the physical properties of the raw materials used for the manufacture. The decay is significant in first 24 hours. With time, the decay rate lessens and forces become more consistent.[3,6,8,18,26] This study also suggest similar rate of force decay in the elastomeric chains in the time interval of 14 days.

The study uses initial force level of 170.10 grams in all brands unlike the studies by Bishara and Andreasen (1970),[6] Matta and Chevitarese (1997)[13]that used same stretching distance for the studied brands. As per the force levels, Ren et al. (2003) had concluded that there is no scientific evidence to recommend the optimum force level in

orthodontics.[16] Few studies suggested that 100-350 grams of force is required for bodily movement of canine, while using friction mechanics. The study is performed with 170.10 grams for synchronizing with the dynamometer markings during initial loading. The samples were immersed in wet solution because studies conducted by Ash and Nikolai,[20] Bishara and Andreasen,[6]and De Genova[8] have shown that decay was higher in moist conditions, owing to water absorption. Also, different studies have pointed that rise in temperature aggravates force degradation and as such the study was conducted in an incubator at 37°C.[8,11]Clinically, closure of spaces are achieved by replacing elastomeric chains every 15 days or 21 days.[25]Therefore, the study was conducted to measure the force levels within this short time frame.

This study has not taken thermal cycling into consideration, which can be referred in future studies for precise measurements. Also, with the movement of teeth, decay rate may differ, which can be implemented in further studies. Similarly, the products should have proper label with instructions for storage, product efficiency, maximum force generated.

Conclusion

All groups of elastomeric chains showed decay in force level irrespective of the type and brand. There was significant decrease in force level after 24 hours in all brands. However, comparison of different brands at different time intervals revealed that significant differences in force decay were dependent upon type of clear elastomeric chains.

Conflict of Interest

The author declares that there was no fundings or support from any manufacturing company for the study.

Acknowledgement

The authors would like to thank Dr. Sujita Shrestha, Faculty, Department of Community Dentistry for support in statistical analysis. Sincere gratitude to Ms.Santwona Dahal and Mr. Bigu Chaudhary,Faculties of the Department of Microbiology for experimental set-up, and Sanchita Rana Magar, Dental Assistant, for her assistance inhandling of the specimens.

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