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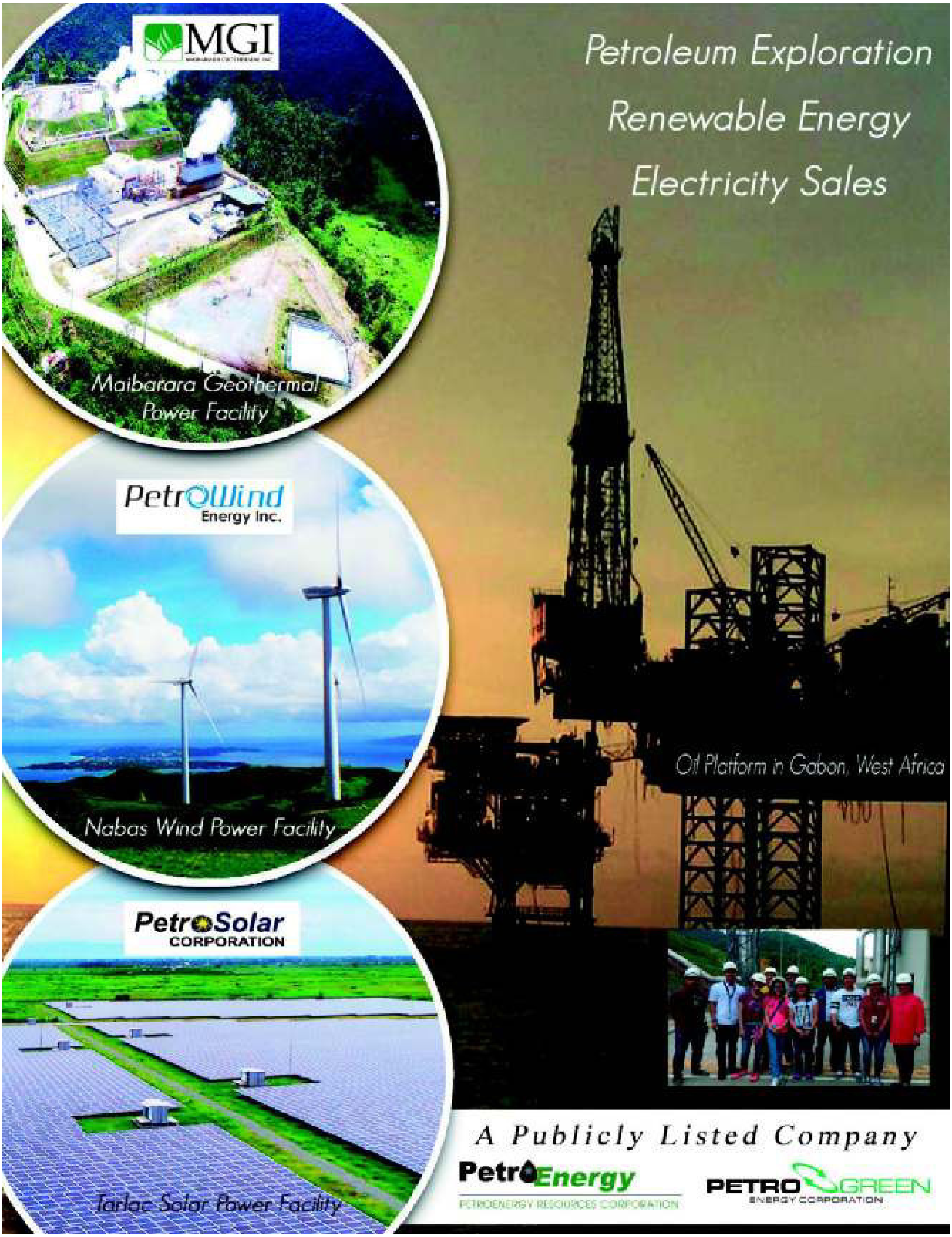
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Reconstruction of Centric Occlusion for the Correction of Temporo-Mandibular Joint Derangement Disorder Using Orthotics and Orthodontic Mechanics: A Case Report

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Sison, Rocelie R. DMD, MS, FAPO

A twenty-nine year old female was admitted to the Advanced Orthodontics Department of the Centro Escolar University School of Dentistry for having jaw clicking, an unstable bite, neck pains and headaches. Diagnosis revealed that she had compression of the retrodiscal tissue on the left temporomandibular joint due to derangement of the condyle-disc complex. Treatment of the case was done in two phases, first using orthotic to reposition the mandible in centric relation and second using orthodontic mechanics to reconstruct the occlusion.

Introduction

Derangement of the condyle-disc complex is one of the frequently occurring intracapsular disorders of the temporomandibular joint that is often overlooked. The several components of the condyle-disc complex, include the muscles, disc, condyle, ligaments, and the dentition and its supporting structures[1]. These structures interact with each other to align the teeth in a convenience bite, which may cause a repositioning of the joint and the appearance of Temporomandibular Joint Dysfunction (TMD) symptoms. The condition may manifest itself through several conditions, such as jaw deviation and deviation, limited opening of the mouth, pain, clicking, muscle soreness and vertigo[2]. In this reported case of TMD, the etiology is due to increased activity of the muscles secondary to bruxism.

The use of an orthodontic loop mechanics in conjunction with splint therapy for TMD is advocated as a viable adjunctive procedure to reconstruct the occlusion. The treatment requires the construction of a repositioning appliance or orthotic[3]. The orthotic is used as a guide to reestablish the jaws in Centric Relation (CR). Orthodontic mechanics allows for careful occlusal reconstruction to move the teeth into an occlusion following the established harmonious centric relation-centric occlusion relationship (CR=CO)[4].

Diagnosis

The patient was admitted as a clinical requirement at the Centro Escolar University Master of Science Program in Orthodontics with the following complaints: unstable bite despite an old splint, frequent headaches, clicking in the left temporomandibular joint, and frequent neck pains and headaches.

Photographic analysis shows a mesofacial patient, with normal facial proportions and a straight profile (Figure 1).

The patient's maxillary and mandibular dental arches are ovoid in shape, symmetrical and had rotations on tooth numbers 11, 21, 31 and 41. The dental classification was class III type 1, with a class II canine relationship on the left side and a class I canine relationship on the right side. The patient also presented a posterior openbite from wearing an old orthotic (Figure 1).

The patient's orthopantomogram shows rounded condyles, normal ramal height, normal sinuses, and a missing 18 (Figure 2).

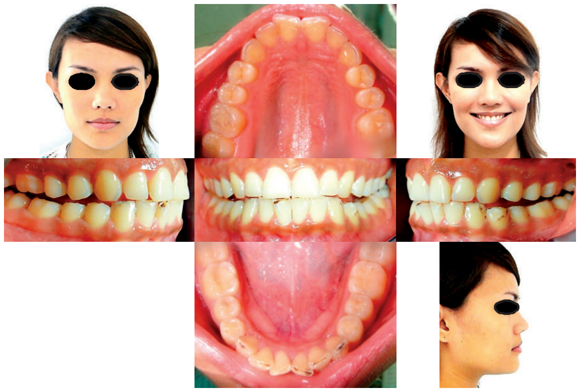


Figure 1. Pre-operative extraoral photographs of the patient.

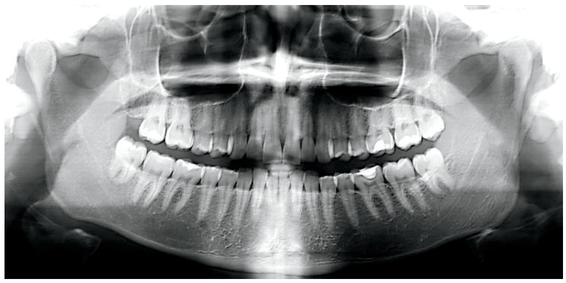


Figure 2. Pre-operative Orthopantomogram.

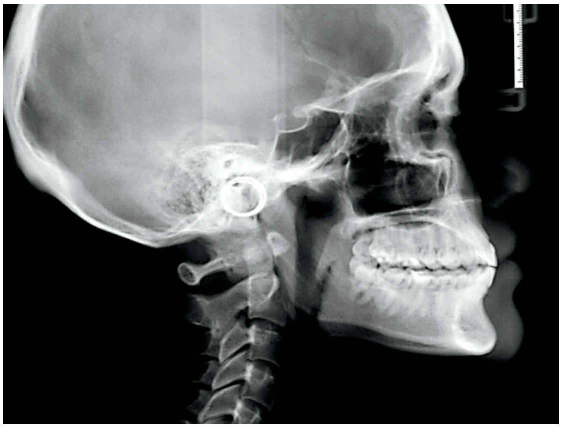
Clinical examination of the Temporomandibular Joint (TMJ) reveals jaw deviation during opening with a soft endfeel until 50mm. Pain was felt at the left temporalis, masseter and trapezius regions. Clicking was also experienced at the immediate and terminal portions of opening (Figure 3). Analysis of transcranial radiograph reveals reduced interarticular space, giving an impression of a deranged condyle-disc assembly on the left side (Figure 4).

Treatment Objectives

The treatment objective was to have a centric occlusion that coincides with centric relation, thereby having a stable bite and asymptomatic TMJ.

Treatment Plan

The treatment plan for the patient was to reposition the condyle into centric relation with the temporal bone and reconstruct the centric occlusion based on the correct mandibular position.



Measurement	Norm	Patient	Interpretation
SNA	83.3 ± 3.3	85	Normal
SNB	79.9 ± 2.8	85	Prognathic Mandible
ANB	3.5 ±2.0	0	Class III
SNPg	79.6 ±2.9	87	Prognathic Mandible
NSBa	130.6 ±4.9	123	Close Angle
Gn-tgo-Ar	121.3 ±6.2	118	Normal
Nordeval angle	68.4 ±5.5	58	Prominent chin
Pg-NB (mm)	-0.4 ±1.6	3.5	Prominent chin
NL-NSL	9.4 ±3.0	1	Anterior rotation
ML-NSL	33.4 ±4.8	22	Anterior rotation
ML-NL	24.0 ±4.8	19	Deepbite
N'- Sp' (mm)	56.4 ±3.4	46	Short middle anterior facial height
Sp'- Gn (mm)	69.3 ±5.7	59	Short lower anterior facial height
N'-Sp'/Sp'-Gn x 100	81.2 ±6.4	77.9	Normal
UI-NA (°)	26.6 ±5.5	23	Normal
UI-NA (mm)	6.6 ±2.4	6	Normal
LI-NB (°)	31.8 ±5.0	30	Normal
LI-NB (mm)	8.6 ±2.2	5	Retrusive
UI-LI	118 ±7.0	125	Normal
Holdaway angle	15.4 ±3.8	2	Concave

Figure 3. Pre-operative lateral cephalogram, values and interpretation.

Treatment Mechanics

The patient's CR was determined by using bimanual manipulation[2] (Figure 5). The CR relationship of the patient was then established using a bite registration material. Impressions were then taken and the casts were mounted. An orthotic of the maxillary arch was then constructed using a thermoplastic sheet and acrylic resin (Figure 6) and was given

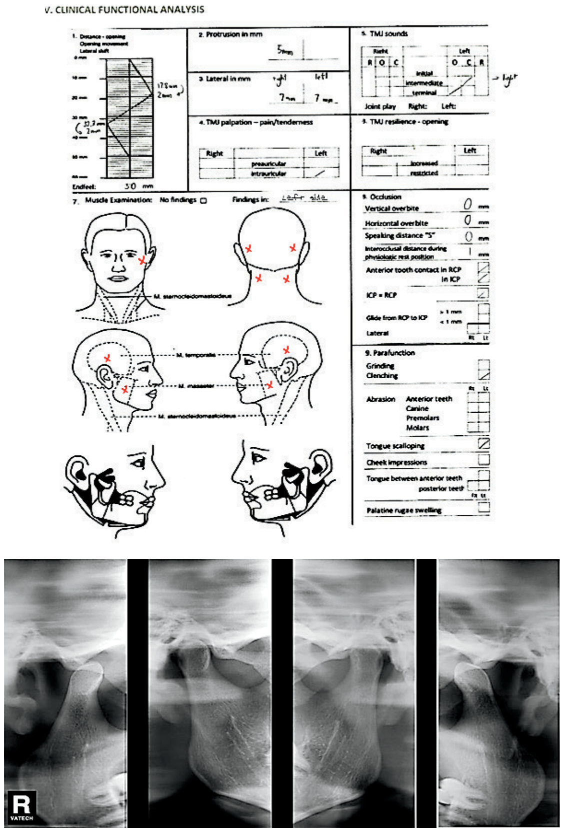


Figure 4. Clinical Functional Chart[5] and transcranial radiograph without orthotic.

to the patient to wear. Magnetic Resonance Imaging (MRI) was then done to confirm if the orthotic has repositioned the jaw in the correct position[2] (Figure 7).

Initial alignment of the mandibular dentition was done using a 0.016 NiTi wire which was changed to a 0.016 x 0.022 Chromium Cobalt wire with multiple L-loops. The orthotic was then relieved and the loops activated at the premolar area to allow contact with the opposing premolars.

The maxillary anteriors were aligned and leveled by relieving the anterior portion of the orthotic (Figure 8).

A 0.016 x 0.022 Chromium Cobalt archwire with multiple L-loops was then placed on the maxillary. Activation was done to extrude the maxillary posteriors with further reduction of the orthotic (Figure 9).

At the finishing stage, an Orthopantomogram radiograph was taken to determine the inclination of the roots. A 0.017 x 0.025 TMA wire with second order bends was engaged and some brackets were repositioned to correct root angulation. The final archwire was 0.017 x 0.025 SS (Figure 10).

Post-orthodontic retention was done using a fixed retainer on the lingual of the mandibular anteriors. A Hawley

Retainer was also constructed for the maxillary and the mandibular arch (Figure 11), to be worn 24 hours for 1 year and then at night time thereafter.

Results/Final Evaluation of the Treatment

Facial Analysis reveals maintained facial esthetics and vertical proportion with improved upper lip position (Figure 12).

Cast Analysis shows that the maxillary incisors were proclined and protracted to achieve a normal overjet and overbite. Class I molar and canine relationship were established on both left and right side. The posterior openbite associated with the use of an orthotic was closed, and normal interdigitation was achieved (Figure 13).

Orthopantomogram reveals good root parallelism (Figure 14).

Lateral cephalogram analysis reveals slight improvement in the values from the pre-operative values. Superimposition following the maxilla reveals that the maxillary incisor proclined slightly and the maxillary molar moved mesially. Superimposition of the mandible revealed slight increase in the middle and lower anterior facial height due to anterior repositioning of the mandible. The position of the incisor was maintained. The molar appears to have moved superiorly (Figure 15).

Post-operative transcranial radiograph shows increase in the interarticular distance between the condyle and the temporal bone and in the left TMJ during maximum intercuspation (Figure 16).

After treatment, derangement disorder of temporomandibular joint was corrected by establishing the centric relation using orthotics and later stabilized by reconstructing the centric occlusion using orthodontic mechanics. The patient presented a well-balanced occlusion, and asymptomatic left joint. Neck pains and headaches diminished ever since the treatment started.

Figure 5. Bimanual Manipulation.

Figure 6. Maxillary orthotic.

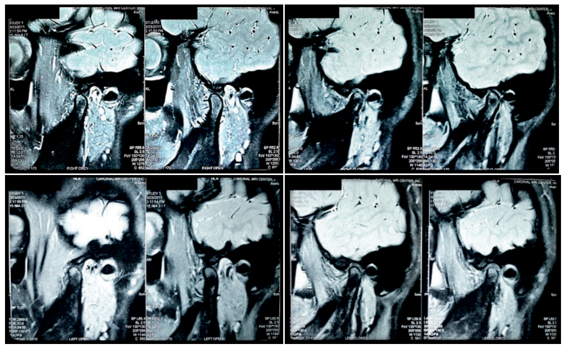


Figure 7. MRI (Clockwise: right max open, right max intercuspation, left intercuspation, left max opening)

Figure 8. Alignment of the maxillary anterior segment and leveling of the mandibular premolars.

Figure 9. 0.016 x 0.022 Chromium Cobalt archwire of the maxillary and mandibular arch .

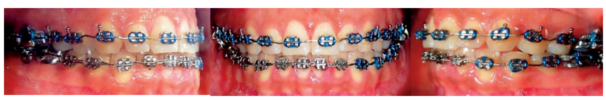


Figure 10. 0.017 x 0.025 TMA wire with artistic bends .

Figure 11. Retention using fixed retainer and Hawley retainer.

Figure 12. Pre-operative and post-operative extraoral photographs of the patient.

Figure 13. Pre-operative and post-operative photographs.

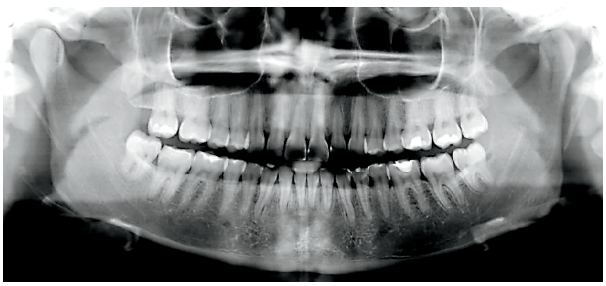
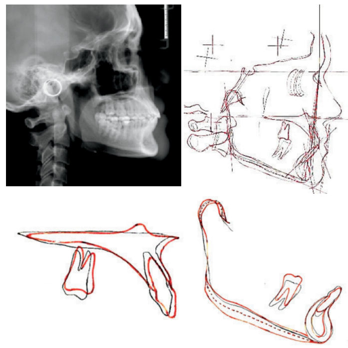


Figure 14. Post-operative orthopantomogram.



Measurement	Norm	Pre-op	Post-Op	Post-Op Interpretation
SNA	83.3 ± 3.3	85	86	Normal
SNB	79.9 ± 2.8	85	84	Prognathic Mandible
ANB	3.5 ±2.0	0	2	Normal
SNPg	79.6 ±2.9	87	85	Protrusive Chin
NSBa	130.6 ±4.9	123	121	Low angle / close angle
Gn-tgo-Ar	121.3 ±6.2	118	119	Normal
Nordeval angle	68.4 ±5.5	58	53	Prominent Chin
Pg-NB (mm)	-0.4 ±1.6	3.5	5	Prominent Chin
NL-NSL	9.4 ±3.0	1	1	Anterior Rotation
ML-NSL	33.4 ±4.8	22	24.5	Anterior Rotation
ML-NL	24.0 ±4.8	19	23	Normal
N'- Sp' (mm)	56.4 ±3.4	46	48	Decreased Middle Anterior Facial Height
Sp'- Gn (mm)	69.3 ±5.7	59	66	Normal
N'-Sp'/Sp'-Gn x 100	81.2 ±6.4	77.9	72.72	Openbite Tendency
UI-NA (°)	26.6 ±5.5	23	26	Normal
UI-NA (mm)	6.6 ±2.4	6	7	Normal
LI-NB (°)	31.8 ±5.0	30	35	Normal
LI-NB (mm)	8.6 ±2.2	5	6	Retrusive Lower Incisors
UI-LI	118 ±7.0	125	117	Normal
Holdaway angle	15.4 ±3.8	2	1	Concave

Figure 15. Post-operative lateral cephalogram, comparison of pre- and post-operative values, interpretation and superimpositions**.**

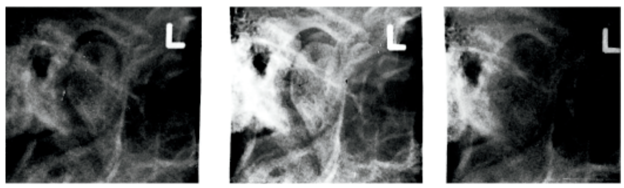


Figure 16. Post-operative Transcranial Radiograph.

Conclusion

Orthodontic mechanics in conjunction with orthotics was an effective technique to reconstruct the centric occlusion in order to stabilize the centric position of the mandible. Having this condition, the healthy condyle-disc complex in the temporomandibular joint is restored.

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Comparison of Frictional Resistance of Conventional ANF Teflon Coated Archwires with Ceramic and Stainless Steel Brackets-An In Vitro Study

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Objective. The aim of this in vitro study was to compare the frictional resistance of conventional and teflon coated arch wires with ceramic and stainless steel brackets.

Materials and Methods. Four types of archwires (conventional nickel-titanium, Teflon coated nickel-titanium, conventional stainless steel, Teflon coated stainless steel) of 0.019X0.025 inch dimension were used. Two types of brackets (0.022 inch slot), a conventional stainless steel bracket and a ceramic bracket, were used for measuring frictional resistance. The measurement of friction between bracket and archwire was done with the apparatus which consisted of a simulated fixed appliance with archwire engaged in the bracket slots oriented in a vertical position. All tests were conducted under dry conditions with an Instron testing machine with crosshead moving downward at a speed of 10mm/min. The data obtained was subjected to statistical analysis using SPSS software ver.20.

Results. Frictional resistance was highest in ceramic bracket-Ni Ti archwire followed by ceramic bracket-Teflon coated Ni Ti archwire, ceramic bracket-SS archwire, ceramic bracket-Teflon coated SS archwire, stainless steel bracket-Ni Ti archwire, stainless steel bracket-Teflon coated NiTi archwire, stainless steel bracket –Teflon coated SS archwire. The least frictional resistance was noted in stainless steel bracket-SS archwire.

Conclusions. Teflon coating of the archwire reduces frictional resistance when used with ceramic brackets. Teflon coating of NiTi archwires reduces friction when used with ceramic as well as stainless steel brackets.

Introduction

Friction or resistance to sliding can be defined as the force that acts at the surface between two objects when one object slides relative to the other. Friction may exist in two forms: 1) static friction, which is the resistance that prevents actual motion and 2) dynamic (kinetic) friction, which exists during motion.[1] The magnitude of the frictional force depends on the amount of normal force pushing the two surfaces together, the surface roughness and the nature of materials from which the surfaces are made.[2] Frictional resistance has always played a vital role in orthodontics. Its ability to impair tooth movement results in the need for greater force to move teeth, prolonged treatment time and leads to loss of anchorage. Friction in orthodontics is usually associated with sliding mechanics. As the archwire passes through the bracket slot, friction results from the local contact that exists among the bracket slot, archwire surface and the ligature material. Substantial friction during sliding mechanics may result in slowed tooth movement or loss of anchorage. Therefore sliding mechanics, which is used in all facets of orthodontics, works best when friction is minimized.[3]

Despite advancements in the aesthetics of ceramic orthodontic brackets, the appearance of orthodontic archwires has changed little. While increasing attention has been given to the use of aesthetically pleasing orthodontic archwires to complement ceramic brackets. Greater demand for aesthetic wires led to polytetrafluoroethylene coating of arch wires which is known as Teflon coating,

Since archwires are the integral part of the orthodontics force application, there were several attempts, made to reduce the friction of archwires. Literature findings also confirm that friction is reduced by surface treatment, Eg: Teflon, Polythene, or Ion-implantation[4]. Teflon or polytetrafluoroethylene (PTFE) is an anti-adherent and esthetic material that has excellent chemical inertia as well as good mechanical stability. Since Teflon has a low coefficient of friction, archwires with a Teflon coating could possibly reduce resistance to sliding[5].

These Teflon coated wires have not been routinely incorporated in treatment due to a lack of evidence-based research and practitioner familiarity. Very few studies have been done to compare the frictional resistance of Teflon coated and uncoated archwires. Hence the current study was undertaken to evaluate and compare the frictional properties of Teflon coated and conventional archwires with ceramic and stainless steel brackets.

Materials and Methods

Four types of archwires were used for the study viz teflon coated and conventional stainless steel and Niti wires (Table 1).

Two types of brackets were used–stainless steel and ceramic brackets (Table 2).

Conventional elastomeric ligatures (Ormco) were used for ligating the archwire to the bracket.

Table 1. Types of Archwires Used to Collect Data.

SL No.	MATERIALS	DIMENSIONS	COMPANY
I	Teflon coated stainless steel archwire	0.019 x 0.025-inch	G&H (Greenwood, Ind)
II	Conventional stainless steel archwire	0.019 x 0.025-inch	G&H (Greenwood, Ind)
III	Teflon coated Ni-Ti archwire	0.019 x 0.025-inch	G&H (Greenwood, Ind)
IV	Conventional Ni-Ti archwirel	0.019 x 0.025-inch	G&H (Greenwood, Ind)

Table 2. Types of Bracket Used to Collect Data.

SL No.	MATERIALS	DIMENSIONS	COMPANY
I	Stainless steel bracket	0.022X0.028-inch	VICTORY SERIES 3M UNITEK MONROVIA CA
II	Ceramic bracket	0.022X0.028 -inch	TRANSCEND SERIES 60003M UNITEK MONROVIA CA

Table 3. Composition of Test Groups.

GROUP	SPECIMEN
Group 1	Ceramic bracket with 0.019" x 0.025" teflon coated stainless steel archwire
Group 2	Ceramic bracket with 0.019" x 0.025" conventional stainless steel archwire
Group 3	Ceramic bracket with 0.019" x 0.025" teflon coated Ni-Ti archwire
Group 4	Ceramic bracket with 0.019" x 0.025" conventional Ni-Ti archwire
Group 5	Stainless steel bracket with 0.019" x 0.025" teflon coated stainless steel archwire
Group 6	Stainless steel bracket with 0.019" x 0.025" conventional stainless steel archwire
Group 7	Stainless steel bracket with 0.019" x 0.025" teflon coated Ni- Ti archwire
Group 8	Stainless steel bracket with 0.019" x 0.025" conventional Ni- Ti archwire

Method

The present in-vitro study evaluated the frictional resistance produced by different brackets and archwires assembly. A total of 80 bracket-wire samples were studied under eight (8) groups (Table 3).

Tidy's[6] frictional test design was used in this study with minor modifications. The measurements of friction between the bracket and the archwire were done with the universal strength testing machine (Figure1). Jig consisted of a simulated half arch fixed appliance with the archwire in vertical position. Four edgewise brackets of 0.022"X 0.028" were bonded on a rigid acrylic plate at 8 mm intervals with 16mm space for a movable test bracket at the center . Ten brackets and archwires were used in each group. The archwire was secured with the elastomeric ligatures, for ease in use and consistent force delivery. The module secured on the movable bracket slackened to permit free sliding.

Table 4. One way ANOVA to compare the 8 Groups.

	Group	N	Mean	Standard Deviation	Mean Square	F	Sig.
Maximun load (gf)	Group 1	10	49.409	1.8709739	1040.207	256.38	<0.001
	Group 2	10	51.679	2.6384021			
	Group 3	10	54.71	1.8732622			
	Group 4	10	58.885	1.6302709			
	Group 5	10	32.714	1.7392923			
	Group 6	10	30.26	1.7050448			
	Group 7	10	41.89	1.5484616			
	Group 8	10	44.105	2.7385408			
	Total	80	45.4565	9.7912223			
Average load at average value (maximum)	Group 1	10	42.892	1.814153	880.569	296.0902	<0.001
	Group 2	10	46.483	2.5397859			
	Group 3	10	49.206	1.4817347			
	Group 4	10	52.269	1.580193			
	Group 5	10	28.35	1.3144327			
	Group 6	10	26.225	1.9223206			
	Group 7	10	37.72	1.8709739			
	Group 8	10	39.154	1.6801931			
			40.287375	8.984885			
Dynamic at coefficient of friction	Group 1	10	0.014	0.00E+00	0	4.174E+32	<0.001
	Group 2	10	0.016	0.00E+00			
	Group 3	10	0.019	0.00E+00			
	Group 4	10	0.022	0.00E+00			
	Group 5	10	0.006	0.00E+00			
	Group 6	10	0.004	0.00E+00			
	Group 7	10	0.008	0.00E+00			
	Group 8	10	0.011	0.00E+00			
	Total	80	0.0125	0.00E+00			
Static at coefficient of friction	Group 1	10	0.034	0.00E+00	0.001	1.78148E+32	<0.001
	Group 2	10	0.036	0.00E+00			
	Group 3	10	0.042	0.00E+00			
	Group 4	10	0.409	0.00E+00			
	Group 5	10	0.409	0.00E+00			
	Group 6	10	0.409	0.00E+00			
	Group 7	10	0.409	0.00E+00			
	Group 8	10	0.03	0.00E+00			
	Total	80	0.03275	0.0094367			

The archwire dimension of 0.019 X 0.025 inch were chosen because it is the recommended size for sliding mechanics with the 0.022 system brackets used in the investigation. Edgewise universal maxillary premolar brackets were used, each incorporating 0^0 torque and 0^0 angulations.

The lower end of the jig was attached to the lower crosshead of the testing machine. Care was taken to align the archwire so that the sample was parallel with the vertical framework of the machine. The measurements of friction between the bracket and archwire were done with an Instron Universal Testing Machine with crosshead speed of 10mm/min over an 8 mm stretch of archwire. All the tests were conducted in dry conditions. The bracket was pulled in a vertical direction by a loop of 0.018 stainless steel wire until the friction was overcome and the bracket started to move through the archwire. The force to overcome resistance to initiate movement of the bracket was measured. This maximum frictional force at initial movement was taken to represent the peak static frictional resistance. The values of frictional force (gf) were recorded for individual combination of bracket-archwire assemblies. Values were recorded for each test run, from the electronic monitor display in the Universal testing machine (UTM). The results were tabulated.

Figure 1. Test apparatus.

Table 4. One way ANOVA to compare the groups.

	Group	N	Mean	Standard Deviation	Mean Square	F	Sig.
Maximun load (gf)	Group 1	10	49.409	[illegible]	1040.207	256.38	<0.001
	Group 2	10	51.679	2.6384021			
	Group 3	10	54.71	1.8732622			
	Group 4	10	58.885	1.6302709			
	Group 5	10	32.714	1.7392923			
	Group 6	10	30.26	1.7050448			
	Group 7	10	41.89	1.5484616			
	Group 8	10	44.105	2.7385408			
	Total	80	45.4565	9.7912223			
Average load at average value (maximum)	Group 1	10	42.892	1.814153	880.569	296.0902	<0.001
	Group 2	10	46.483	2.5397859			
	Group 3	10	49.206	1.4817347			
	Group 4	10	52.269	1.580193			
	Group 5	10	28.35	1.3144327			
	Group 6	10	26.225	1.9223206			
	Group 7	10	37.72	1.8709739			
	Group 8	10	39.154	1.6801931			
			40.287375	8.984885			
Dynamic at coefficient of friction	Group 1	10	0.014	0.00E+00	0	4.174E+32	<0.001
	Group 2	10	0.016	0.00E+00			
	Group 3	10	0.019	0.00E+00			
	Group 4	10	0.022	0.00E+00			
	Group 5	10	0.006	0.00E+00			
	Group 6	10	0.004	0.00E+00			
	Group 7	10	0.008	0.00E+00			
	Group 8	10	0.011	0.00E+00			
	Total	80	0.0125	0.00E+00			
Static at coefficient of friction	Group 1	10	0.034	0.00E+00	0.001	1.78148E+32	<0.001
	Group 2	10	0.036	0.00E+00			
	Group 3	10	0.042	0.00E+00			
	Group 4	10	0.409	0.00E+00			
	Group 5	10	0.409	0.00E+00			
	Group 6	10	0.409	0.00E+00			
	Group 7	10	0.409	0.00E+00			
	Group 8	10	0.03	0.00E+00			
	Total	80	0.03275	0.0094367			

Statistical Analysis

Statistical analysis was done using SPSS software version 20.0. The mean and standard deviation for all groups were established. One way ANOVA was used for group comparison and POST HOC TUKEY test was used to find out which sub group was significant (Table 4).

Significance for all tests was set at $p \leq 0.05$.

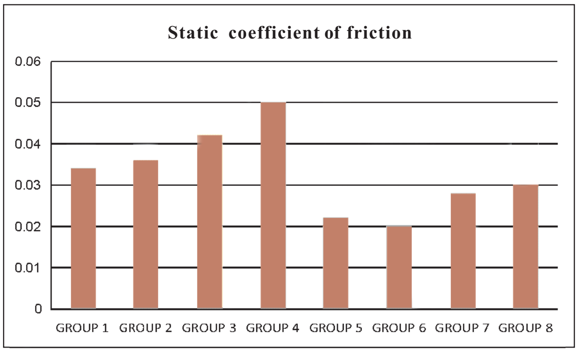

Figure 2. Static coefficient of friction between the Groups.

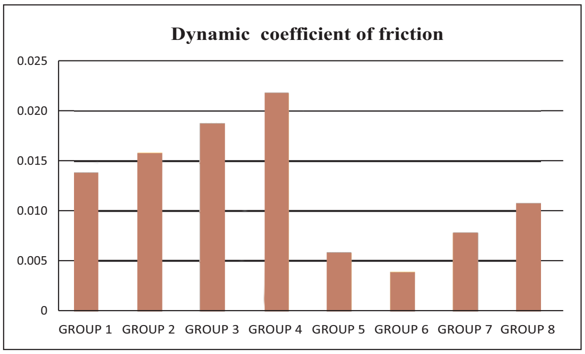

Figure 3. Dynamic coefficient of friction between the Groups.

Results

The mean values and standard deviation of co-efficient of friction of all groups were calculated. The coefficient of friction of 0.019 X 0.025 inch archwires in 0.022 inch slot brackets were compared using one-way ANOVA test(table 4). A statistically significant difference was found between all groups at a p value lower than 0.001 (Figures 2 & 3). A posthoc Tukey multiple comparison test was carried out to detect significant difference between the sub-groups. Statistically significant differences were found between all sub-groups at a p value lower than 0.001.

There was a statistically significant interaction ($p<0.001$) between type of the archwire material and brackets, which indicated that the frictional characteristics depended on the particular combination used. Frictional resistance was highest in ceramic bracket-Ni Ti archwire ($p<0.001$) followed by ceramic bracket-Teflon coated Ni Ti archwire, ceramic bracket-SS archwire, ceramic bracket-Teflon coated SS archwire, stainless steel bracket-Ni Ti archwire, stainless steel bracket-Teflon coated NiTi archwire, stainless steel bracket –Teflon coated SS archwire. The least frictional resistance was noted in stainless steel bracket-SS archwire ($p<0.001$) (Figures 2 & 3).

Table 5a. Posthoc Tukey Test to see which Subgroup is significant-***Maximum load (gf)***.

Tukey HSD					
Dependent Variable	**Group (I)**	**Group (J)**	**Mean Difference (I-J)**	**Std. Error**	**P Value**
Maximum load (gf)	Group 1	Group 2	-2.27	0.900809	0.204
		Group 3	-5.3010000*	0.900809	<0.001
		Group 4	-9.4760000*	0.900809	<0.001
		Group 5	16.6950000*	0.900809	<0.001
		Group 6	19.1490000*	0.900809	<0.001
		Group 7	7.5190000*	0.900809	<0.001
		Group 8	5.3040000*	0.900809	<0.001
	Group 2	Group 1	2.27	0.900809	0.204
		Group 3	-3.0310000*	0.900809	0.026
		Group 4	-7.2060000*	0.900809	<0.001
		Group 5	18.9650000*	0.900809	<0.001
		Group 6	21.4190000*	0.900809	<0.001
		Group 7	9.7890000*	0.900809	<0.001
		Group 8	7.5740000*	0.900809	<0.001
	Group 3	Group 1	5.3010000*	0.900809	<0.001
		Group 2	3.0310000*	0.900809	0.026
		Group 4	-4.1750000*	0.900809	<0.001
		Group 5	21.9960000*	0.900809	<0.001
		Group 6	24.4500000*	0.900809	<0.001
		Group 7	12.8200000*	0.900809	<0.001
		Group 8	10.6050000*	0.900809	<0.001
	Group 4	Group 1	9.4760000*	0.900809	<0.001
		Group 2	7.2060000*	0.900809	<0.001
		Group 3	4.1750000*	0.900809	<0.001
		Group 5	26.1710000*	0.900809	<0.001
		Group 6	28.6250000*	0.900809	<0.001
		Group 7	16.9950000*	0.900809	<0.001
		Group 8	14.7800000*	0.900809	<0.001
	Group 5	Group 1	-16.69510000*	0.900809	<0.001
		Group 2	-18.9650000*	0.900809	<0.001
		Group 3	-21.9960000*	0.900809	<0.001
		Group 4	-26.1710000*	0.900809	<0.001
		Group 6	2.454	0.900809	0.132
		Group 7	-9.1760000*	0.900809	<0.001
		Group 8	-11.3910000*	0.900809	<0.001
	Group 6	Group 1	-19.1490000*	0.900809	<0.001
		Group 2	-21.4190000*	0.900809	<0.001
		Group 3	-24.4500000*	0.900809	<0.001
		Group 4	-28.6250000*	0.900809	<0.001
		Group 5	-2.454	0.900809	0.132
		Group 7	-11.6300000*	0.900809	<0.001
		Group 8	-13.8450000*	0.900809	<0.001
	Group 7	Group 1	-7.5190000*	0.900809	<0.001
		Group 2	-9.7890000*	0.900809	<0.001
		Group 3	-12.8200000*	0.900809	<0.001
		Group 4	-16.9950000*	0.900809	<0.001
		Group 5	-9.1760000*	0.900809	<0.001
		Group 6	11.6300000*	0.900809	<0.001
		Group 8	-2.215	0.900809	0.23
	Group 8	Group 1	-5.3040000*	0.900809	<0.001
		Group 2	-7.5740000*	0.900809	<0.001
		Group 3	-10.6050000*	0.900809	<0.001
		Group 4	-14.7800000*	0.900809	<0.001
		Group 5	11.3910000*	0.900809	<0.001
		Group 6	13.84500000*	0.900809	<0.001
		Group 7	2.215	0.900809	0.23

*Significant at the 0.05 level

Table 5b. Posthoc Tukey Test to see which Subgroup is significant-***Average load at average value (maximum)***.

Tukey HSD					
Dependent Variable	**Group (I)**	**Group (J)**	**Mean Difference (I-J)**	**Std. Error**	**P Value**
Average load at average value(maximum)	Group 1	Group 2	3.5910000*	0.770176	<0.001
		Group 3	-6.3140000*	0.770176	0.016
		Group 4	-9.3770000*	0.770176	<0.001
		Group 5	14.5420000*	0.770176	<0.001
		Group 6	16.6670000*	0.770176	<0.001
		Group 7	5.1720000*	0.770176	<0.001
		Group 8	3.7380000*	0.770176	<0.001
	Group 2	Group 1	-3.5910000*	0.770176	<0.001
		Group 3	-2.7230000*	0.770176	<0.001
		Group 4	-5.7860000*	0.770176	<0.001
		Group 5	18.1330000*	0.770176	<0.001
		Group 6	20.2580000*	0.770176	<0.001
		Group 7	8.7630000*	0.770176	<0.001
		Group 8	7.3290000*	0.770176	<0.001
	Group 3	Group 1	6.3140000*	0.770176	<0.001
		Group 2	2.7230000*	0.770176	0.016
		Group 4	-3.0630000*	0.770176	0.001
		Group 5	20.8560000*	0.770176	<0.001
		Group 6	22.9810000*	0.770176	<0.001
		Group 7	11.4860000*	0.770176	<0.001
		Group 8	10.0520000*	0.770176	<0.001
	Group 4	Group 1	9.3770000*	0.770176	<0.001
		Group 2	5.7860000*	0.770176	<0.001
		Group 3	3.0630000*	0.770176	0.004
		Group 5	23.9190000*	0.770176	<0.001
		Group 6	26.0440000*	0.770176	<0.001
		Group 7	14.5490000*	0.770176	<0.001
		Group 8	13.1150000*	0.770176	<0.001
	Group 5	Group 1	-14.5420000*	0.770176	<0.001
		Group 2	-18.1330000*	0.770176	<0.001
		Group 3	-20.8560000*	0.770176	<0.001
		Group 4	-23.9190000*	0.770176	<0.001
		Group 6	2.125	0.770176	0.122
		Group 7	-9.3700000*	0.770176	<0.001
		Group 8	-10.8040000*	0.770176	<0.001
	Group 6	Group 1	-16.6670000*	0.770176	<0.001
		Group 2	-20.2580000*	0.770176	<0.001
		Group 3	-22.9810000*	0.770176	<0.001
		Group 4	-26.0440000*	0.770176	<0.001
		Group 5	-2.125	0.770176	0.122
		Group 7	-11.4950000*	0.770176	<0.001
		Group 8	-12.9290000*	0.770176	<0.001
	Group 7	Group 1	-5.1720000*	0.770176	<0.001
		Group 2	-8.7630000*	0.770176	<0.001
		Group 3	-11.4860000*	0.770176	<0.001
		Group 4	-14.5490000*	0.770176	<0.001
		Group 5	9.3700000*	0.770176	<0.001
		Group 6	11.4950000*	0.770176	<0.001
		Group 8	-1.434	0.770176	0.581
	Group 8	Group 1	-3.7380000*	0.770176	<0.001
		Group 2	-7.3290000*	0.770176	<0.001
		Group 3	-10.0520000*	0.770176	<0.001
		Group 4	-13.1150000*	0.770176	<0.001
		Group 5	10.8040000*	0.770176	<0.001
		Group 6	12.9290000*	0.770176	<0.001
		Group 7	1.434	0.770176	0.581

*Significant at the 0.05 level

Table 5c. Posthoc Tukey Test to see which Subgroup is significant-***Dynamic at coefficient of friction.***

Tukey HSD					
Dependent Variable	**Group (I)**	**Group (J)**	**Mean Difference (I-J)**	**Std. Error**	**P Value**
Dynamic at coefficient of friction	Group 1	Group 2	-0.0020000*	0.00E+00	<0.001
		Group 3	-0.0050000*	0.00E+00	<0.001
		Group 4	-0.0080000*	0.00E+00	<0.001
		Group 5	0.0080000*	0.00E+00	<0.001
		Group 6	0.0100000*	0.00E+00	<0.001
		Group 7	0.0060000*	0.00E+00	<0.001
		Group 8	0.0030000*	0.00E+00	<0.001
	Group 2	Group 1	0.0020000*	0.00E+00	<0.001
		Group 3	-0.0030000*	0.00E+00	<0.001
		Group 4	-0.0060000*	0.00E+00	<0.001
		Group 5	0.0100000*	0.00E+00	<0.001
		Group 6	0.0120000*	0.00E+00	<0.001
		Group 7	0.0080000*	0.00E+00	<0.001
		Group 8	0.0050000*	0.00E+00	<0.001
	Group 3	Group 1	0.0050000*	0.00E+00	<0.001
		Group 2	0.0030000*	0.00E+00	<0.001
		Group 4	-0.0030000*	0.00E+00	<0.001
		Group 5	0.0130000*	0.00E+00	<0.001
		Group 6	0.0150000*	0.00E+00	<0.001
		Group 7	0.0110000*	0.00E+00	<0.001
		Group 8	0.0080000*	0.00E+00	<0.001
	Group 4	Group 1	0.0080000*	0.00E+00	<0.001
		Group 2	0.0060000*	0.00E+00	<0.001
		Group 3	0.0030000*	0.00E+00	<0.001
		Group 5	0.0160000*	0.00E+00	<0.001
		Group 6	0.0180000*	0.00E+00	<0.001
		Group 7	0.0140000*	0.00E+00	<0.001
		Group 8	0.0110000*	0.00E+00	<0.001
	Group 5	Group 1	-0.0080000*	0.00E+00	<0.001
		Group 2	-0.0100000*	0.00E+00	<0.001
		Group 3	-0.0130000*	0.00E+00	<0.001
		Group 4	-0.0160000*	0.00E+00	<0.001
		Group 6	0.0020000*	0.00E+00	<0.001
		Group 7	-0.0020000*	0.00E+00	<0.001
		Group 8	-0.0050000*	0.00E+00	<0.001
	Group 6	Group 1	-0.0100000*	0.00E+00	<0.001
		Group 2	-0.0120000*	0.00E+00	<0.001
		Group 3	-0.0150000*	0.00E+00	<0.001
		Group 4	-0.0180000*	0.00E+00	<0.001
		Group 5	-0.0020000*	0.00E+00	<0.001
		Group 7	-0.0040000*	0.00E+00	<0.001
		Group 8	-0.0070000*	0.00E+00	<0.001
	Group 7	Group 1	-0.0060000*	0.00E+00	<0.001
		Group 2	-0.0080000*	0.00E+00	<0.001
		Group 3	-0.0110000*	0.00E+00	<0.001
		Group 4	-0.0140000*	0.00E+00	<0.001
		Group 5	0.0020000*	0.00E+00	<0.001
		Group 6	0.0040000*	0.00E+00	<0.001
		Group 8	-0.0030000*	0.00E+00	<0.001
	Group 8	Group 1	-0.0030000*	0.00E+00	<0.001
		Group 2	-0.0050000*	0.00E+00	<0.001
		Group 3	-0.0080000*	0.00E+00	<0.001
		Group 4	-0.0110000*	0.00E+00	<0.001
		Group 5	0.0050000*	0.00E+00	<0.001
		Group 6	0.0070000*	0.00E+00	<0.001
		Group 7	0.0030000*	0.00E+00	<0.001

*Significant at the 0.05 level

Table 5d. Posthoc Tukey Test to see which Subgroup is significant-***Static at coefficient of friction***.

Tukey HSD					
Dependent Variable	**Group (I)**	**Group (J)**	**Mean Difference (I-J)**	**Std. Error**	**P Value**
Static at coefficient of friction	Group 1	Group 2	-0.0020000*	0.00E+00	<0.001
		Group 3	-0.0080000*	0.00E+00	<0.001
		Group 4	0.0160000*	0.00E+00	<0.001
		Group 5	0.0120000*	0.00E+00	<0.001
		Group 6	0.0140000*	0.00E+00	<0.001
		Group 7	0.0060000*	0.00E+00	<0.001
		Group 8	0.0040000*	0.00E+00	<0.001
	Group 2	Group 1	0.0020000*	0.00E+00	<0.001
		Group 3	-0.0060000*	0.00E+00	<0.001
		Group 4	-0.0140000*	0.00E+00	<0.001
		Group 5	0.0140000*	0.00E+00	<0.001
		Group 6	0.0160000*	0.00E+00	<0.001
		Group 7	0.0080000*	0.00E+00	<0.001
		Group 8	0.0060000*	0.00E+00	<0.001
	Group 3	Group 1	0.0080000*	0.00E+00	<0.001
		Group 2	0.0060000*	0.00E+00	<0.001
		Group 4	-0.0080000*	0.00E+00	<0.001
		Group 5	0.0200000*	0.00E+00	<0.001
		Group 6	0.0220000*	0.00E+00	<0.001
		Group 7	0.0140000*	0.00E+00	<0.001
		Group 8	0.0120000*	0.00E+00	<0.001
	Group 4	Group 1	0.0160000*	0.00E+00	<0.001
		Group 2	0.0140000*	0.00E+00	<0.001
		Group 3	0.0080000*	0.00E+00	<0.001
		Group 5	0.0280000*	0.00E+00	<0.001
		Group 6	0.0300000*	0.00E+00	<0.001
		Group 7	0.0220000*	0.00E+00	<0.001
		Group 8	0.0200000*	0.00E+00	<0.001
	Group 5	Group 1	-0.0120000*	0.00E+00	<0.001
		Group 2	-0.0140000*	0.00E+00	<0.001
		Group 3	-0.0200000*	0.00E+00	<0.001
		Group 4	-0.0280000*	0.00E+00	<0.001
		Group 6	0.0020000*	0.00E+00	<0.001
		Group 7	-0.0060000*	0.00E+00	<0.001
		Group 8	-0.0080000*	0.00E+00	<0.001
	Group 6	Group 1	-0.0140000*	0.00E+00	<0.001
		Group 2	-0.0160000*	0.00E+00	<0.001
		Group 3	-0.0220000*	0.00E+00	<0.001
		Group 4	-0.0300000*	0.00E+00	<0.001
		Group 5	-0.0020000*	0.00E+00	<0.001
		Group 7	-0.0080000*	0.00E+00	<0.001
		Group 8	-0.0100000*	0.00E+00	<0.001
	Group 7	Group 1	-0.0060000*	0.00E+00	<0.001
		Group 2	-0.0080000*	0.00E+00	<0.001
		Group 3	-0.0140000*	0.00E+00	<0.001
		Group 4	-0.0220000*	0.00E+00	<0.001
		Group 5	0.0060000*	0.00E+00	<0.001
		Group 6	0.0080000*	0.00E+00	<0.001
		Group 8	-0.0020000*	0.00E+00	<0.001
	Group 8	Group 1	-0.0040000*	0.00E+00	<0.001
		Group 2	-0.0060000*	0.00E+00	<0.001
		Group 3	-0.0120000*	0.00E+00	<0.001
		Group 4	-0.0200000*	0.00E+00	<0.001
		Group 5	0.0080000*	0.00E+00	<0.001
		Group 6	0.0100000*	0.00E+00	<0.001
		Group 7	0.0020000*	0.00E+00	<0.001

*Significant at the 0.05 level

Teflon coated archwires produced less friction than uncoated archwires with ceramic brackets (p<0.001). Teflon coated NiTi archwires produced less friction in both stainless steel and ceramic brackets (p<0.001) (Figures 2 & 3).

Teflon Coated NiTi archwires had less friction than uncoated wires in both ceramic and stainless steel brackets (Figures 2 & 3).

Posthoc pairwise comparison showed that the stainless steel brackets produced significantly lower frictional force than did conventional ceramic brackets, for both static and kinetic coefficient of friction (p<0.001) (Tables 5a to 5d). Static frictional forces were greater than the kinetic frictional forces in all bracket archwire combination (Figures 2 & 3).

Discussion

In the present study we followed Tidy's[6] protocol because of its ability to simulate clinical situation. The measurement of friction between bracket, archwire and elastomeric ligature were done with the apparatus that simulated the fixed appliance in the mouth with the archwire in the vertical position. Each sample of wire was run on the Instron Universal testing machine, only once to eliminate the surface wear effects.

Testing was done under dry condition because of variable nature of saliva and to achieve results in non-contaminated conditions, as observed in many previous studies.[10,11,12,]

Here we used edgewise maxillary premolar brackets with 0° tip and 0° torque, since the studies have shown that increasing tip and torque produced increase in sliding resistance. Studies showed that both tip and torque had significant effect on friction.[13,14]

In this study, the effect of two variables-bracket material, conventional and Teflon coated archwires on frictional resistance were studied. The coefficient of static and kinetic friction for each bracket –archwire combinations were calculated and analyzed.

Our study showed Static frictional resistance to be greater than the kinetic frictional resistance for all the bracket-archwire combinations. This was also in agreement with the result of previous studies by Keith et al[16], Downing A et al[15].

Among the different groups tested, stainless steel brackets with stainless steel archwires showed lowest frictional values for both static and kinetic co-efficent of friction and ceramic bracket with conventional NiTI archwires exhibited highest frictional values.

Conventional stainless steel archwires with stainless steel brackets produced less frictional resistance than conventional nickel-titanium archwires. This is because stainless steel archwires have smoother surface than nickel-titanium archwires.[17,18] These findings are in accordance with the findings of previous studies by Garner et. al.,[19] Dresher et al,[9] Tidy et. al..[6]

In this study, the highest coefficient of friction was found between ceramic bracket-Ni Ti archwire. NiTi has higher friction due to its flexibility and surface roughness.[17] Highest friction in ceramic bracket is due to increased roughness and porosity of the material surface.[20] The results are in agreement with those of Angolkar PV et al[20],Kapila S et al[7], Drescher et al[9], Tidy DC[6], Kusy RP et al[10], Doshi UH et al[21],Garner LD et al[19] who showed that nickel titanium wires exhibited higher friction than stainless steel archwires. NiTi archwires have greater surface roughness compared with stainless steel archwires.[17,18,20] They are more flexible than stainless steel archwires so they can bind during sliding mechanics and produce more resistance to movement. Despite of teflon coating,Niti showed higher friction than coated stainless steel wires. Higher free titanium content in NiTi wires could also explain the higher frictional values.[21].

In our study, ceramic brackets showed higher coefficient of friction than stainless steel brackets. Our results are in agreement with those of previous studies by Angolkar PV et al[20], Cacciafesta V et al[22], Nishio C et al[23], Tanne K et al[24]. They found that conventional ceramic brackets generated higher frictional resistances than did stainless steel brackets. The higher frictional resistance is due to increased surface roughness, hardness, stiffness and porosity of the material surface. The roughness of bracket interface slows the sliding of archwire through the bracket.[20] Scratches on the wire produced by ceramic brackets were indicated as a cause of reduced tooth movement.[17]

Our study showed that Teflon coated NiTi, Teflon coated stainless steel archwires had less friction than conventional NiTi and stainless steel archwires with ceramic brackets. Husmann et al[4] reported that Teflon coating of archwire significantly reduced the frictional resistance compared with uncoated archwire of the same alloy. This finding was consistent in the present study for both stainless steel and NiTi Teflon coated archwires with ceramic brackets. The results were also in agreement with the result of previous studies by Farronato G et al[5], Mendes K et. al.[25]

The present study also demonstrated that different archwires used in the study had a significant influence on frictional resistance. Significant differences were found between stainless steel and nickel-titanium archwires in this study. Nickel-titanium archwires showed higher frictional resistance (*P*<0.001) then stainless steel archwires. These findings were in accordance with the findings of previous studies by Nishio C, et. al[23], Doshi UH, et. al[21], Pratten DH, et. al.[17]

Studies done by Hussman, et. al[4], Ryan, et. al[26], Wichelhaus, et al[27], Burstone[28] showed that Ion-implanted surface modified NiTi archwires exhibited lower co-efficient of friction when compared with the unmodified control archwires.

Our study showed that Teflon coated NiTi archwires had less frictional resistance than uncoated NiTi archwires in both ceramic and stainless steel brackets. Teflon coated NiTi and Teflon coated stainless steel archwires had less friction resistance with ceramic brackets. The surface treatment contributes to a reduction in the frictional properties of the archwire. Literature findings also confirm that the friction is reduced by surface treatment, eg. Teflon, polythene, Ion-implantation. The best result was reported for Teflon coated wires[4]. The reduction in friction by surface modification is in agreement with Burstone.[28] Coating or refining the wire surface with other materials has an influence on frictional behavior. Teflon is an anti-adherent aesthetic material that has excellent chemical inertia as well as good mechanical stability. Since Teflon has a low coefficient of friction, archwires with Teflon coating could possibly reduce frictional resistance.[5]

Conclusions

The results of this study indicate that;

- Teflon coating of the archwires reduces frictional resistance when used with ceramic brackets.
- Teflon coating of NiTi archwires reduces friction when used with ceramic as well as stainless steel brackets.
- Stainless steel brackets with stainless steel archwire combination offers the least frictional resistance.
- Teflon coated archwires may be recommended to be used with ceramic brackets for aesthetics as well as to reduce the frictional resistance.

The clinical applications of this study are numerous. The ability to reduce friction in the orthodontic appliance system by coating archwires with Teflon should facilitate quicker and more physiologic tooth movement with subsequent reduced treatment time if aesthetic is concern. The tooth-like colour of Teflon-coated archwires together with their improved frictional performance, may lead to widespread use of this type of archwires in future orthodontic practice.

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Functional Appliance, Orthodontic Treatment and Guillain-Barré Syndrome

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Introduction

Guillain-Barre syndrome (GBS) is an acute or subacute demyelinating polyradiculoneuritis and is the most common cause of acute generalized paralysis[1]. There is an increased incidence of certain infections in the weeks before onset of GBS. Most patients describe influenza, a respiratory infection or diarrhea, although the organism is positively defined in only about half[2]. The infecting organism has usually been eliminated from the body when neurological symptoms start and is rarely isolated directly[3]. It typically begins with fine distal paresthesia followed by leg weakness. The weakness then extends proximally and is accompanied by pain in the large muscles of the legs or back then spreads to involve upper limbs and cranial nerves, but other patterns are recognized. In severe cases, the disease then affects respiration, eye movements, swallowing or autonomic function. The duration of worsening of disease was later arbitrarily defined as less than 4 weeks to distinguish GBS from chronic inflammatory demyelinating polyradiculoneuropathy (CIDP).

Most patients have numbness, tingling and pain, and many have bladder disturbance, facial weakness and difficulty swallowing[4]. The cerebrospinal fluid (CSF) protein concentration is elevated in 80% of patients. Autonomic disturbance is common, with fluctuations in blood pressure, heart rate and bowel function. Weakness is usually maximal 1-2 weeks from onset, when approximately 20% of patients require artificial ventilation because of respiratory muscle weakness, 40% are bedbound, 20% can walk only with assistance, 10% can walk but not run, and 10% have only mild symptoms.[2] This paper reports of a case of Class II skeletal pattern with GBS. Parents decided that she undergoes orthodontic treatment because they understood that the benefits of the treatment outweigh the potential risks.[5] She was initially treated with a functional appliance, an Activator with screw for 19 months followed by 25 months of treatment with Edgewise appliance. To our knowledge, there is no study yet that mentions the dental characteristics and orthodontic management of patients with GBS. This study was designed to assess the dental and skeletal changes post-treatment and post-retention with considerations to their clinical features of difficulty in breathing and maintained open airway.[6]

Case Report

A 6 year 11 month old female was referred for evaluation of orthodontic treatment. She was diagnosed of Guillain-Barré syndrome for several years. Her mother noticed her maxillary central incisors were higher compared to the adjacent teeth, and diastema was noted on her maxillary anterior teeth, which prompted her to seek consult.

The patient presented with a brachyfacial, symmetrical face, deep mentolabial sulcus and a retrognathic mandible with a Class II appearance (Figure 1). Intraorally, she had 6.7mm overjet and 60% overbite with a moderate curve of Spee. She had full step Class II molar relationship on the right side while Class I molar relationship on the left side. She showed mild spacing and mild crowding in the maxillary anterior dentition with a moderate curve of Spee. Compared to her facial midline, her mandibular dental midline was deviated 2mm to the right. No oral habits and no signs of maintained open airway were visible though she exhibits difficulty in breathing. She has deep bite tendency (FH – MP: 24.3º, Table 1).

A panoramic radiograph showed no caries or pathologies, a number of succedaneous teeth were still expected to erupt. There were no congenitally missing teeth. (Figure 2).

Analysis of her lateral cephalometric radiograph (Figure 3) indicated a skeletal Class II pattern (ANB: 6.8º), with a retrognathic mandible (SNB: 76.6º). Her mandibular incisors were proclined (IMPA: 100.3º). Her lower lip was posteriorly positioned relative to the esthetic plane (Lower lip: -2.4mm).

The following treatment objectives were established: (1) to correct mandibular jaw deficiency; (2) correct the midline; (3) establish Class I canine and molar relationships; (4) obtain a normal overjet and overbite; (5) correct irregularities in the dentition by creating space for the erupting succedaneous teeth; (6) level the curve of Spee; (7) obtain a stable occlusal relationship; and (8) improve facial and dental esthetics by establishing an esthetic smile.

Given the child patient's stage of development, she has significant maxillomandibular growth potential wherein wearing of a functional appliance would allow advancement

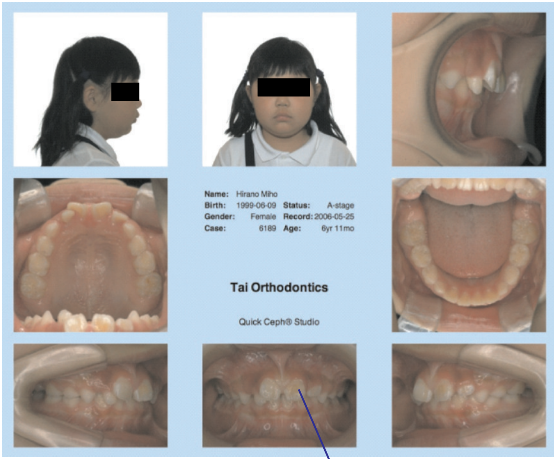

Figure 1. Pre-operative photographs

Is this dentin hypoplasia?
Is this related with the syndrome?

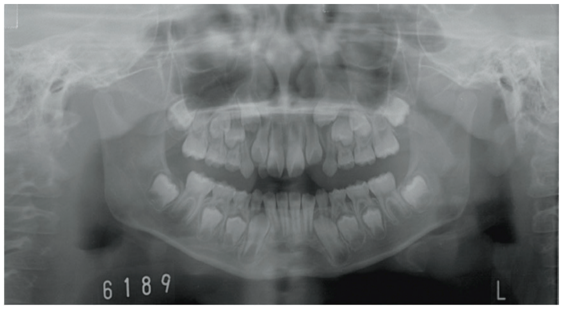

Figure 2. Pre-operative panoramic radiograph.

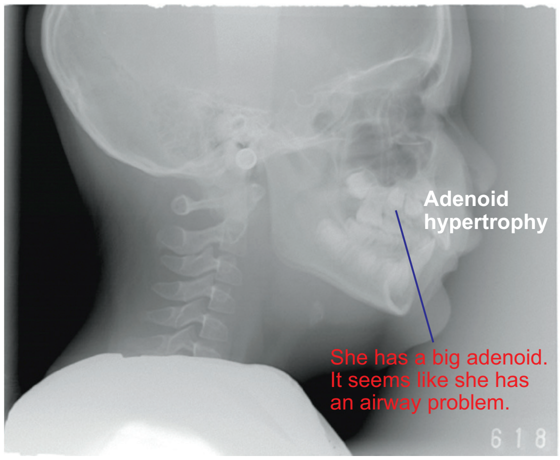

Figure 3. Pre-treatment cephalometric radiograph.

Table 1. Cephalometric measurements.

Measurement	*Norm*	*S.D.*	*Pretreatment*	*Posttreatment*	*Retention*
SNA (°)	82.0	3.0	83.4	82.2	
SNB (°)	80.0	3.0	76.6	78.0	
ANB (°)	2.0	2.0	6.8	4.1	
Wits (mm)	1.1	1.9	-0.5	-1.6	
SN - MP (°)	32.0	4.5	32.5	35.7	
FH - MP (°)	30.6	4.5	24.3	28.3	
LFH(ANS-Me/N-Me)(%)	55.0	3.0	57.3	57.9	
U1 - SN (°)	104.0	6.0	105.4	109.8	
U1 - NA (°)	22.0	6.0	22.0	27.6	
IMPA (°)	90.0	6.0	100.3	105.2	
L1 - NB (°)	25.0	6.0	29.4	38.8	
U1/L1 (°)	124.0	6.0	121.8	109.4	
Upper lip (mm)	1.2				
Lower lip (mm)	2.0	2.0	-2.4mm	2.9	

MP, mandibular plane

of the mandible, with the possibility of maxillary retraction. Follow-up fixed orthodontic treatment would depend on the results of functional appliance wear and if her physician would give her approval. Considering the patient's medical condition and the possible risks, the parents and the patient's medical specialist allowed her to undergo the first phase of treatment, during which she will have series of medical check-ups.

Instructions on the proper use and time of wear of an activator with screw were explained to the patient and mother. This allowed lateral expansion of the maxillary arch. She was very cooperative and the appliance was worn for 18 months. During this period, difficulty in appliance wear was not reported. Overjet, deep bite, tooth irregularities, deviated midline, and Class II canine relationship were noted (Figure 4). To address these concerns, there was a need to continue with the second phase of treatment. Three months passed before an .018 Edgewise appliance was bonded and continuous archwires were engaged. She had to return to the hospital for check-ups and treatment until her physician gave her the clearance. After seven months with fixed appliance, she had to go back to the hospital again. Two months later, a lingual arch was placed to correct her mandibular right second molar, which is becoming impacted (Figure 5). It took almost six months to upright the tooth. Eleven months later, she was already in her final wire for the detailing stage until she needed to go back to the hospital and was not seen for five months. Twenty-five months since the placement of brackets, the fixed appliance was removed. A lingual retainer was bonded on both arches. Postretention photographs (Figure 6), and postretention cephalometric radiograph (Figure 7) showed improved profile, revealing that the treatment objectives were accomplished. Alignment of crowding on maxillary anteriors, ideal overjet (2.6mm), improved overbite (10%) were achieved, and dental midlines were aligned with the facial midline. Class I canine and molar relationships (-1.0mm) were established with canine guidance. Post-treatment panoramic radiograph shows acceptable root parallelism (Figure 8). Total treatment time for this patient was five years and five months.

Post-treatment lateral cephalometric analysis and superimposition (Figure 9) revealed skeletal changes with forward movement of the mandible (ANB: 4.1º). The mandible

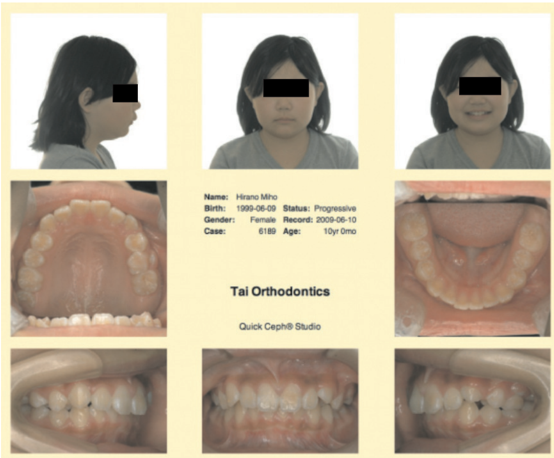

Figure 4. Post functional appliance treatment.
What was accomplished from the phase I tx?

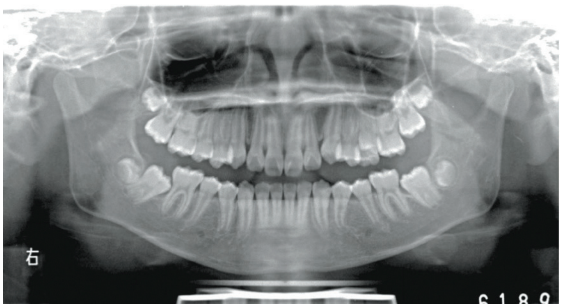

Figure 5. Impacted mandibular right second molar.

Figure 6. Post-treatment photographs.

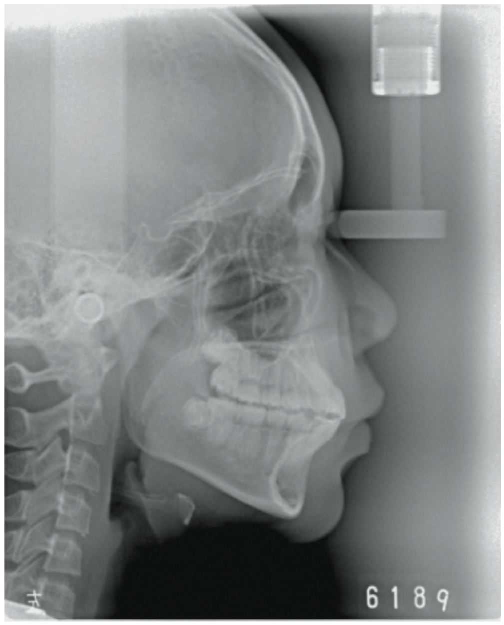

Figure 7. Post-retention cephalometric radiograph.

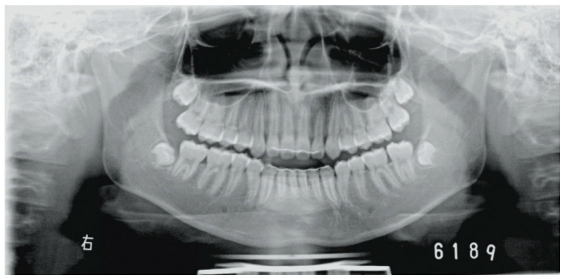

Figure 8. Post-treatment panoramic radiograph.

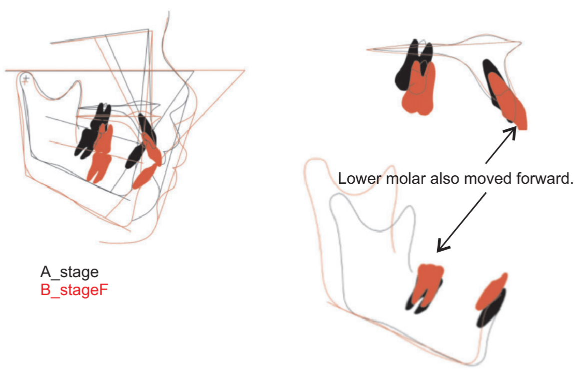

Figure 9. Cephalometric superimposition.

rotated downward and backward and there was an increase in the mandibular plane angle (SN-MP: 35.7º) and an increase in the lower facial height (LFH: 57.9º). A slight proclination of the maxillary incisor (U1 to SN: 109.8º) was observed and the mandibular incisors became more proclined (IMPA: 105.2º). The patient's facial profile especially the position of lower lip and soft-tissue pogonion was improved (Lower lip: 2.9mm).

Discussion

Guillain-Barre syndrome is a serious disease that requires immediate hospitalization because of the rapid rate at which it worsens.[6] The sooner appropriate treatment is started, the better the chance of a good outcome. Our patient was diagnosed early of this condition and has been continuing with orthodontic treatment for five years already.

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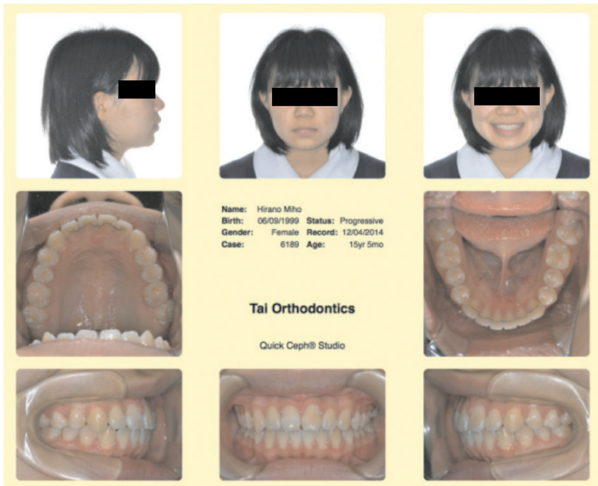

Comparison of Shear Bond Strength of Four Different Flowable Composites and Conventional Orthodontic Adhesive With and Without Prior Adhesive Primer Application

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Background and objectives. Flowable composites were marketed for bonding of brackets during early 21st century. Flowable composite merits special attention because of their clinical handling characteristics of non-stickiness, fluid injectability and shear bond strength comparable to that of traditional composite adhesives.

The purpose of this invitro study was to evaluate and compare the shear bond strength of a conventional composite and four different flowable composites with and without prior adhesive primer application used for bracket bonding in orthodontic treatment.

Methods. The present invitro study was designed to have 100 pre-adjusted edgewise stainless steel premolar brackets (Gemini, 3M Unitek) and 100 freshely extracted premolar teeth were divided into 5 groups and 2 Subgroups to be bonded with the above mentioned five adhesives. The brackets were bonded with Transbond XT, Transbond supreme LV, G-aenial Universal flow, Admira flow, Tetric Flow and cured using LED from the occlusal, gingival, mesial and distal aspects for 15 seconds each. The bonded teeth were then stored in distilled water for 24 hours before evaluation of bond strength.

The shear debonding force was applied with Instron testing machine at cross head speed of 0.5mm/min. A custom made wire was used to apply the shear bond load with occluso-gingival direction. The exact force at which the bracket was debonded was noted from the electronic console attached to INSTRON Universal testing machine (33R 4467). Chi-square analysis was used to compare the mode of bond failure (ARI score).

Results. Inferential statistics was done by using various tests of significance like independent t test, one way ANOVA, two way ANOVA and chi-square test. While doing ANOVA, bonferroni post hoc test was done to compare between two groups. $P<0.05$ is considered significant. All the tests were done using SPSS software.

However the result showed with prior adhesive primer application, Transbond XT showed the highest SBS and without prior adhesive primer application, Transbond supreme LV showed the highest SBS among all the flowable composites, whereas, SBS of conventional composite i.e. Transbond XT showed a significant reduction.

Interpretation and conclusion. Though Transbond XT is a clinically efficient material as again confirmed from this study, flowable composites, (mainly Transbond supreme LV) if their flow and viscosity are balanced to improve handling property can definetly be considered as a time saving and alternative bonding system due to its comparable bond strength without bonding agent and debonding characters and other reported properties of biocompatibility.

Introduction

Flowable composites were marketed for bonding of brackets during early 21st century. Flowable composite merits special attention because of their clinical handling characteristics of non-stickiness, fluid injectability[1] and shear bond strength comparable to that of traditional composite adhesives.[2]

Ostertag et.al.,[3] designed an experimental study to evaluate the influence of adhesive filler concentration on bond strength, keeping the filler particle size constant. The results of that study indicate that there is an increase in shear and torsional bond strength with increasing concentrations of adhesive filler.

Some authors believe that charged particles in the composite resin limit the free flow of adhesive into the enamel pores, inhibiting the formation of resintags.[4,5,6] others believe that the liquid phase of the composite is present in sufficient amount to flow into the conditioned enamel porosities and act independently of the charged particles. These workers use this as an explanation for the equal size of resin tags obtained when the composite resin or the sealant is applied directly to the conditioned enamel.[7,8]

Considering the merits and demerits of BisGMA based composite resin, and flowable composite the present in-vitro study was planned to evaluate Transbond supreme LV, G-aenial Universal flow, Admira flow, Tetric Flow flowable composites as an alternative orthodontic bonding agent by determining its shear bond strength with and without bonding agent and debonding characters and to compare it with that of conventionally used BisGMA based composite resin-Transbond XT composite.

Objective

To evaluate and differentiate the shear bond strength of a conventional composite and four different flowable composites with and without prior adhesive primer application used for bracket bonding, and to determine and compare the amount of adhesive remnant on each tooth after debonding brackets for different composites.

Methodology

One hundred (100) pre-adjusted edgewise upper premolar stainless steel brackets (Gemini 3M Unitek) and 100 freshly extracted premolar teeth were used in the study.

The freshly extracted teeth were cleaned to remove blood or any tissue debris and stored in 0.5% chloramine T solution to prevent bacterial contamination and dehydration.

One hundred (100) teeth were divided into 5 experimental groups with 20 teeth in each experimental group (N=20) and 4 experimental groups (N=20X4=80) of flowable composites will be used to test shear bond strength and one experimental group (N=20) of conventional composite will be used to test shear bond strength.

The teeth were then mounted on self cured, stainless steel blocks of dimensions 25X10 mm such that the roots were completely embedded into the acrylic block up to cemento-enamel junction and the buccal surface of the crowns were perpendicular to base of the block. The blocks were color coded to differentiate between different groups.

The teeth to be bonded with stainless steel metal brackets using five adhesives under study were grouped as given below (Figure 15).

Bonding Procedure

Conditioning of the enamel surface.

The buccal surface of the teeth was polished with pumice slurry using rubber cup mounted on low speed hand piece.

Color coding of blocks	Adhesive used for bonding	No of metal brackets (sample size)
Red-Group I	Tetric flow, Ivoclar	20
Yellow-Group II	GC- aenial universal flow	20
White-Group III	Admira flow, Voco	20
Green-Group IV	Transbond supreme LV	20
Blue-Group V	Transbond XT	20

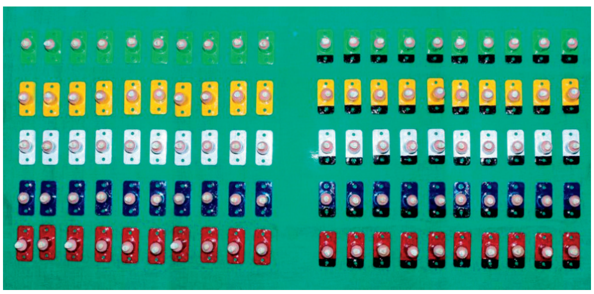


Figure 15. Colour coded of custom made aluminium sleeves.

After polishing, the teeth were washed with distilled water and dried using oil free air from a three-way syringe. 37% ortho phosphoric acid was applied to the labial surface and left for a period of 15 seconds. The acid was then washed away with a spray of water for 10 seconds. The tooth surface was then air-dried using oil and moisture free three 3-way syringe until a dullfrosty appearance was seen on the surface.

The above procedure was done for all the test specimens, to be bonded with five adhesives to be evaluated.

Bonding procedure using Tetric N flow, Ivoclar : Group 1.

The primer was applied to the etched surface with the help of an applicator brush and cured with LED for 30 seconds, rinsed for 15 seconds and dried with oil-free and moisture-free air for 20 seconds until the enamel will become faintly white.

After acid etching, for each experimental group, half of the specimens (N=10) a thin layer of Transbond XT primer was applied and light cured according to manufacturer's instructions. Primer was not applied for another half of the specimen (N=10) of each experimental group.

The adhesive was then applied to the base of the metal bracket directly from the syringe. The bracket was held and carried to the tooth surface by a bracket holder. The bracket was then positioned on the tooth surface along the midline at a distance of 4 mm from the occlusal surface. The positioning was achieved with the help of a bracket positioner.

The bracket was pressed on the tooth surface using the reverse end of the bracket holder using uniform finger pressure. The flash around the bracket was then removed with an explorer. The adhesive was cured using a LED (light emitting diode) curing unit. A radiometer was used to determine the intensity of the LED. The adhesive was cured from the occlusal, gingival, mesial and distal aspects for 10 seconds each.

The bonded teeth were then kept in distilled water at room temperature for 24 hours before debonding.

Bonding using G-aenial Universal flow, Admira flow, Transbond Supreme LV , Transbond XT

The Bonding procedure for these adhesives was the same as that for Group I.

Evaluation of Bond Strength

Shear bond strength was tested with a INSTRON Universal testing machine (Figure 16, 33R 4467) and was evaluated according to the following procedure for all the five samples. The machine has two vertically placed jaws.

- The custom made aluminium sleeves with the tooth embedded was placed in the lower jaw with custom made jig (Figures 18 and 17, Fixed head).
- A custom made chiesel was fitted to the upper jaw of the machine (Figure 18, Movable head).

At the start of the testing, the jaws were positioned such that the sharp edge of the chiesel from the upper block fits under the occlusal wings of the bracket bonded to the tooth. An occluso-gingival force was applied to each bracket producing a shear force at the bracket –tooth interface at a crosshead speed of 0.5mm/min.

The INSTRON Universal testing machine (Figure 16, 33R 4467) unit was attached to an electronic console that displayed the debonding forces acting on the bracket tooth interface. Thus, the exact force at which the bracket debonded was noted from the console. This force was expressed in Newtons.

To evaluate the Shear Bond Strength in MPa, from the force value, the following formula was used.

$$\text{Shear Bond Strength (MPa)} = \frac{\text{Force in Newtons}}{\text{Area of the bracket base (sq. mm.)}}$$

The area of the bracket base as measured by using Digital VernierCalipers.

Evaluation of the Debonding Characteristics

The debonded tooth surface was examined under an optical microscope at 16X magnification to determine the bond failure interface.

The adhesive remaining on the bracket base after debonding was scored according to the modified Adhesive Remnant Index (ARI) based on the following guidelines;

Score 0 = no adhesive left on bracket,
Score 1 = less than 25% of adhesive left on bracket,
Score 2 = 25% of adhesive left on bracket.
Score 3 = 50% of adhesive left on bracket,
Score 4 = 75% of adhesive left on bracket,
Score 5 = 100% of adhesive left on bracket.

Figure 16. INSTRON Universal testing machine (33R 4467).

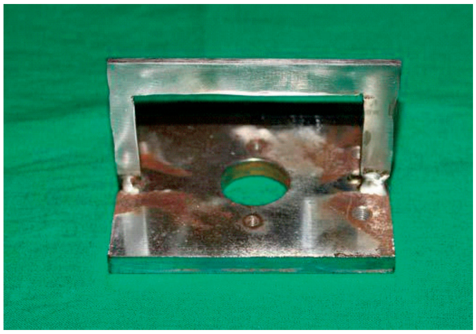


Figure 17. Custom made metal jig.

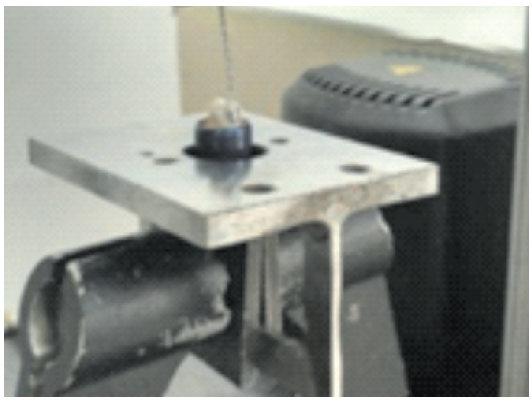


Figure 18. Aluminum block with Tooth embedded attached to lower jaw of testing machine with custom made jig and chiesel mounted to upper jaw.

The values obtained from the Shear Bond Strength testing (SBS) and the modified ARI scores of the three adhesives were tabulated and the subjected to statistical analysis.

Results

Statistical Methods Applied

The values obtained from the Shear Bond Strength testing and modified ARI scores of the five adhesives were tabulated and analysed using the following statistical analysis to determine the statistical significance of the data:

1. Mean and Standard deviation
2. ANOVA
3. Chi square test

The result obtained by this are as follows,

Table 2a displays the descriptive data in terms of mean shear bond strengths and standard deviations between the various groups and subgroups**.**

Table 2b shows the result of between samples effect on shear bond strength**.**

Table 2c shows the estimated marginal means between the various groups. Group 5 showed the lowest while Group 4 had the highest**.**

Table 2d shows pairwise comparison among the 5 Groups in terms of shearbond.Significant difference was obtained between Group 1 - Group 5, Group 3 – Group 4 and Group 4- Group 5**.**

Table 2e displays the estimated marginal means between the subgroups. The difference obtained was significant with p<0.001**.**

Table 2f shows the mean value, standard error and the 95% confidence interval of the five (5) Groups and Subgroups**.**

Table 3a shows the result of 2 way ANOVA to compare between the 5 materials directly without taking into consideration the application of bonding agent. The results were statistically significant**.**

Table 3b displays the results of Post Hoc test**.**

Table 4 shows the results comparison of shear bond strength with and without bonding agent application among the different Groups. Significant differences were noticed on shear bond strength of all groups with and without bonding agent**.**

Table 5 shows the ARI (Adhesive Remanent Index) with and without the bonding agent.

Table 2a. Mean Shearbond strength

Group	Subgroup	N	Mean	Std. Deviation
1	1	10	10.80	1.25
	2	10	12.55	1.42
2	1	10	10.66	1.54
	2	10	12.41	0.45
3	1	10	12.79	0.84
	2	10	8.38	1.19
4	1	10	11.06	1.74
	2	10	12.76	1.34
5	1	10	14.42	1.62
	2	10	6.31	1.46

Table 2b. Tests of Between-Samples Effects-Shearbond.

Source	Type III Sum of Squares	df	Mean Square	F	p-value
Corrected Model	509.35[a]	9	56.59	31.51	<0.001*
Intercept	12581.88	1	12581.88	7007.16	<0.001*
Group	38.39	4	9.59	5.34	0.001*
Subgroup	53.71	1	53.71	29.91	<0.001*
Group * Subgroup	417.24	4	104.31	58.09	<0.001*
Error	161.60	90	1.79		
Total	13252.83	100			
Corrected Total	670.95	99			
a. R Squared = .759 (Adjusted R Squared = .735)					

* P<0.05 Statistically Significant
p>0.05 Non Significant, NS

Table 2c. Estimated Marginal Means - Group.

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	11.67	.30	11.08	12.27
2	11.54	.30	10.94	12.13
3	10.58	.30	9.99	11.18
4	11.91	.30	11.31	12.50
5	10.36	.30	9.77	10.96

Table 2d. Pairwise comparison - Group Shearbond

(I) Group	(J) Group	Mean Difference (I-J)	95% Confidence Interval for Difference		p-value
			Lower	Upper	
1	2	0.13	-1.08	1.35	1.00(NS)
	3	1.08	-0.13	2.30	0.11(NS)
	4	-0.23	-1.45	0.98	1.00(NS)
	5	1.30	0.09	2.52	0.02*
2	3	0.95	-0.26	2.17	0.27(NS)
	4	-0.37	-1.59	0.84	1.00(NS)
	5	1.17	-0.04	2.39	0.06(NS)
3	4	-1.32	-2.54	-0.10	0.02*
	5	0.22	-0.99	1.44	1.00(NS)
4	5	1.54	0.32	2.76	0.004*

* P<0.05 Statistically Sgnificant
p>0.05 Non Significant, NS

Table 2e. Estimated Marginal Means - Subgroup.

Subgroup	Mean(95 CI%)	Std. Error	Mean Difference (95% CI)	p-value
1	11.95(11.57, 12.32)	0.19	1.46(0.93, 1.998,)	<0.001*
2	10.48(10.10, 10.86)	0.19		

*P<0.05 Statistically Significant
p>0.05 Non Significant, NS

Table 2f. Group * Subgroup.

Group	Subgroup	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	10.800	.424	9.958	11.642
	2	12.552	.424	11.710	13.394
2	1	10.668	.424	9.826	11.510
	2	12.412	.424	11.570	13.254
3	1	12.792	.424	11.950	13.634
	2	8.383	.424	7.541	9.225
4	1	11.067	.424	10.225	11.909
	2	12.761	.424	11.919	13.603
5	1	14.422	.424	13.580	15.264
	2	6.312	.424	5.470	7.154

Table 3a. Comparison between the five (5) materials.

Subgroup		N	Mean	SD	F(df1,df2)	P-value
1	1	10	10.80	1.25	12.76(4,45)	<0.001*
	2	10	10.66	1.54		
	3	10	12.79	0.84		
	4	10	11.06	1.74		
	5	10	14.42	1.62		
2	1	10	12.55	1.42	57.49(4,45)	<0.001*
	2	10	12.41	0.45		
	3	10	8.38	1.19		
	4	10	12.76	1.34		
	5	10	6.31	1.46		

ANOVA
*P<0.05 Statistically Significant
p>0.05 Non Significant, NS

Table 3b. Post Hoc Tests.

Subgroup	(I) Group	(J) Group	Mean Difference (I-J)	95% Confidence Interval		p-value
				Lower Bound	Upper Bound	
1	1	2	0.13	-1.76	2.03	1.00(NS)
		3	-1.99	-3.89	-0.09	0.03*
		4	-0.26	-2.16	1.63	1.00(NS)
		5	-3.62	-5.52	-1.72	<0.001*
	2	3	-2.12	-4.02	-0.22	0.01*
		4	-0.39	-2.29	1.50	1.00(NS)
		5	-3.75	-5.65	-1.85	<0.001*
	3	4	1.72	-0.17	3.62	0.10(NS)
		5	-1.63	-3.52	0.26	0.14(NS)
	4	5	-3.35	-5.25	-1.45	<0.001*
2	1	2	0.14	-1.48	1.76	1.00(NS)
		3	4.16	2.54	5.79	<0.001*
		4	-0.20	-1.83	1.41	1.00(NS)
		5	6.24	4.61	7.86	<0.001*
	2	3	4.02	2.40	5.65	<0.001*
		4	-0.34	-1.97	1.27	1.00(NS)
		5	6.10	4.47	7.72	<0.001*
	3	4	-4.37	-6.00	-2.74	<0.001*
		5	2.07	0.44	3.69	0.005*
	4	5	6.44	4.82	8.07	<0.001*

*P<0.05 Statistically Significant
p>0.05 Non Significant, NS

Table 4. Comparison with and without bonding agents.

Group	Subgroup	N	Mean	SD	Mean Difference (95% CI)	t	df	p-value
1	1	10	10.80	1.25	-1.75(-3.01, -0.49)	-2.92	18	0.009*
	2	10	12.55	1.42				
2	1	10	10.66	1.54	-1.74(-2.86, -0.62)	-3.43	10.57	0.006*
	2	10	12.41	0.45				
3	1	10	12.79	0.84	4.40 (3.43, 5.38)	9.48	18	<0.001*
	2	10	8.38	1.19				
4	1	10	11.06	1.74	-1.69(-3.15,-0.22)	-2.43	18	0.02*
	2	10	12.76	1.34				
5	1	10	14.42	1.62	8.11(6.66, 9.55)	11.75	18	<0.001*
	2	10	6.31	1.46				

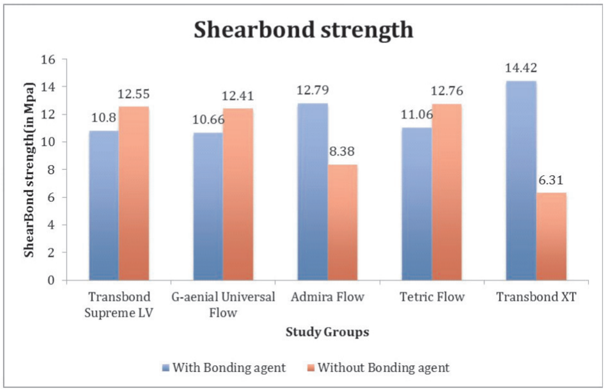
*P<0.05 Statistically Significant
p>0.05 Non Significant, NS

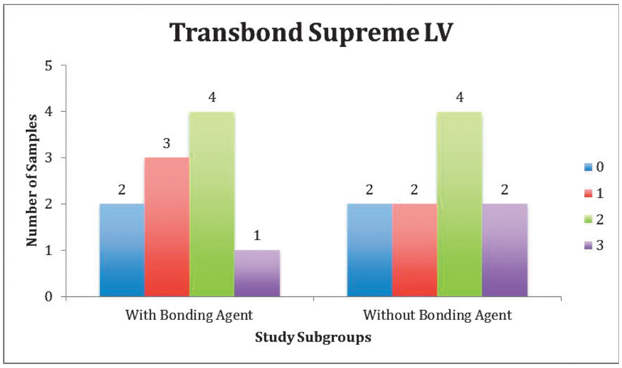
Table 5. Remnants.

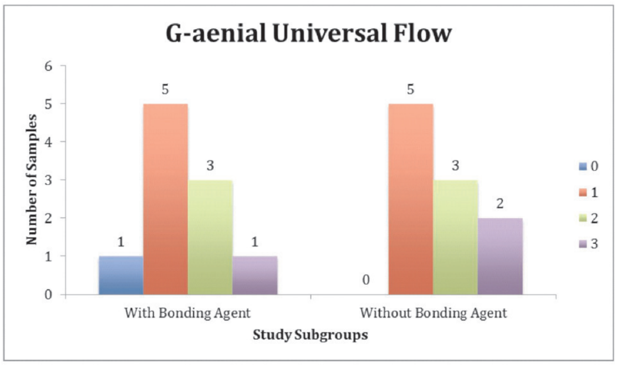
Group			Adhesive Remanent				Total	p-value
			0	1	2	3		
1	Subgroup	1	2	3	4	1	10	1.00(NS)
		2	2	2	4	2	10	
	Total		4	5	8	3	20	
2	Subgroup	1	1	5	3	1	10	1.00(NS)
		2	0	5	3	2	10	
	Total		1	10	6	3	20	
3	Subgroup	1	2	4	3	1	10	0.65(NS)
		2	1	2	5	2	10	
	Total		3	6	8	3	20	
4	Subgroup	1	1	5	3	1	10	1.00(NS)
		2	0	5	3	2	10	
	Total		1	10	6	3	20	
5	Subgroup	1	2	4	3	1	10	1.00(NS)
		2	1	4	3	2	10	
	Total		3	8	6	3	20	

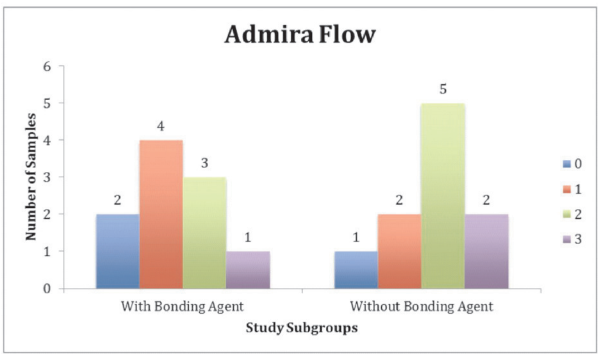
*P<0.05 Statistically Significant
p>0.05 Non Significant, NS

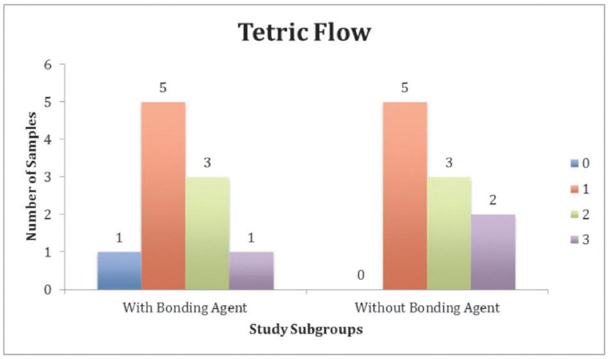
When using an adhesive system, the four flowable composites performed similarly to the conventional orthodontic composite resin, similar to that observed in some previous studies.[15, 16] Without adhesive, the SBS increased in three out of four flowable composites i.e. in Tetric flow, G-aenial universal flow and Transbond Supreme LV. Albaladejo A et al, also found similar results with Transbond supreme LV.[14] A review of the published literature indicates that many researchers have achieved similar SBS values,[15, 17] indicating that certain flowable composites of thinner viscosity may bond to enamel adequately without the requirement of an intermediate bonding resin, reason being , penetration of liquids into narrow capillaries, such as the microporosities of etched enamel, is influenced by properties of the liquid, such as viscosity and the surface free energy of the capillary wall[17] and flowable composites like Transbond supreme LV contains a dimethacrylate polymer that modifies the rheology of the material and provides a flow-on demand handling characteristic, allowing the material to flow under pressure yet hold its shape after placement until light cured.[18] On the other

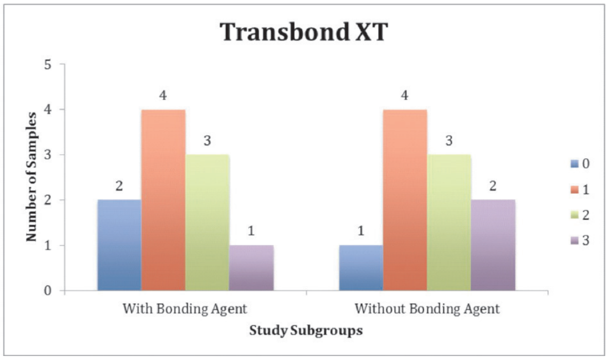












hand, Transbond XT showed 6.31 MPa. This orthodontic composite resin had a higher filler concentration (77% quartz-silica filler)[19] than the other flowable composites used. The influence of filler concentration on the viscosity remains a clinically important issue[20] because charged particles in the composite resin limit the free flow of adhesive into the enamel pores, inhibiting the formation of resin tags.[21,22]

Olsen , Owens.Jr , Bishara.SE, Oesterle.LJ and Tecco.S et al to name a few have reported higher SBS values for Transbond XT when evaluated under different testing conditions as observed in the present study.[9]

Simona.T[12] and Michele.D.Attilio[11] have reported very high values of 23.23 MPa and 23.47 MPa for Transbond XT and 34.80 MPa and 24.98 MPa for Flowable composites compared to the values expressed in the present study. They suggested that Flowable composites can be used for orthodontic bonding.

Dong-Bum-Ryou[13] reported a lower SBS value for Flowable composites compared to that of Admira Flow in the present study and he concluded that Flowable composites with no intermediate bonding resin could be conveniently applied for orthodontic bracket.

However, Tancan Uysal[10] reported a very low value for Flowable composites ranging from 6-8 Mpa compared to 17.10 MPa showed for Transbond XT and concluded that

Flowable composites were not suitable for orthodontic bonding.

At this juncture it is worthwhile to note that the bond strength of all the five adhesives are quite above the clinically acceptable level of 5.9-7.8 MPa as suggested by Reynolds, Lopez[23] recommended a value of 7 MPa as minimum bond strength for successful clinical bonding.

Moreover, according to Pickett et al.,[24] the mean bond strengths recorded in vivo following comprehensive orthodontic treatment are significantly lower than bond strengths recorded in vitro. Although mean SBSs were within the acceptable range, they would be considered marginal, at the lowest acceptable level. It should be stated that with the exception of Tetric Flow, G-aenial universal flow and Transbond Supreme LV, the bond strengths of the materials were approximately 50% of the bond strengths obtained when the bonding agent was included.

The frequency distribution of the modified ARI scores reveals that 60-70% of the samples in all the five study groups showed score 1-2 suggestive of a cohesive fracture i.e. debonding occurred mainly within the adhesive. The cohesive fracture noted in the present study was favorable and indicates moderate amount of bond strength at clinically acceptable level, and facilitate easy debonding after treatment. Further, it requires minimal clean up and less damage during debonding.

The above discussion on the present study reveals that Transbond XT had the highest bond strength i.e., 14.42 MPa when used with prior adhesive primer application whereas, all the four flowable adhesives showed more SBS than Transbond XT when used without primer. However, the SBS values of all the five adhesives were within the clinically acceptable levels and they exhibit cohesive type of bond failure. Probability of failure rate is almost similar for all the 5 adhesives groups.

The flowable composites have decreased filler particle i.e. it flows while being applied and contoured but remains firm when stationary. However, when they were used for bonding in the present study drifting of the brackets was noticed due to its increased flowability which required extra care to position the brackets.

It is evident from the present study that flow property and viscosity of adhesive plays an important role. Within certain limits, thinner and flowable adhesive paste will facilitate better penetration of the adhesive into mesh of the bracket base and the micro porosities of the etched enamel surface and improve handling properties and bond strength. Therefore, a balance is required between the flow and viscosity to obtain optimal consistency to achieve optimal bond strength and improve handling property.

Though Transbond XT is a clinically efficient material as again confirmed from this study, flowable composites, (mainly Transbond supreme LV) if their flow and viscosity are balanced to improve handling property can definetly be considered as an alternative bonding system due to its comparable bond strength with and without bonding agent and debonding characters and other reported properties of biocompatibility. Considering the invivo nature of the present study the findings should be interpreted with caution while applying it for clinical application. The efficacy of the flowable composites as a bonding agent needs invivo and clinical assesment through a survival analysis. Preliminary evaluation done in this study however will be a valuable guide for future in clinical use and it would be helpful to the orthodontic clinician to know the percentage reduction in SBS that was observed with each material in this study when the step of bonding agent placement was eliminated to allow the clinician to make conclusions about the acceptability of this.

CONCLUSION

Based on our findings we can draw the following conclusions:

1. Among the five composite Transbond XT had the highest SBS when used with prior adhesive primer application for bracket bonding.
2. Among the five composite Transbond supreme LV had the highest SBS when used for bracket bonding without prior adhesive primer application.
3. Transbond Supreme LV was the only flowable resin performing similarly with or without adhesive system application. Admira flow was the only flowable composite which has more SBS when used with prior adhesive primer application.
4. All the five composites have ARI score of 1-2 and the debonding mainly occurs within the adhesive.
5. Flowable composites mainly Transbond supreme LV can be considered as an alternative orthodontic bonding agent for bracket bonding without adhesive primer.

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Bisphenol A Released by Three Polymerized Orthodontic Adhesives and Its Effect on MCF-7 Breast Cell Proliferation*

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The aims of this study were to identify the presence of Bisphenol A in three polymerized orthodontic adhesives namely: Quick-Bond Adhesive Paste from Forestadent, Germany; Transbond™ from 3M Unitek, USA and Bracket Paste from BISCO, USA. And to evaluate its effect on MCF-7 breast cancer cell line. Three sets of 20 pieces of 2mm diameter by 1mm thick adhesives were placed on a glass slab and then covered with a celluloid strip and brackets were firmly pressed on the covered adhesives and were removed before curing. The curing was done in 10 seconds at 90° degrees at a distance of 1mm. The samples then were weighed and immersed in a vial containing of 20 ml artificial saliva (ISO 10993-15) and incubated for 1 day, 7days and 14 days at room temperature. HPLC was used to identify the presence of Bisphenol A. After Identification of Bisphenol A, the samples were lyophilized and pulverized and seeded in a 9 sterile 96-well microtitter plates containing at least 5000 cells/ml. The cells were incubated at 37°C with relative humidity of 5% CO2 in an incubator for 1 day, 3 days and 7 days. Methyl Thiazolyl Tetrazolium (MTA) Assay was used to measure the metabolic activity of living cells and optical absorbance was performed by ELIZA reader. The data were treated using one-way ANOVA and statistical analysis was done using IBM SPSS version 21.
The study revealed that the three polymerized orthodontic adhesives, releases Bisphenol A and there is no sufficient evidence of cancer cell proliferation signifying the absence of estrogenicity of the polymerized orthodontic adhesives.

Introduction

The advent of orthodontic adhesive has replaced the use of bands in fixed orthodontic treatment. Moreover, the generations of system introduced and marketed gave several options for more reliable effective bonds. However, the resinous matrix of orthodontic adhesive which is bis-GMA or bisphenol-A glycidyl dimethacrylate has been of great concern because of its biological effects (Eliades, V, D, E, & G, 2007). Some effects include human exposure and reproductive toxicity in animals. (NTP-CERHR Expert Panel Report on The Reproductive and Developmental Toxicity of Bisphenol A, November 26, 2007).

According to studies, Bisphenol A could potentially be present as an impurity or released during the degradation of the material (European-Union. Risk Assessment Report - 4,4'-isopropylidenediphenol (Bisphenol A), 2003), and other said, Bisphenol A could leach during polymerization (Jagdish, et al., 2009). The degree of conversion of a typically cross-linked bis-GMA is about 50%-60% of methacrylate groups have been polymerized. However this does not imply that the remaining percent of the monomer molecules are left in the resin, some molecules could still be covalently bonded to the polymer structure forming a pendant group (Anusavice, Chiayi, & Rawls, 2013).

Conversely, there are reports about a varying degree of level of Bisphenol A released in saliva after application of resin based sealant, (Olea, et al., 1996), (Arenholt-Bindslev, Breinholt, Preiss, & Schmalz, 1999), (Fung EY, 2000). Other had reported about the presence of Bisphenol A in both saliva and urine (Joskow, et al., 2006). On the contrary, a study on orthodontic adhesives found no Bisphenol A release from the materials after simulated aging (Eliades, Hiskia, Eliades, & Athanasiou, 2007). But a study on plastic orthodontic bracket placed in water revealed that it releases Bisphenol A at 0.01-0.40 mg/kg material. (Suzuki, Ishikawa, Sugiyama, Furuta, & Nishimura, 2000).

With regards to reproductive toxicity, bis-GMA and UDMA causes irreversible effects on cellular metabolism (Modena, et al., 2009). It has a binding affinity to estrogen receptors (Gaido, et al., 1997), and can induce developmental abnormalities in reproductive system in animals (Bitman & Cecil, 1970). Lastly there is a significant report that confirms the estrogenicity of resinous material by proliferation test on human breast cancer cells (Olea, et al., 1996). But this was denied by the study of Eliades et. al. stating that no evidence of proliferation on cancer cells were found (Eliades, V, D, E, & G, 2007). Nevertheless, there are insufficient data to evaluate whether Bisphenol A causes male and female reproductive toxicity in human. However, animal data are assumed relevant for the assessment of human hazard (NTP-CERHR Expert Panel Report on The Reproductive and Developmental Toxicity of Bisphenol A, November 26, 2007).

The aims of the study were to determine the presence of Bisphenol A released by the three polymerized orthodontic adhesives and to assess the effect of the three polymerized adhesive on MCF-7 breast cancer cell according to varying incubation period.

Materials and Methods

The study is in-vitro, single blinded and controlled trial. The adhesives used were, Quick-Bond Adhesive Paste from Forestadent, Germany (lot # 142); Transbond™ from 3M Unitek, USA (lot # ER3UD) and Bracket Paste from BISCO USA (lot#1300005055).

*This study won the 1st Resident's Forum organized by the Association Philippine of Orthodontists held in University of the Philippines, Manila last October 2016.

Specimen preparation

Three sets of 20 pieces of 2mm diameter by 1mm thick adhesives were placed on a glass slab and covered with a celluloid strip; Each adhesive were measured using a caliper, brackets were firmly pressed on the covered adhesives and were removed before curing. The samples were cured using a halogen curing light manufactured by Dentsply QHL75® model number 502. The emitting light intensity is about 700 to 600 nm visible light range. The tip has a 3 inches length. Radiometer was used CureRite™ to standardize the accuracy of cure. The curing was done in 10 seconds at 90° degrees to the adhesives at a distance of 1mm. The samples were then removed from the glass slab using a sharp instrument then weighed and immersed in vial with 20 ml artificial saliva (ISO 10993-15) and incubated for 1 day, 7days and 14 days at room temperature (Figure 1).

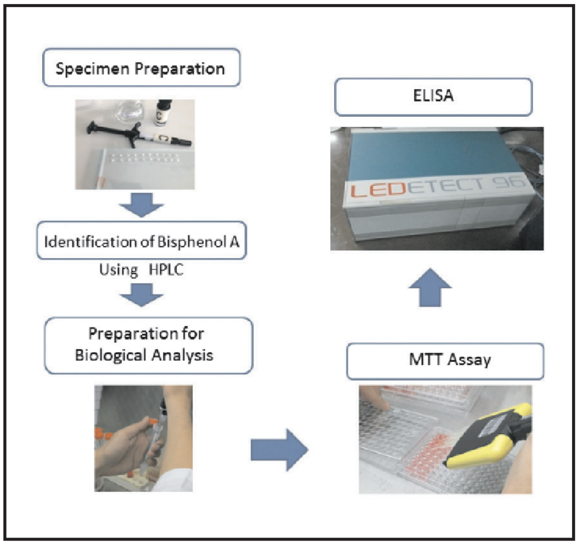

Figure 1. Preparation of the Specimen

Identification of Bisphenol A using HPLC

The sample consists of 3 sets of polymerized resin immersed in artificial saliva. They are called the spent media, they were incubated at different time intervals (1 day, 7 days, 14 days). A total of 9 prepared spent media were tested using HPLC. The internal standard used is authentic BPA ($C_{15}H_{16}O_{1}$=228.29).

A C-18 column and a UV detector of 230nm were used. The mobile phase consists of water and acetonitrile 60:40 ratio and the sample is the Bisphenol A at 1 *ug/ml* in acetonitrile (Aurand, 2013). The elution temperature is 35°C and an injection volume is 1uL. The flow rate is at 0.1mL/min and a pressure of 3268 psi (225 bar). The samples are the spent media while the mobile phase is the same as mentioned above. The only difference is the flow rate which is 0.1ml/min and the sample solution is 20 ul.

Preparation of samples for Biological Analysis

There are three samples tested, each samples has three replicates. The samples were pulverized using porcelain mortar and pestle then weighed accordingly. The samples were immersed in DMSO or dimethyl sulfoxide and diluted to a concentration of 20mg/ml. The dilution is based on the weight per sample and the standard measurement for DMSO. The samples were placed in a vortex mixer for 10 minutes then it was set aside. Observation revealed that not all test samples were dissolved in DMSO. The positive control consist of a 56 mg Progynova® 2mg with generic name of estradiol valerate was pulverized and dissolved in DMSO, the same formula was also used. The positive control was immediately dissolved in DMSO without a mixer. While negative control, is in form of DMSO (dimethyl sulfoxide).

The media preparation for 100 ml MCF- 7 includes, 10% of Fetal bovine serum or FBS, 88.0% for minimum essential media or MEM, 1.0% of Penstrep and 1.0% of insulin.

Preparation for MTT Assay

To evaluate the estrogenicity of the samples, the cell line was seeded in a 9 sterile 96-well microtitter plates containing at least 5000 cells/ml. The cells were incubated at 37°C with relative humidity of 5% CO2 in an incubator for 24h.

After incubation, the sample solution from each brand was added to the micro plates. Observation was done after 30 minutes and 1 hour using inverted microscope. Pictures were taken for evaluation and analysis.

Samples at 50 mg/ml DMSO were diluted to a concentration of 20 mg/ml. Ten microliters of spent media were obtained and dispensed onto the plated cells to obtain the final screening concentration of 1mg/ml. The cells treated with estradiol served as the positive control while those treated with DMSO served as the negative control.

Three replicates wells were used per samples. The treated cells were then incubated at 37°C and 5%CO2 for three different incubation periods. Three plates were incubated for 24h, another three plates for 72h and another three plates for 168h.

After each incubation period, the media was removed and 20 ul of 3-(4,5-dimethyllethylthiazol-2-yl)-2-5 diphenyltetrazolium bromide (MTT) at 5 mg/ml PBS was added to each well. The wells were set aside for 4 hours then absorbance was read at 570 nm using LEDETECT 96.

ELISA –Enzyme-linked Immunosorbent Assay

To test for the effect of the adhesives on MCF-7 breast cell proliferation, the optical absorbance from ELISA reader was used. The absorbance provides a basis to quantitatively measure the amount of attenuation which depends on the concentration of absorbing molecules and the path length over which absorption occurs (Skoog, West, Holler, & Crouch, 2013). It is also known as optical density (OD). This is defined as the logarithmic ratio that measures the intensity of light hitting a sample and the intensity of that very light transmitted to the sample. The reading for absorbance is based on Beer's law that absorbance can measure the concentration of the solution from the test samples. The formula (Turgeon, Mary Louise , 2012) for absorbance is:

$$A = 2 - \log \%T$$

The comparisons of the three orthodontic adhesives were measured by using one- way ANOVA. The level of significance which is 0.05 was used with the p-value of >0.05 interpreted as not significant, <0.05 is interpreted as significant and <0.01 very significant.

Statistical Analysis

To identify the presence of Bisphenol A using HPLC, the retention time was used and compared to the negative control. There are three varying incubation periods used: 1day, 7days and 14days.

To identify the proliferation of MCF-7 cell line in all samples with varying degrees of incubation period these were 1day 3 days and 7 days and samples were compared according to brands. One way ANOVA was used at a level of <0.05 level of significance.

IBM SPSS version 21 was used for statistical treatment.

Result

Confirmatory test revealed that Forestadent Quick-Bond Adhesive Paste has shown the presence of Bisphenol A from day 1 and 14 days but non-existent on 7th day. Both 3M Transbond ^{XT} and Bisco Ortho One Bracket Adhesive revealed the absence of Bisphenol A form day 1 and 7 except for 3M Transbond which is present in day 7. However, on the 14th day all samples displayed the presence of Bisphenol A on its eluent (Figure 2).

With regards to proliferation, the data showed that immediately upon exposure after 30 minutes and 1 hour, there was an intense proliferation of MCF-7 cell line. However the proliferation decreases on day1, day3 and day7. Although there is a very low activity based on ELISA readings, the eluents or sample media were unable to stimulate any proliferation activity (Figure 3).

Discussion

This study was made to answer the report mentioned by Sakaguchi and Power. They stated that the estrogenicity of trace levels of Bisphenol A of uncured resin has been proven in vitro tests but, estrogenicity from cured composites has not yet been confirmed. (Sakaguchi & Powers, 2012). Polymerized orthodontic adhesives were used and stored in artificial saliva with varying incubation periods. After each incubation period the samples where tested using HPLC and compared to the internal standard: an authentic Bisphenol A.

The data showed that all sample eluent or the spent media was identified to contain Bisphenol A, this is not surprising because Bisphenol A is a high-production volume chemical used in the production of epoxy resins, polyester resins, polysulfone resins, polyacrylate resins, polycarbonate plastics, and flame retardants. (NTP-CERHR Expert Panel Report on The Reproductive and Developmental Toxicity of Bisphenol A, November 26, 2007). In addition polymers used in dental sealants, adhesive, plastic brackets, denture base and tooth coatings are all made up of resin which contains Bisphenol A. This study just confirmed that Bisphenol A is present in all adhesive samples especially on 14th day. The study also mentioned about absence of Bisphenol A in day 1 and day 7, this may be due to a possibility of laboratory error due to the different retention time elicited by internal standard in each incubation period.

Optical absorbance using ELISA showed a moderate proliferation activity of cell in day 1 (Figure 4). The data revealed that the absorbance of the test samples is between 0.43-0.52 nm which means that the average transmittal is between 30-40%. Implying that almost half of the cell proliferates and half of the 5000 cell did not proliferate. On day 3 and day 7 there is a continued decline of cell proliferation, the absorbance on day 7 revealed the scores between 0.26- 0.33 nm with an equivalent of 20-30% of transmittal suggesting of a very low proliferation activity.

The MCF-7 used is an estrogen sensitive cell line which is derived from human breast cancer cell. This cell when exposed to minute levels of estrogen will show an intense proliferation activity (Eliades, V, D, E, & G, 2007). This is an indication that Bisphenol A is capable of interfering with the estrogen cell line (Schierow & A, 2010) The continued decline in the proliferation activity on the other hand may be due to the fact that resins, polycarbonate plastics and other products manufactured from Bisphenol A contain a trace amount of residual monomer and additional monomer may be generated during the breakdown of the monomer (European-Union. Risk Assessment Report - 4,4'-isopropylidenediphenol

(Bisphenol A), 2003). This implies that there is insufficient evidence to support cell proliferation. Furthermore, bracket bonding requires a small amount of adhesive, an average thickness of 150-250 *um* (Eliades, Viazis, & Eliades, Bonding ceramic brackets to enamel: morphologic and structural considerations, 1991). a sometimes only the margins are exposed to the oral environment or none at all. Tarumi et.al., explain that although there is a proliferation in their study. The low dosage of eluted BPA in polymerized resin sealant which is 10 ng/mL is insufficient to cause harm to human health (Tarumi, Imazato, Narimatsu, Matsuo, & Ebisu, 2000). And in animal study harmful effect is mounting for about 10 years. (Schierow & A, 2010). Therefore the amount of Bisphenol A eluted in each orthodontic adhesives when added together during the entire orthodontic treatment is not enough to cause harm to the body.

The comparison of the effect of the three orthodontic adhesives on MCF-7 cell line when grouped according to brands (Figure 5) reveals that there is has no significant differences among the samples. This entails that all samples have the same result which is decrease in the number of cell proliferation. The decrease in the proliferation is due to the concept of critical concentration referring to the required amount of substance to induce effects. Since Bisphenol A mimics the function of natural estrogen, the defense system may have the inability to recognize Bisphenol A as a foreign substance. (Eliades, V, D, E, & G, 2007).

Conclusion

There is no sufficient evidence on estrogenic activity seen among the three polymerized orthodontic adhesive.

Day	Brands	Retention Time (minutes) Scores	Interpretation	Internal Standard Average
1	Forestadent -Quick-Bond Adhesive Paste	1.86	**Present**	
	3M Transbond XT	1.89	*Not Present*	
	Bisco Ortho One Bracket Adhesive	1.92	*Not Present*	
7	Forestadent -Quick-Bond Adhesive Paste	1.71	Not Present	
	3M Transbond XT	1.86	**Present**	1.82 SD +-0.05
	Bisco Ortho One Bracket Adhesive	1.91	*Not Present*	
14	Forestadent -Quick-Bond Adhesive Paste	1.83	**Present**	
	3M Transbond XT	1.87	**Present**	
	Bisco Ortho One Bracket Adhesive	1.84	**Present**	

Figure 2. Retention time of the three orthodontic adhesive as compared to the retention time of the internal standard.

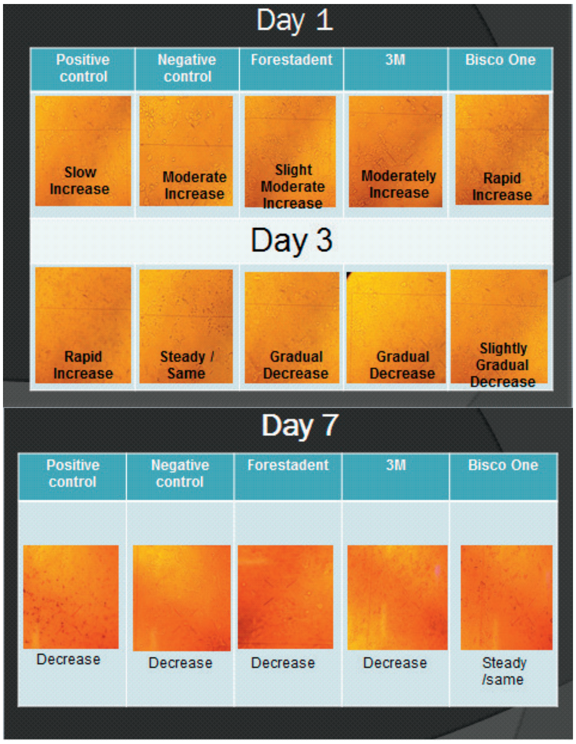

Figure 3. Proliferation of the MCF-7 Breast Cancer Cell Line After exposure to Orthodontic Adhesive From Day1, Day3 and Day7

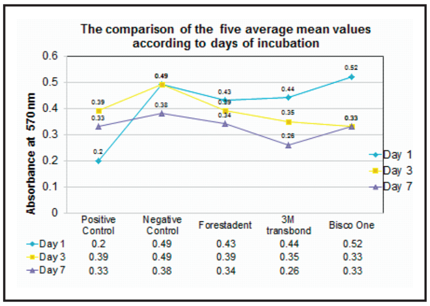

Figure 4. Result of Optical Absorbance after using ELISA.

Comparison of the Effect of Three Orthodontic Adhesive on MCF-7 Breast Cell Proliferation when Grouped According to Brand

Brands	Day	Mean	SD	F-value	p-value	Interpreted
Forestadent-Quick-Bond Adhesive Paste	Day 1	.431	.087	.376	P = 0.702 > 0.05	Not significant
	Day 3	.439	.056			
	Day 7	.518	.211			
3M Transbond XT	Day 1	.389	.120	.293	P = 0.756 > 0.05	Not significant
	Day 3	.350	.081			
	Day 7	.330	.083			
Bisco Ortho One Bracket Adhesive	Day 1	.341	.006	.865	P = 0.468 > 0.05	Not significant
	Day 3	.257	.057			
	Day 7	.328	.135			

Figure 5.

Acknowledgement

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Correlation Between Facial Form and Buccal Corridors and Its Influence on Smile Esthetics

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The present study was conducted to determine whether buccal corridor width with the total smile width changes along with change in the facial form and also to substantiate the influence of buccal corridors on the smile esthetics when judged by lay persons. The sample comprised of photographs obtained from 60 patients(30 males and 30 females) with age range of 17-30 years. Out of the 60 subjects selected: 20 subjects had leptoposopic facial form, 20 subjects had mesoprosopic facial form and the rest had euryprosopic facial form. Measurements of the frontal facial photographs, to determine the facial form accurately, were done following the method of Johnson and Smith using adobe photoshop cs6 version13.0. Standardized frontal facial photographs(to evaluate the facial form) and standardized frontal smile photographs(to determine the smile width and buccal corridor width) of the individuals selected were obtained. An album assembled with the 60 printed smile photographs , were given to 15 lay people for esthetic evaluation, using visual analog scale. All the results were statistically evaluated with the P value set at 0.05. The difference between the means were evaluated by Analysis of Variance (Tukey) Test. From the study it was concluded that in a normal population, the percentage of buccal corridor width with the total smile width does not change considerably with change in facial form and is not a significant factor affecting smile esthetics.

Introduction

The smile is one of the most important facial expressions and is essential in expressing friendliness, agreement and appreciation. An attractive, well balanced smile definitely enhances the acceptance of an individual in our society by improving the initial impression in interpersonal relationships. Therefore, it is essential to control the esthetic effects caused by orthodontic treatment, which is only possible by knowing the principles that manage the balance between teeth and soft tissues during a smile.[1-2]

During a smile, bilateral spaces appear between the buccal surface of the most visible maxillary posterior teeth and the lip commissure called as the negative spaces, black spaces or the buccal corridor. [3-8]The purpose of this study was to verify whether buccal corridor width with the total smile width changes along with change in the facial form and also to substantiate the influence of buccal corridors on the smile esthetics, ie, whether individuals with larger or smaller negative spaces have altered esthetics because of this factor.

Materials and Methods

The present study was conducted using photographs obtained from 60 patients(30 males and 30 females) from the student population of K.V.G Dental college, Sullia. The subjects were in the age group of 17-30years.

Out of the 60 subjects selected:

1. 20 subjects had leptoprosopic facial form.
2. 20 subjects had mesoprosopic facial form.
3. 20 subjects had euryprosopic facial form.

The subjects were selected only if they fulfilled the following criteria:

1. Good dental alignment with a possible exception of moderate crowding/rotations in the lower arch and mild crowding/rotations in the upper arch which is not visible during smile.
2. Balance between the facial thirds.
3. No history of orthodontic treatment. All the subjects who participated in the study signed an informed consent form approved by the university ethics committee.

Photographs-Standardized frontal facial photographs (to evaluate facial form) and standardized frontal smile photographs (to determine the smile width and the buccal corridor width) of the individuals selected on the basis of the criteria outlined above, were obtained.

Standardised frontal facial photographs- frontal facial photographs of each subject were taken in order to determine the facial form. All photographs were taken in the same closed environment under standard conditions with a NIKON COOLPIX L820. Photographs were standardized according to the following criteria[8]:

1. Camera- subject distance- 5 feet.
2. Camera was fixed on the tripod in portrait position.
3. Camera height was kept the same as that of patient's face.
4. Camera flash in 3 o' clock position.
5. Focus on the nose tip of the patient.
6. Manual mode was used.
7. Aperture f= 3 to 5.

8. Shutter speed = 1/800,
9. Film speed= ISO 125,
10. Maximum zoom was avoided to avoid capturing the surrounding.

Standardized frontal smile photographs- frontal view photographs of lower facial third, including the nose tip and chin were taken. All the subjects were photographed with a "natural smile". The distance from the subject to the camera was kept constant at 20 centimeters. Photographs were taken in the same closed environment under standard conditions with a NIKON COOLPIX L820.

Photographs were standardized according to the following criteria[8];

1. Photographs were taken in 'macro mode' (format-JPEG),
2. Focal length- 20 centimeters,
3. Aperture size- maximum; f=8,
4. Resolution- 16 mega pixel,
5. Sensitivity- ISO 125.

Determination of the facial form- measurements of the frontal facial photographs, to determine the facial form accurately, were done using ADOBE PHOTOSHOP CS6. The faces were classified as mesoprosopic, euryprosopic or leptoprosopic based on the morphologic facial index by Martin and Saller(1957).[9] The morphologic facial index was determined by dividing the morphologic facial height by the bizygomatic width. The morphologic facial height is defined as the distance between the nasion and the menton. The bizygomatic width is defined as the distance between the zygoma points(Figure 1).

Subjects having a morphologic facial index value of 83.9% or below were classified as euryprosopic; subjects having a value between 84-87.9% were classified as mesoprosopic and subjects having a value 88% and above were classified as leptoprosopic.

Measurements of the smile photographs- measurements of the frontal smile photographs were done accurately following the method of Johnson and Smith using ADOBE PHOTOSHOP CS6.Maximum smile width was determined as the distance between the right and the left lip commissures. The right and the left buccal corridor spaces were determined as the distance between the most buccal surface of the visible, posterior most maxillary tooth on either side and the right and the left commissures respectively. On the basis of smile width, right buccal corridor space and left buccal corridor space measurements, the percentage of right and left buccal corridor spaces with the smile width during smile was determined (Figure 2 and Table 1).

Euryprosopic Face Mesoprosopic Face Leptoprosopic Face

Figure 1. Facial forms.

A - Smile width. **B** - Distance between the last visible teeth in the maxilla. **C** - Upper intercanine distance.

Figure 2. Smile measurement.

	Leptoprosopic	Mesoprosopic	Euryprosopic
1	13.4	25.66	20.07
2	16.44	14.44	14.30
3	19.77	26.8	24.02
4	18.42	22.27	21.68
5	22.81	19.41	19.65
6	30.38	16.28	18.86
7	15.59	17.43	12.19
8	6.59	15.13	21.30
9	21.5	17.59	21.7
10	18.18	26.65	22.3
11	23.54	18.98	22.26
12	19.31	16.73	18.51
13	21.65	22.99	16.62
14	19.86	19.18	20.85
15	21.93	20.59	19.72
16	26.18	24.26	26.24
17	16.84	21.16	23.32
18	20.21	20.51	19.95
19	23.78	27.06	15.17
20	14.02	19.07	17.33
Mean	19.52	20.6	19.82

Overall Mean= 19.98 **(N =60)**

Table 1. Percentage of the bucal corridor width with total smile width..

Selection of esthetic smile- An album was assembled with the 60 printed photographs, showing only the mouth area, including the lips, teeth, and intraoral visible structures, to avoid interference from other facial structures, such as the nose and chin. The album was given to 15 lay persons for esthetic evaluation. The esthetic evaluation was carried out using VISUAL ANALOG SCALE(VAS) supplied along each photograph. The VAS varies progressively in values from esthetically very poor, poor, neutral and good to very good. Each examiner was asked to mark on the VAS a point on which the smile was closest to the corresponding value of the VAS. After each examiner completed the esthetic evaluations, the points marked on the VAS were converted into grades from 0 to 10, 0 being the minimum esthetic value and 10 being the maximum esthetic value.

Statistics-All the results were statistically evaluated with the P value set at 0.05. The differences between the means were evaluated by Analysis of Variance (Tukey) test.

Results

An album with all the 60 photographs were distributed to 15 lay persons for evaluation of the smiles. The esthetic evaluation was done using Visual Analog Scale as described before.

Mean of esthetic scores was determined for each photograph. Those photographs which received a mean esthetic score of 7 and above were considered as esthetic and were further selected for statistical analysis.

According to 15 lay persons, out of a total of 60 smiles, 23 were esthetic and the percentages of buccal corridor with the total smile width for these 23 photographs are shown in Table 2.

Out of these 23 subjects, 6 had leptoprosopic facial form, 11 had mesoprosopic facial form and 6 had euryprosopic facial form.

There was no statistically significant difference between the means of the percentage of the buccal corridor width with the total smile width of 20 leptoprosopic, 20 mesoprosopic and 20 euryprosopic individuals.The differences between the means of percentage of buccal corridor (BC) and total smile width (TSW) in esthetic smiles, of leptoprosopic, euryprosopic and mesoprosopic individuals were statistically evaluated using Anova(Tukey) test.

There was no statistically significant difference between the means of percentage of buccal corridor and total smile width in esthetic smiles, of leptoprosopic, mesoprosopic and euryprosopic individuals as evaluated by the lay persons.

Table 5. Comparison of overall means of percentage of buccal corridor and total smile width in esthetic smiles, as evaluated by lay persons and the overall mean of the sample selected.

	N	Mean	Standard Deviation
Lay persons	23	20.16	3.0767
Overall	60	19.98	4.1723

Table 2. Percentage of the buccal corridor width with total smile width by facial form.

	Leptoprosopic	Mesoprosopic	Euryprosopic
1	19.77	25.66	14.3
2	18.42	26.8	21.68
3	21.5	22.27	21.30
4	20.21	19.41	21.7
5	23.78	16.28	22.3
6	14.02	17.59	18.51
7		18.98	
8		19.18	
9		20.59	
10		20.51	
11		19.07	
Mean	19.61	20.57	19.98

Overall mean = 20.16

Table 3. Comparison of means of percentage of bucal corridor with the total smile width.

Face type	N	Minimum	Maximum	Mean	Standard Deviation
Leptoprosopic	20	6.59	30.38	19.52	5.09075
Mesoprosopic	20	14.44	27.06	20.60	3.93103
Euryprosopic	20	12.19	26.64	19.82	3.46769
Total	60	6.59	30.38	19.98	4.17235

p>0.05. Anova (Tukey) test was used.

Table 4. Comparison of means of percentage of BC and TSW in esthetic smiles in the 3 facial form types (groups).

Type of face	N	Mean	Standard Deviation	Anova (Tukey) Test
Leptoprosopic	6	19.61	3.2866	p>0.05
Mesoprosopic	11	20.57	3.2066	
Euryprosopic	6	19.96	3.0788	
Total	23	20.16	3.0737	

There was no statistically significant difference between the overall means of percentage of buccal corridor and total smile width in esthetic smiles, as evaluated by lay persons and the overall mean of the percentage of buccal corridor width and total smile width of the sample selected. (p>0.05).

Discussion

It has been suggested by various researchers in the past that facial form has an effect on arch width with leptoprosopic individuals having narrow arch form and euryprosopic individuals having broad arch form[10,11,12,13,14,15,16].

This should have resulted in increased buccal corridor in subjects with leptoprosopic facial form and decreased buccal corridor in subjects with euryprosopic facial form. However this study showed that there is no difference between the means of percentage of the buccal corridor width with the total smile width in leptoprosopic, mesoprosopic and euryprosopic subjects. This may be explained by referring to the work done by **Rigsbee et al(1988).**[16] According to their study, upon smiling, width of the mouth increases by as much as 30% in males.

Also **Sabri(2005)**[17], suggested that transverse lip extension during a smile may have a role to play in the amount of buccal corridor. So it can be stated that , the amount of increase in the width of the mouth during a smile is in harmony with the facial form and the arch form associated with it i.e. this increase is less in leptoprosopic individuals, moderate in mesoprosopic individuals and more in euryprosopic individuals, in order to develop a harmonious buccal corridor. In other words, the dental arch develops in line with the facial form such that the width of the face, the dental arches and the buccal corridors become propotional to each other.

The mean percentage of the buccal corridor width with the total smile width for the sample selected in this study was found to be 19.98%. This value is larger than the values found out by **Johnson and Smith**(1995).[7] According to their study the mean percentage of the buccal corridor width with the total smile width was found out to be 9% for cases treated with extraction of premolars and 8% for cases treated without extractions. The large difference between the results of this study and the findings of Johnson and Smith can be attributed to the difference in the light conditions under which the photographs were taken. The less iluminated the photograph, the larger will be the buccal corridor because fewer teeth will be observed, thus reducing the arch width, whereas the smile width is the same.

The mean value of the percentage of the buccal corridor with the total smile width as found out by **Rigsbee et al** (1988)[16] was 40% in an orthodontically treated group and 42% in a non orthodontically treated group.The large difference between the results of this study and the findings of Rigsbee can be attributed to the fact that these authors measured the buccal corridor by Hulsey's method[2] considering the distance between the maxillary canines as the lateral limit of the maxillary arch.

The mean value of the percentage of the buccal corridor with the total smile width as found out by **Ritter et**. **al**., (2006)[18] was 19.20%. Our study is in accordance with their study wherein the mean value of the percentage of the buccal corridor with the total smile width was found out to be 19.98%.

There was no statistically significant difference between the overall means of percentage of buccal corridor width and total smile width in esthetic smiles as evaluated by the evaluators and the overall mean of the percentage of the buccal corridor width and total smile width of the sample selected which is representative of normal population(Table 5). This means that the esthetic smiles were judged to be "esthetic" on the basis of other criteria such as the lip line[5,7,13,14,21,22],smile line[4,5,20,23,24],smile symmetry[5,12,24], upper lip curvature[5,17,26],dental and the gingival components.[17,26,27] This is a significant finding because it can conclude that in a normal population , width of the buccal corridor does not play a significant role in smile esthetics. Therefore it can be stated that the width of the buccal corridor does not affect smile esthetics if it is in the normal range of variation. This statement is in accordance with conclusions of **Frush and Fisher**(1958)[4] and **Johnson and Smith**(1995).[7] These authors agree that size of the buccal corridor is not esthetically critical, provided its within typical limits of individual differences.

In contrast with our study, **Moore et**. **al**., (2005)[28] found out that lay persons were able to discriminate between the degrees of smile fullness and that they preferred smiles which were visibly filled with dentition, commissure to commissure. This difference can be explained by the fact that in their study, sample from a normal population was not evaluated. Instead one smile was digitally altered to produce a wide range of variation in the width of buccal corridor.

Our study is in agreement with the study done by **Roden-Johnson et**. **al**., (2005)[29]. This study showed that when digital alteration of the smile photographs was not done to extremes, it did not affect the ratings of the smile as evaluated by the lay persons.

Parekh et. **al**., (2006)[30] in their web based survey concluded that both lay persons and orthodontists preferred smiles in which the smile arc paralleled the upper lip and buccal corridors were minimum. However these results cannot be compared with the results obtained from our study as the effect of smile arc is not evaluated by us which may be an important factor in smile esthetics.

The results of the current study are in harmony with the results of **Hulsey** (1970)[5] and **Ritter et al** (2006)[18]. In his study, Hulsey studied the effect of buccal corridor by establishing a ratio between the distance between the upper canines and corners of the smile. The smile scores were found to be completely independent of the buccal corridor ratio. This could be because, the actual buccal corridors (Frush and Fisher[4]) of his subjects would have in the normal range of variation. In the study done by Ritter et al, the buccal corridors were 19.20% of the total smile width.

A study was conducted by **Hideki loi et al** (2009)[31] in Japanese population, to test the hypothesis that the buccal corridor has no influence on smile evaluations of orthodontists and dental students. One photograph of a smiling female, displaying first molar to first molar, was constructed. Buccal corridors were modified digitally in 5% increments, from 0% to 25%buccal corridor compared with the inner commissural width. Using a visual analog scale (VAS), 32 Japanese orthodontists and 55 Japanese dental students rated the attractiveness of six smiles with altered buccal corridors. The results was that there was no significant difference in judging the effects of buccal corridors on the smile attractiveness between the male and female raters for both the orthodontists and dental students.

Extensive research is required towards the verification of the aforementioned statement, that is the dental arch develops in line with the facial form such that the width of the face, the dental arches and the buccal corridors become propotional to each other, wherein dimensions of the dental arch, movements of the corners of the mouth and the amount of buccal corridor for each facial type should be determined.

Conclusions

- The percentage of the buccal corridor width and the total smile width does not change along with change in the facial form.
- The buccal corridor space did not influence the esthetic evaluations of the smile photographs.
- Lay people did not consider the buccal corridor space as an important factor influencing their esthetic evaluations.
- The percentage of buccal corridor width and the total smile width as evaluated in "esthetic smiles" is the same as that found in the normal population.

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Stress Birefringence between Elastomeric Chain and Closed Coil Springs on a Photoelastic Model: An Interface

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Summary. The aim of this study was to compare the stress birefringence caused by the elastomeric chain and closed coil springs on a lower Photoelastic model. A Photoelastic model was prepared using Easy Cast Epoxy Resin and lower canine, second premolar and molar teeth were embedded in the mould space. The natural teeth were collected at the University of East graduate school clinic and ideally extracted within six months. The teeth segments were stabilized using an 18/25 stainless steel wire and secured in place using a 0.010 ligature wire. In order to simulate lower premolar extraction, a space of roughly fifteen millimeters was calculated between the proximal surfaces of the canine and second premolar tooth. A polariscope was built using acrylic sheets and a Canon EOS 1100 D camera was used to capture the various stress zones caused by both materials. The study was used only to qualitatively measure the various stress zones.

Result. The results of the experiment confirmed that the mesial apical & distal cervical of canine and mesial cervical & distal apical of molars were subjected to greater stress with regards to the elastomeric chain models whereas in the coil spring models the apical portion of canine, premolar and molars were seen to be subjected to greater stress.

Conclusion. The closed Niti coil spring produced stress zones on the bifurcation areas of the molars compared to the elastomeric chain samples. There was no significant difference in stress birefringence caused by elastomeric chain and closed Niti coil springs for canine retraction. Upon immediate loading, the current study showed signs of distal tipping of the canines and mesial tipping of the molars.

Introduction

Orthodontic tooth movement occurs as a result of the application of force on the tooth and the corresponding cellular response within the supporting structures of the teeth namely cementum, periodontal ligament and bone with vascular tissue. Every tooth has a center of rotation which is the point around which rotation occurs when a force is applied to move the tooth. The center of resistance is approximately at one thirds to two thirds or at the approximate midpoint of the embedded root and varies with root length and bone level. When a force is applied the possible tooth movements are tipping, rotation, translation depending on the location, direction and magnitude of the force.

There are various methods of canine retraction in use. The most commonly used methods of canine retraction are by employing elastomeric chain and Nitinol coil springs. Both materials are applied to the bracket on the crown of the teeth; depending on the magnitude of force a tipping or bodily movement can be produced.

Elastic chains are widely used in orthodontics to move teeth, to close or open spaces. Their main advantages being that they are easily available and economic compared to the other materials. It has the advantage that it requires minimal patient cooperation and compliance and it is much easier to use. It also has the added advantage of minimal trauma to the tissues and is available in a wide variety of colors to choose from.

The other most commonly used material for space closure is Nitinol coil springs known as NITINOL (Naval Ordinance Laboratory). Nickel titanium coil springs are made of nickel titanium alloy which is highly resistant to heat deformation called as A-NiTi (Austenitic). They exhibit features of super elasticity and shape memory. The advantages of using coil springs are that there is less rapid force decay. It produces continuous light forces which are biologically tolerable and produces efficient tooth movement.

The Photo Elastic Method/analysis helps in studying the various complex processes involved in orthodontic tooth movements. The concept of Photo Elasticity was first established by Sir David Brewster, a British physicist and the first person to apply the technique in dental research was B Zak in 1935. Photo means light rays and optical techniques whereas elasticity is the study of stress and deformation in elastic materials. Transparent materials exhibit colorful patterns when polarized light passes through. Photo elasticity is the property of some isotropic solids which become doubly refracting when subjected to stress. The principle is based on the fact that polarized light, passing through a transparent plastic under stress, will split into two polarized beams, which travel in the plane of principal stress.

These beams have different velocities and the resulting phase difference shift is observed by viewing the light through a polarizing filter. These resultant stresses are observed as color fringes within the photo elastic model. Photo-elastic materials have been used for many years for visualization and analysis of strains in medical and dental applications, since many are mechanically similar to the relevant tissues. The use of photo elasticity for tissue analysis has been mainly limited to qualitative analysis since there are many issues that require consideration when developing flexible birefringent surrogate tissue materials for quantitative validation purposes.

In this study, the researcher used epoxy resin, as it has many advantages like being cost efficient, sensitivity to light, good transparency and creep comparable to other materials. Epoxy resins have been commercially available since the early 1950's and are now used in a wide range of industries and applications. Epoxies are classified as thermosetting and thermoplastic resin. The thermosetting resin sets by a chemical reaction. The curing agent used will determine whether the epoxy cures at ambient or elevated temperatures and influence physical properties such as toughness and flexibility.

There are two basic types of epoxy resin, a) Bisphenol A - Diglycidyl Ether b) Epoxy Phenol. Low viscosity, low molecular weight Bisphenol A epoxies are the ones most widely used in the composites industry. They are available as two pack systems which can be cured at room temperature using a suitable curing agent, the various types of which are as follows (a) Amines (b) Polyamides (c) Anhydrides.

According to various studies, the stress fringes caused can be viewed with the help of a more economic polariscope like set up which includes the following: A photo elastic model with embedded teeth, two polarizing filters – one ahead of the model and one attached to the lens of the camera, a camera to photograph the resulting images, a single white light source. With such a setup, the white light passes through the polarizing filter, the model, the second polarizing filter attached to the lens and finally the observer. According to studies conducted by various researchers, usually it is seen that when greater stress is applied the fringes are closer to each other and greater in number.

Figure 1. Photo elastic model of epoxy resin and hardener.

Figure 2. Photo elastic model.

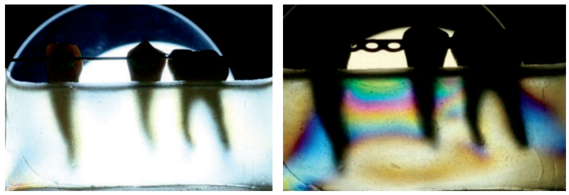
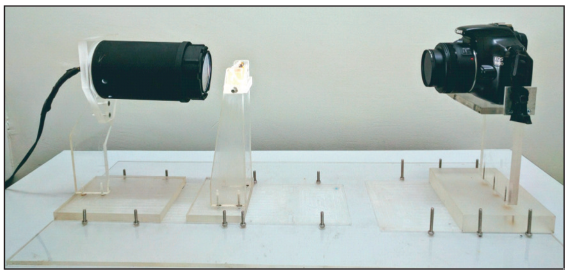


Figure 3. E-Chain Models Camera set-up..



Materials and Methods

In this study, ten sets (thirty brackets) of 018 slot standard edgewise brackets were placed on the lower canine, premolar and buccal tubes with single slot were placed on the molar teeth. The brackets and buccal tubes were placed according to standard heights using light cure composite resin (ORMCO, USA) before placing the teeth in the photo elastic resin. Excess resin around the brackets and buccal tube were removed.

The photo elastic model was prepared using epoxy resin and hardener according to manufacturer's instructions and sound natural teeth free of extensive caries, enamel defects were embedded in the resin except for the first premolar to simulate premolar extraction space.

An acrylic block of dimensions forty-five millimeters by twenty millimeters by twenty-five millimeter was used for creating the mould space for the epoxy resin. Condensation silicone material was used to make impressions of the acrylic block which would create the future mould space for the resin. Separating medium was applied on the acrylic block so that it can be removed from the silicone mould easily. Five such impressions were made for the elastomeric chain models and five for the coil spring models.

An 018/025 stainless steel wire was placed in the bracket slots to stabilize the canine, premolar and molar segment and figure of eight ties were placed using a 0.010 ligature wire on the premolar and molar tooth. An inter bracket distance (canine and second premolar) of roughly fifteen mm of space was maintained in all the models to simulate first premolar extraction space and was measured using an orthodontic caliper.

Epoxy resin and hardener were taken in two separate plastic graduated containers. The hardener was poured in the plastic container containing the epoxy resin and mixed using a Popsicle stick according to manufacturer's instruction for about five to ten minutes. Air bubbles were avoided during mixing. The resin was allowed to rest for few minutes to remove any remaining air bubbles.

The teeth segments were placed in the moulds made from the condensation silicone. The resin was filled up to two mm below the cervical region of the teeth. Five such models were prepared for the elastomeric chain and five for coil spring models. The resin with the embedded teeth was then allowed to cure completely at room temperature for twenty-four hours.

The set up consisted of the light source with the polarizing filter fifty-eight millimeters (HOYA brand), the prepared photo elastic model, a Canon EOS 1100 D camera with fifty millimeter macro lens fitted with a forty nine millimeter polarizing filter respectively.

A 016 Stainless Steel wire was placed in the bracket slot to simulate canine retraction. Figure 2 ligature tie using 0.010 wire was placed on the molar and premolar to serve as a single anchor unit Five pieces of twelve millimeters closed coil springs (ORTHO ORGANIZER, USA) and five pieces of colored, continuous short elastomeric chain (ORMCO, USA) were used in this study. A dynamometer was used to measure the force and it was set to approximately 112 grams of force.

Results

The results were tabulated and it was seen that on the elastomeric chain models stress was seen on all the regions of the canine tooth surface namely the cervical or 1/3rd middle or 2/3rd and apical or 3/3rd of the mesial and distal surfaces (Table 1).

With respect to the coil spring models, stress was seen to be concentrated on the cervical and apical thirds of the mesial surface whereas on the distal surface, it was seen on all the surfaces of the canine tooth.

With regards to the molar tooth, stress seemed to be concentrated on the cervical and apical third of the molar on the coil spring models. Stress was seen on all the surfaces of the molar tooth with regards to elastomeric chain models (Table 2).

Discussion

In the current study, the elastomeric chain samples had greater stress zones observed on the cervical 3rd of the distal surface of the root and on the apical 3rd of the mesial surface of the root. The stress birefringence zones on the mesial surface of the canine were due to the tension and compressive forces on the distal area.

Table 1. Stress birefringence for E- Chain Models.

Canine	Mesial surface			Distal surface		
Stress birefringence %	1/3rd	2/3rd	3/3rd	1/3rd	2/3^{d}	3/3^{d}
	100	100	100	100	100	100

Table 2. Stress birefringence for Coil Spring Models.

anine	Mesial surface			Distal surface		
Stress birefringence %	1/3^{d}	2/3^{d}	3/3^{d}	1/3rd	2/3^{d}	3/3rd
	100	0	100	100	100	100

With regards to the molar, stress birefringence zones were seen on the mesial cervical and the distal apical regions of the molar tooth determined by blue-green and violet blue stress zones. The stress on the mesial surface of molar was due to the compressive forces from the E-Chain. This produced a distal tipping of the crown of the canine and mesial tipping of the crown of molar tooth which concur to the theories of biomechanics of tooth movement.

With regards to the coil spring models, it was seen that there were greater stress zones in the mesial apical and distal cervical regions of the canine determined by the blue-green stress birefringence zones. The result of this study was consistent with the biomechanics of tooth movement as described by Proffit's Contemporary Orthodontics.

There was stress seen in the apical portion of the roots of the molar determined by blue-violet and blue-yellow zones of stress. This can be interpreted as an uncontrolled tipping of the molar. In the present study, stress birefringence zones were noted upon initial force loading for both elastomeric chain and closed NiTi coil spring.

While the closed Niti coil spring produced stress birefringence zones on the apical portion of the mesial and distal roots and bifurcation areas of the molars. The results of the study validated and are consistent with previous studies. Both materials were able to produce the expected stress zones at specific areas upon initial loading of 112g of force. Therefore, both materials were adept for canine retraction and advocate the use of either of the two materials**.** This study does not take into account the oral conditions such as saliva, temperature and ph of the oral cavity as well as the force decay of the materials used.

It is difficult to view the tooth movement inside the oral cavity while applying orthodontic forces, hence this study could be possibly used as a reference for simulation of stress regions on the tooth surface as the resin simulates the bone in which the tooth is embedded. This study is an economic alternative to the Finite Element Study.

Conclusion

Based on the findings of the study, the following conclusions were drawn;

- The closed Niti coil spring produced stress zones on the bifurcation areas of the molars compared to the elastomeric chain samples,
- There was no significant difference in stress birefringence caused by elastomeric chain and closed Niti coil springs for canine retraction,
- Upon immediate loading, the current study showed signs of distal tipping of the canines and mesial tipping of the molars.

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