

To Evaluate the Plastic Deformation of the Bracket Slot in Metal Brackets Due to Applied Twisting Forces – An In Vitro Study

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Original Research Article

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Article History

Received: 05.07.2018

Accepted: 15.07.2018

Published: 30.07.2018

DOI:

10.21276/sjds.2018.5.7.3



Abstract: Orthodontic tooth movements involve controlling crown and root positions in all three planes of space i.e. vertical, transverse and saggital planes. This can be achieved by various types of tooth movements like tipping, translation, rotation and torque. Torque can be expressed in Begg's, Refined Begg's, Tip edge technique which uses round wire with the help various torquing auxiliaries. In edgewise technique the control of torque is achieved by interaction of rectangular arch wire in a rectangular bracket slot. The purpose of this study is to investigate the effect of the third order torque on three different types of metal brackets having MBT prescription and manufactured by different companies. The study is done by analyzing the bracket's plastic deformation in conjunction with the expressed torque at varying angles of twist.

Keywords: Torque and Torque angle.

INTRODUCTION

'Torque' has 2 different but related meanings for an orthodontist. It refers to buccopalatal root inclination, which can be measured on the lateral cephalogram as the incisor inclination in relation to anterior cranial base or the maxillary plane and the other refers to the activation generated by torsion of the arch wire in the bracket slot[2,3].

Torque can be expressed in Begg's, Refined Begg's, Tip edge technique which uses round wire with the help various torquing auxiliaries. In edgewise technique the control of torque is achieved by interaction of rectangular arch wire in a rectangular bracket slot[7,8].

A recent numeric analysis by Huang et al evaluated torque expression with various wire bracket combinations but did not report bracket or wire strain in response to the loading stress[6,8].

The purpose of this study is to investigate the effect of the third order torque on different types of metal brackets having MBT prescription and manufactured by different companies.

AIMS AND OBJECTIVES

To determine the angle of twist (torque angle) and the twisting force at which the plastic deformation of stainless steel 0.022 inch slot MBT brackets occurs in the following companies:

- 3M Unitek
- Leone

MATERIALS AND METHODS

Materials used in the study were

- Customized torque measuring machine.
- Optical microscope[1,7] (Fig 7)
- Video imaging software [7] – M Power Image Analyser System 3.010 (Metal Power {INDIA} Private Limited; Mumbai).
- 30 Maxillary central incisor stainless steel brackets of MBT 0.022inch prescription, each of the following companies:
 - 3M Unitek
 - Leone
- 0.019 inch x 0.022inch stainless steel rectangular wires of Rabbit Force company.
- Stop watch.

A customized torque measuring machine was designed and fabricated for this study purpose. The specifications of the torque measuring machine were:

- Application of the force up to 20 kg.
- Least count 0.01kg.
- Protractor: Least count 1degree.
- Adjustable jig for holding brackets.
- Shaft for holding rectangular wire of 0.019 x 0.025 inch.

The parts of the torque measuring machine are:

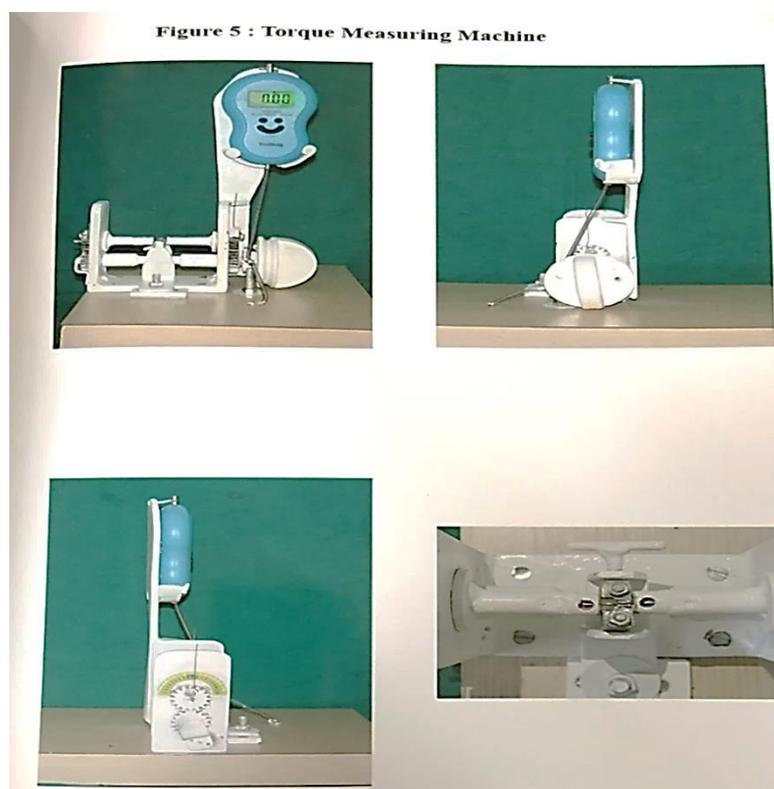
- Gear train (consists of 4 gears).
- Bracket holding jig.
- Bearings.
- Load cell.
- Adjustable stopper.
- Protractor.
- Pointer.

PRINCIPLE OF WORKING: (Fig.5)

The torque measuring machine has 4 gears mounted with a shaft and bearings on the body in such a way that it forms a gear train to which a lever is attached on right side. For ensuring the accuracy of the torque application i.e. to reduce the losses, equitable types of gears were selected. Hence there was no lash back resulting in no play. Thus the torque application on the lever and the bracket remained constant. A

hollow shaft was selected for the assembly of the gears. Size of the hole was made in a way to ensure smooth and straight entry of a 0.019 inch x 0.025 inch rectangular wire with no play. The distance between 3 brackets was measured in 15 patients. The average length between the 2 brackets on either side was calculated. The mean of all measurements was 7.5 mm on both sides. Hence the distance between the two shafts was taken as 15 mm[4]. The machine has an alignment assembly that guarantees perfect alignment between the arch wire and the bracket slot[6].

The load cell was attached to the lever with the help of a spring because of limited travel of the stem of the load cell. Care was taken to match the zero value on the load cell with the zero degree pointer of the protractor. Another spring was attached to the lever and the base to maintain a reverting mechanism and ensure return of the pointer of the protractor to its original position of zero degree. The protractor was attached to left side of the body. The centre of the protractor and the centre of the wire rotating shaft were matched. This assembly helps us to measure the degree of torque placed and the force generated while torquing the wire. An adjustable jig for holding the bracket was mounted to ensure the placement of the wire in the bracket slot was at zero degree.



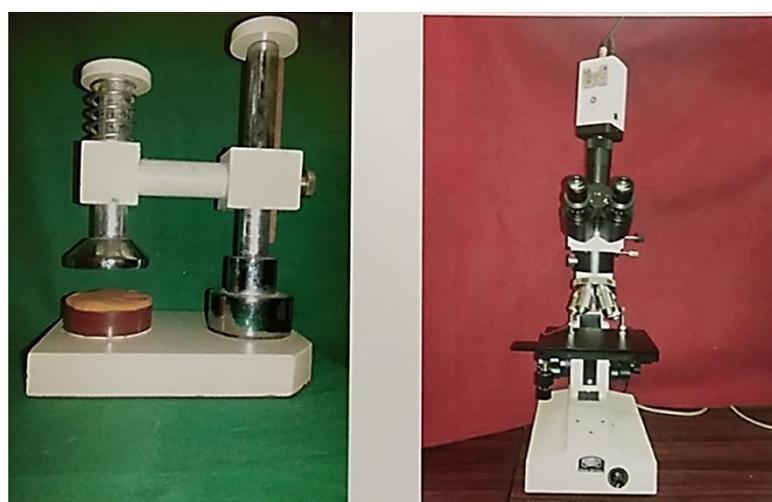
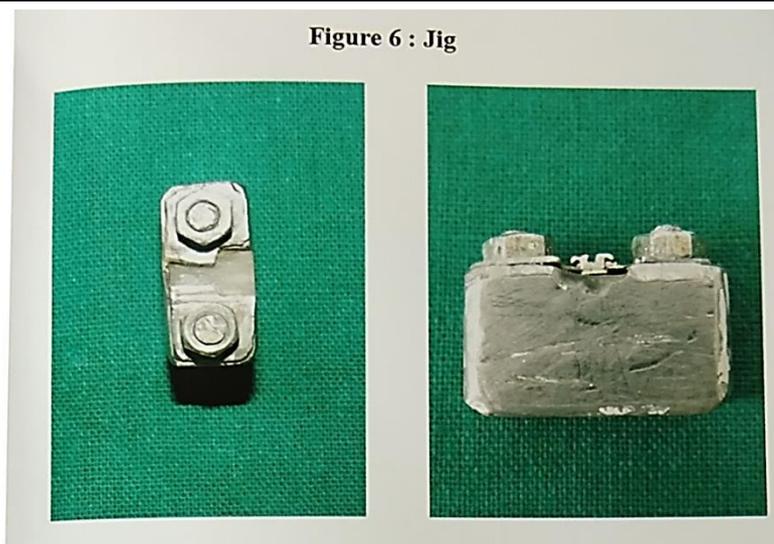


Fig-7: Optical Microscope

Selection criteria

- 3M Unitek Company was selected because the MBT system was developed in collaboration with this company. Thus we consider 3M Unitek as standard bracket company to compare. It is available in comparatively high cost range.
- Leone was selected as it was available in comparatively medium cost range.

Inclusion criteria

All the brackets were observed under the optical microscope. The brackets in which the slot walls were not parallel were excluded.

The selected brackets were numbered from 1 to 30 and tested. (Fig.3) A new section of the wire was used for each test[4]. Each bracket was measured under the optical microscope before application of the torque.(Fig.8) The bracket was mounted on a putty block and pressed to match the plane of the putty block. The microscope was adjusted accordingly at 50x magnification to view the slot. The dimensions were measured with the help of Video imaging software[7].

M Power Image Analyser System. These profile images are then processed to give measurements. Two parameters were measured i.e. the distance between the slot on right side and left side of the bracket[1]. They were denoted as Right Hand Side (RHS) and Left Hand Side (LHS)[1].

The bracket was placed in the jig and the section of the wire was inserted in to the slot at zero degree (Fig.6). With the help of the lever, torque was applied at 10 degrees for 5 minutes in the torque measuring machine.. The force on load cell was noted. After 5 minutes the torque was released and the wire came to its original position of zero degree[4]. The bracket was measured again on the optical microscope with the video imaging software. The RHS and LHS of the bracket were noted.

Same procedure was carried out for 20⁰, 30⁰, 40⁰, 50⁰ and 60⁰[1]. The dimensions at each interval of torque were noted. The same protocol was followed for brackets and the data was collected (Fig.9.10.11).

STATISTICAL ANALYSIS

The statistical analysis was performed by using unpaired ‘t’ test, paired ‘t’ test and ANOVA test. The mean and standard deviation were calculated for each company and at each torque interval.

The unpaired ‘t’ test was performed for comparing the deformation at the RHS and LHS. A paired ‘t’ test is applied for comparing the same sample before the intervention and after the intervention.

ANOVA was applied to evaluate the deformation of the brackets among the companies.

Statistical significance was set at p-value less than 0.05. (p<0.05)

RESULTS

The collected data was statistically analysed. The mean and standard deviation of RHS and LHS data table was calculated for all the three bracket companies (Table 1,2,3).

Table-1: Mean dimensions of the slot at each degree of torque interval in inches with Standard Deviation (SD) for 3M Unitek brackets.

Degree	RHS		LHS	
	Mean	SD	Mean	SD
0	0.6141	0.0081	0.6164	0.0086
10	0.6173	0.0077	0.6191	0.0088
20	0.6202	0.0081	0.6211	0.0084
30	0.6225	0.0077	0.6239	0.0093
40	0.6241	0.0076	0.6274	0.0095
50	0.6284	0.0080	0.6262	0.0186
60	0.6334	0.014	0.6330	0.0100

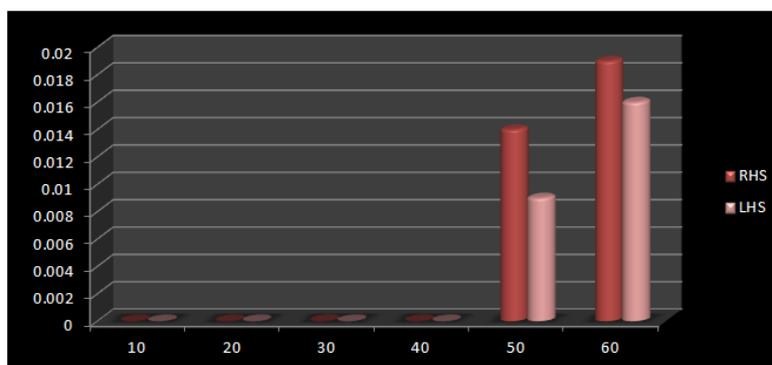
Table-2: Mean dimensions of the slot at each degree of torque interval in inches with Standard Deviation (SD) for Leone brackets

Degree	RHS		LHS	
	Mean	SD	Mean	SD
0	0.6495	0.0066	0.6559	0.0053
10	0.6504	0.0075	0.6577	0.0054
20	0.6522	0.0071	0.6604	0.0058
30	0.6552	0.0072	0.6616	0.0047
40	0.6582	0.0068	0.6653	0.0059
50	0.6625	0.0084	0.6667	0.0071
60	0.6679	0.0066	0.6717	0.0074

There was no statistically significant difference found in deformation at the RHS and LHS of the bracket of the same company. Thus the deformation was same on both sides of the bracket slot after giving torque.

To analyse the deformation occurring in single company a paired ‘t’ test was applied. The results were:

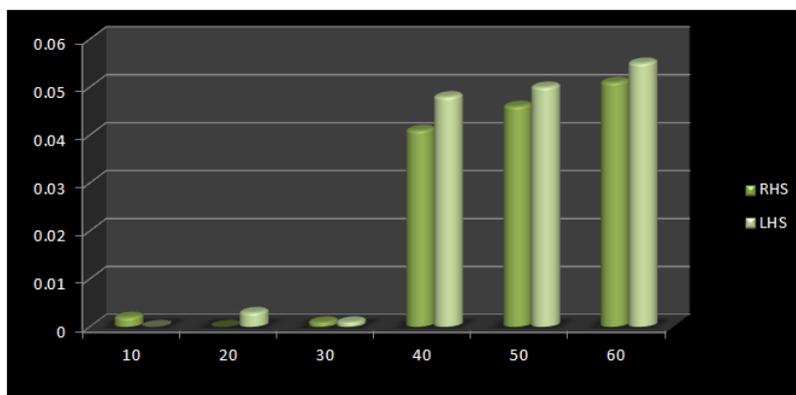
- The difference between the change in dimension of the slot (plastic deformation) of 3M Unitek brackets was statistically significant at 50⁰ torque interval and 43mg force with a p value at RHS 7.15E-21 and LHS 0.0058.



Graph-1: To compare the deformation at each degree of torque interval by paired ‘t’ test (3M Unitek brackets)

- The difference between the change in dimension of the slot (plastic deformation) of Leone brackets was statistically significant at 40° torque interval

and 30mg force with a p value at RHS 4.44606E-25 and LHS 8.40222E-33.



Graph-2: To compare the deformation at each degree of torque interval by paired ‘t’ test (Leone brackets)

From the previous results there was no difference in the deformation observed at the RHS and

LHS. Hence the ANOVA test was applied on the deformation observed on the RHS. The results were:

Comparison between 3M Unitek and Leone for the amount of deformation at each degree of torque interval by ANOVA

Degree	P value
10	1.16E-20
20	2.13E-29
30	2.59E-29
40	1.42E-06
50	5.88E-17
60	5.68E-19

DISCUSSION

Torque is the force that enables the orthodontist to control the axial inclinations of the teeth and to place them in harmonized position which is desirable for a completely finished case with stable results[9].

To evaluate the plastic deformation same protocol was followed at different degrees of angle of twist. The brackets were evaluated at 10°, 20°, 30°, 40°, 50° and 60° of angle of twist to determine the plastic deformation[1].

3M Unitek

3M Unitek brackets plastically deform at 50°. This suggests 3M Unitek brackets have the ability to resist deformation after applying torque at 50°. It also suggests that the modulus of elasticity of these brackets were significantly high. Thus at initial degree of torque the bracket regained its original dimensions. This corresponds to accurate torque expression. As change in slot dimensions increases the play, it inversely affects the torque expression.²⁷ In clinical situations, where torque requirement is higher, eg : Angle’s class II division 2 malocclusion where the central incisors require high torque values to correct its ladiopalatal position, 3M Unitek brackets serves the purpose as it

withstands the plastic deformation at higher angle of twist (torque).

Leone

Leone brackets plastically deform at 40° of angle of twist. It suggests that the ability to withstand the permanent deformation of the bracket was significant but less than the 3M Unitek brackets. In clinical situation, where the torque requirement was less or average, Leone brackets can be used. However in situations with high torque requirement Leone brackets will not be able to express desired torque as it will deform permanently, thus affecting the torque expressions.

At 10°, 20° and 30° of torque (angle of twist)

There was statistically no significant difference observed in amount of deformation among the Leone brackets and 3M Unitek brackets.

At 40°, 50° and 60° of torque (angle of twist)

There was statistically significant difference observed in amount of deformation. Deformation observed was least for 3M Unitek brackets. Deformation of Leone brackets was more above 40°. This can be justified as Leone brackets plastically deformed at 40°. Therefore, the force exerted on the slot

was reduced as compared to the Leone brackets which didn't have any play. Thus the deformation was less as compared to Leone which started to deform plastically at 40⁰.

In the present study plastic deformation of the bracket slot of 3M Unitek brackets started at 50⁰ of torque, Leone started at 40⁰.

The plastic deformation of slot was least in 3M Unitek brackets, than Leone brackets.

Clinical implications

Torque is an integral part of the orthodontic treatment mechanics in the following clinical situations:

- In Angle's class II division 2 malocclusion, to correct the labiopalatal positions of the central incisors.
- To correct labially placed lateral incisor or a canine, single root torque is required.
- In enmasse retraction cases during retraction, torque is required to control of the axial inclinations of the incisors.
- In class C anchorage cases, torque requirement is higher to maintain the anchorage unit in the anterior segment.
- Torque requirement is higher in horizontally growing patients.

CONCLUSION

From this study it can be concluded that the available standard brackets (3M Unitek) which are in comparatively higher range of cost withstand the deformation at clinically relevant torque levels. Similarly, the comparatively medium range of cost brackets (Leone) also withstands clinically relevant torquing levels but less than 3M Unitek brackets.

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