



ORIGINAL ARTICLE

Estimation and comparative evaluation of tip and torque values of Saudis for bracket prescription



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Abstract Objectives: The present study aimed at determining the tip and torque values of the teeth of Saudi adults with normal occlusion to develop orthodontic bracket prescription. In addition, we proposed to compare the results with published data of varied geographical distribution.

Materials and Methods: The study sample consisted of 60 upper and lower study models of Saudi adults (30 males and 30 females) with normal occlusion and a balanced facial profile. Evaluated by experts, the torque and tip of teeth were measured using a torque angulation device. The collected data was analyzed using SPSS (IBM SPSS Inc., version 20, Chicago, IL, USA). The mean, and standard deviation were obtained for each measurement. Paired *t*-test, Independent *t*-test and student *t*-test were used for the comparison at a significant level of ($p \leq 0.05$).

Result: The results of torque and tip of teeth for the Saudi adult population showed no significant differences between the right and the left quadrants of the analyzed study sample. In general, there was no significant observed difference between male and female samples, accordingly, the Saudi tip and torque data were combined. However, the comparisons of the combined Saudi data to the published data showed significant differences ($p \leq 0.05$).

Conclusion: Statistically Significant differences were found between the combined Saudi data when compared to North American, Italian, African, Japanese, and Indian data. We inferred, that racial differences should be considered when presenting bracket prescriptions.

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1. Introduction

Harmonious dental and facial aesthetics along with long-term occlusal stability and functional occlusion have been the main objectives of orthodontic management (Soboku et al., 2019). Judicious treatment planning with ardent bracket prescription according to the patient needs results in efficient treatment procedures and high precision in treatment outcomes. Further, the appropriate bracket prescriptions can reduce the time

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involved in finishing tip and torque adjustments (McLaughlin and Bennett, 2015). Ever since the introduction of straight wire appliances in 1972 by Andrews, evolutions of variations in tip and torque prescriptions continued (Andrews, 1972). Brackets were manufactured with build-in pre-adjusted values to guide teeth movement into the desired position. Tip and torque expressions have been understood to be influenced by several factors like amount of play between the archwire and the slot (Archambault et al., 2010), differences in bracket tolerance (Major et al., 2010), method of ligation (Al-Thomali et al., 2017) and labial surface morphology of the bonded teeth (Mestriner et al., 2006).

Andrews in 1972 pioneered the measurement of the tip and torque values for the North American whites and called them the bracket prescriptions (Andrews, 1972). He developed the straight wire patented and manufactured them, with an aim to produce the optimum esthetic results (Andrews, 1979). In spite of the extensive usage in North America, the treatment results were not encouraging (Currim and Wadkar, 2004; Roth, 1987; Watanabe and Koga, 2001). In addition, researchers found that Andrew's brackets were not suitable for worldwide applications (Haskell and Segal, 2014; Rinchuse et al., 2007). Further, researchers also hypothesized that the bracket prescription should be customized for an individual population (Doodamani et al., 2011; Penning et al., 2017). Accordingly, several bracket prescriptions were developed including Japanese (Watanabe and Koga, 2001), Indian (Currim and Wadkar, 2004; Doodamani et al., 2011), Italian (Lombardo et al., 2015), and African (Lombardo et al., 2015). However, to date, there are no reported bracket prescriptions for the Saudi population.

A new orthodontic bracket was invented and patented by the authors (Bukhary et al., 2018), for utilization in the present study. The literature describes the bracket prescription as the values guiding the orientation of the wire slot inside the body of each bracket (Andrews, 1989; Mestriner et al., 2006; Watanabe and Koga, 2001). This includes a comprehensive measurement of the tip which is the mesiodistal angulation, the torque - the labiolingual protrusion, and the prominence is the in-out alignment of brackets. Notably, tip and torque are angles whereas the prominence is a distance requiring different methods and instruments for measurement. In 1972, Andrews manually measured the tip and torque angulations using a protractor. The tip being the angle formed between the long axis of the clinical crown (LACC) and a line perpendicular to the occlusal plane whereas for the torque, it was the angle between a line that is parallel and tangent to the LACC at its midpoint (LA) and the line perpendicular to the occlusal plane (Andrews, 1972).

In the current study, we aimed at measuring and standardizing the tip and torque values of the orthodontic bracket prescription for the Saudi adult population with normal occlusion. We also would like to compare the research outcome with published data with different ethnic groups to evaluate a possible racial difference. The data of this study will be compared to the North American whites data of Andrews (Andrews, 1989), Italian and African data of Lombardo et al. (2015), Japanese data of Watanabe and Koga (Watanabe and Koga, 2001) and the Indian data of Doodamani et al. (2011).

2. Materials and methods

2.1. The sample selection

The study sample consisted of 60 sets of dental models of Saudi adults with normal occlusion. The samples were selected after thorough observation of 1130 participants screened over a period of 26 months at the college of dentistry, King Saud University, and private clinics in Riyadh city. The ethics and consent forms for this study were approved by the Institutional Review Board (IRB) of King Saud University Medical City, (E-18-3072). Sample selection was based on the inclusion criteria:

1. Saudi Adults with normal occlusion and harmonious facial profile.
2. Presence of fully erupted permanent teeth excluding third molars.
3. Class I molar and canine relationship, with normal overjet and overbite (2 ± 1 mm).
4. No or minimal degree of crowding or spacing with no rotation of the teeth (Little's index < 3).
5. No previous orthodontic or extensive restorative treatment.
6. Stable articulation without sliding.

Individuals with unpleasant profile, malocclusion, missing, malformed, broken, chipped or carious teeth, and unstable articulation was excluded from the study. The final sample consisted of 60 sets of dental models, obtained from 30 female and 30 male study participants.

2.2. The methodology

From each of the selected participants, upper and lower impression for a dental model, panoramic radiograph, cephalometric radiographs, extraoral and intraoral photographs were obtained. Standardized trimmed orthodontic dental models were prepared using white hard orthodontic stone.

2.2.1. Measuring device

TAD, The torque angulation device (IN-tendo, Chaing Mai, Thailand) was utilized as an electronic protractor (Sheffield, 2011) and consists of a flat metal base with a mirror finish working area, a vertical shaft, measuring compartment, and a model holder (Fig. 1a). The model holder has a flat metal base to slide over the flat working area and an adjustable table with three arms to hold the dental model and control the horizontal level of the occlusal plane. The measuring compartment has a measuring blade with a mark at the middle of the tip of the blade. The movement of the measuring blade is controlled by two knobs, the first knob for vertical motion and the second for rotation from right to left. The measuring compartment is supported with an electric power supply, LCD monitor to display the measurements, and USB cable for direct recording of data measured into the computer. The measuring compartment is moved up and down on the vertical shaft to control the height and can be locked in position by the screw.

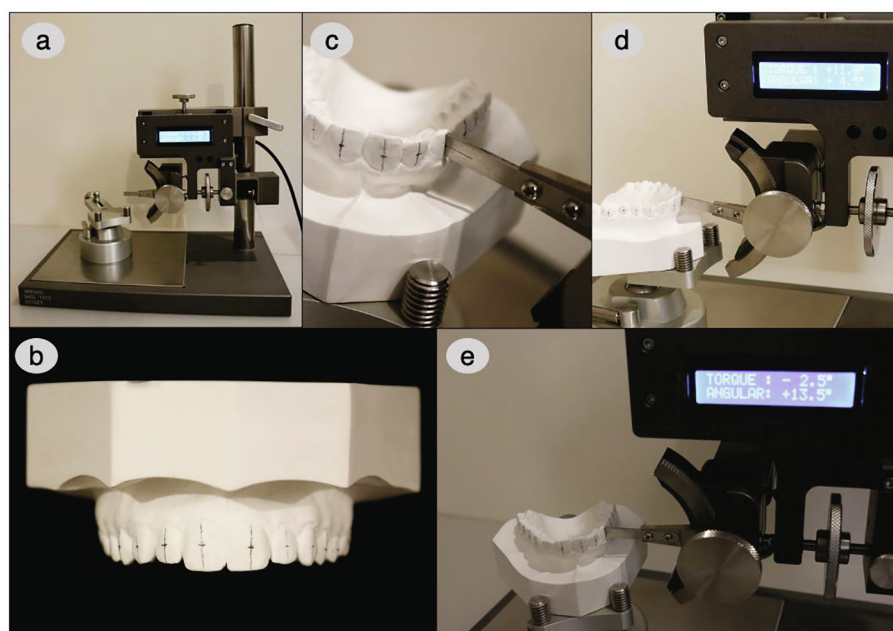


Fig. 1 a. TAD. b. Dental models with the marked LACC and LA point – frontal view. c. The measuring blade on the LA point. d. The tip and torque of the upper right central. e. The tip and torque of upper right canine.

2.2.2. Method of measurements

A panel of three experienced orthodontists evaluated the study models and excluded any subject that does not pass the inclusion criteria. All measurement was made by the same investigator (F.B) to minimize errors. Intra-observer reliability was ascertained by a pilot sample of 20 randomly selected dental models, with highly reliable correlation values (77–99%). On the dry upper and lower standardized orthodontic dental models the long axis of the clinical crown (LACC), and the midpoint of the clinical crown (LA) were drawn for each tooth (Andrews, 1972). The LACC was drawn by hard pencil on the labial surface of the clinical crown for the incisors, canines, and premolars teeth whereas for the molars teeth the buccal groove was marked. The LA point was marked on the middle of the LACC of each tooth by bisecting the height of the clinical crown (Fig. 1b).

Subsequently, the base of the model with pencil marking was seated and locked on the top surface of the adjustable table. It was positioned with the occlusal surfaces of teeth facing upwards and the occlusal plane parallel to the working surface of the metal base. Then, the model holder was moved towards the measuring compartment. The measuring compartment was then adjusted for height. As the technic of measurement demands, the tip of the measuring blade was brought into contact with the convex buccal surface of the teeth. The mark on the tip of the measuring blade was made to coincide with the LA midpoint of the clinical crown (Fig. 1c).

To display the measurements in the LCD monitor, we ensured a tight contact between the tip of the measuring blade and the buccal tooth surface. The measuring blade was moved to the right or to the left to fit the blade on the marked LACC line. This step measured the tip of the tooth. Then the measuring blade was moved up or moved down to fit the slope of the inclination of the tooth surface at the convex buccal surface of

the tooth. This step measured the torque of the tooth. Thus, the screen displayed two measurements (Fig. 1 d and e).

The positive torque values indicated the buccal crown torque whereas the negative values are for the lingual crown torque. On the other hand, the positive tip values indicated the mesial crown tip, and the negative values is for the distal crown tip. The measurements of the crown torque and tip displayed on the screen were recorded immediately on the computer as part of data collections. This step was performed on the central incisor followed by the lateral incisor and the canine, then the premolars and molars. These measurements of the dental models were organized to be measured in quadrants. First, the upper right quadrant measurements were done followed by the upper left quadrant and then the lower left and finally ended with the lower right quadrant respectively.

2.3. Statistical analysis of the data

Statistical analysis was performed with SPSS software (IBM SPSS Inc., version 20, Chicago, IL, USA). For this study the level of significance was set at $P < 0.05$, $\alpha = 0.05$ with estimated standard deviation of $SD = 0.82$, maximum difference of 0.5 and $\beta = 0.10$ (power 90%). The statistically calculated sample size was 60 subjects for this study.

Pearson's correlation coefficient (r) and dependent paired t -test were used for analyzing the intra-examiner reliability. It was determined by measuring twenty randomly selected models with a two-week interval, of about 560 variables of tip and torque values. All measurements were made by the same operator (F.B).

The mean and standard deviation for the 60 sets of dental models were obtained. Kolmogorov-Smirnov test was used to check the normality of the measurements. At a significance level of $P < 0.05$, a paired t -test evaluated the differences

between the right side and left side, while an independent *t*-test evaluated the male and female variations. The student *t*-test compared the tip and torques values between this study and the previously published data.

3. Results

Table 1 shows the mean, standard deviation, p-value, and correlation coefficient (*r*) for tip and torque values of repeated measurements for 20 sets of models determined within an interval of 2 weeks. Measurements were presented in quadrants starting from the central incisor to the second molar, wherein UR1 represents the upper right central incisor. The comparisons between the first and second measurements for the tip and torque showed no statistically significant difference ($P \leq 0.05$). The correlation coefficient between the two readings for the torque and tip values were very high.

Table 2 shows the mean, SD, and P-values of the paired *t*-test for the comparison of the tip and torque values between the right and left data for the maxillary and mandibular teeth. The results showed no statistical differences ($P \leq 0.05$) between the right and left sides for all teeth.

Table 3 shows the mean, SD, and P-values of the paired *t*-test comparing the tip and torque values between the male and female at $P \leq 0.05$. The results showed no significant difference in the tip values for the male compared to the female, except

for (U3), (L3), and (L4). However, the torque values showed a significant difference between the male and female participants, for (U1), (U2), and (L3).

Table 4 shows the combined Saudi data. The tip and torque values for the right and left sides, and for the male and female were combined to be presented as Saudi data. The total teeth evaluated for the combined Saudi data were 120.

Table 5 shows the mean, SD, and the p-values for the comparison between Saudi data and North American whites, Italian, African, Japanese, and Indian published data. Comparing the tip values between Saudi data and published data showed significant differences. The comparison with the North American indicates a greater value for Andrews data in the tip of the posterior teeth, however, the torque of the upper incisors indicates more proclined teeth in our study, and the lower posterior teeth were more lingually inclined in the North American. The Italian and African values of the tip for the lower molars were the highest among all groups. Also, for the torque of the upper central incisors, the Italian 7.41° shows straighter teeth compared to the Saudi data 13.43° whereas the Japanese were 12.82° and the Indian shows the most proclined teeth 16.68°. However, non-significant differences in the tip values were shown for (L4) and (L5) between Saudi and North American, for (L1) between Saudi and Japanese, and for (L1) and (L2) between Saudi and Indians. Also, for the torque values the non-significance differences were between (U3) and

Table 1 Repeated measurements of 20 sets of dental models.

No	Tooth	N	Tip Values				p-value	<i>r</i>	Torque Values				p-value	<i>r</i>
			First		Second				First		Second			
			M	SD	M	SD			M	SD	M	SD		
1	UR1	20	4.87	0.50	4.92	0.53	0.220	0.942	14.79	2.40	14.87	2.32	0.196	0.993
2	UR2	20	8.25	0.46	8.26	0.43	0.843	0.878	8.87	0.89	8.91	0.91	0.372	0.977
3	UR3	20	12.41	1.22	12.46	1.29	0.403	0.984	-2.91	0.61	-2.99	0.64	0.126	0.938
4	UR4	20	0.07	0.27	0.06	0.28	0.733	0.895	-7.14	0.35	-7.21	0.34	0.263	0.994
5	UR5	20	0.03	0.31	0.05	0.29	0.204	0.962	-7.21	0.29	-7.23	0.28	0.498	0.842
6	UR6	20	-0.06	0.69	-0.06	0.67	0.834	0.989	-11.83	0.91	-11.85	1.029	0.746	0.968
7	UR7	20	-0.06	1.37	-0.06	1.35	0.881	0.994	-11.73	0.95	-11.70	0.89	0.509	0.971
8	UL1	20	4.93	0.46	4.96	0.47	0.320	0.947	14.85	2.36	14.86	2.33	0.707	0.997
9	UL2	20	8.32	0.41	8.31	0.37	0.776	0.924	8.92	0.87	8.95	0.85	0.522	0.972
10	UL3	20	12.49	1.22	12.48	1.29	0.881	0.994	-2.98	0.59	-3.04	0.68	0.172	0.973
11	UL4	20	0.05	0.38	0.10	0.37	0.131	0.944	-7.17	0.33	-7.23	0.35	0.126	0.904
12	UL5	20	0.05	0.37	0.04	0.34	0.755	0.927	-7.25	0.28	-7.26	0.33	0.776	0.888
13	UL6	20	-0.08	0.76	-0.10	0.72	0.494	0.987	-11.87	0.88	-11.91	0.96	0.372	0.981
14	UL7	20	-0.03	1.37	-0.05	1.33	0.330	0.997	-11.82	0.87	-11.80	0.91	0.470	0.987
15	LR1	20	1.38	0.54	1.40	0.50	0.541	0.964	-1.34	0.73	-1.35	0.75	0.873	0.938
16	LR2	20	1.42	0.54	1.46	0.58	0.134	0.983	-1.75	0.63	-1.68	0.61	0.171	0.988
17	LR3	20	6.70	1.02	6.76	1.12	0.163	0.990	-10.98	1.33	-10.99	1.45	0.864	0.990
18	LR4	20	1.35	0.67	1.38	0.61	0.400	0.974	-16.45	1.92	-16.42	1.96	0.629	0.998
19	LR5	20	1.44	0.72	1.39	0.74	0.283	0.970	-20.87	2.26	-20.81	2.24	0.214	0.992
20	LR6	20	0.07	0.47	0.06	0.50	0.858	0.970	-27.01	3.10	-27.02	2.99	0.872	0.999
21	LR7	20	-0.21	1.19	-0.20	1.25	0.863	0.996	-29.56	2.73	-29.59	2.75	0.398	0.981
22	LL1	20	1.35	0.47	1.34	0.44	0.725	0.865	-1.34	0.70	-1.30	0.73	0.226	0.962
23	LL2	20	1.38	0.49	1.42	0.56	0.259	0.957	-1.86	0.63	-1.81	0.60	0.137	0.992
24	LL3	20	6.70	1.05	6.75	1.07	0.179	0.987	-11.02	1.28	-11.01	1.32	0.793	0.979
25	LL4	20	1.29	0.58	1.32	0.59	0.330	0.964	-16.45	1.90	-16.33	2.00	0.231	0.991
26	LL5	20	1.42	0.67	1.39	0.69	0.439	0.958	14.79	2.40	14.87	2.32	0.196	0.993
27	LL6	20	0.08	0.53	0.07	0.54	0.897	0.950	8.87	0.89	8.91	0.91	0.372	0.977
28	LL7	20	-0.23	1.24	-0.21	1.25	0.519	0.994	-2.91	0.61	-2.99	0.64	0.126	0.938

N: sample size; M: mean value; SD: standard deviation; *r*.: Pearson's correlation coefficient; UR1: tooth abbreviation related to upper right central incisor; First: first measurement.

Table 2 Right and left comparison of the tip and torque.

Tooth	N	Tip Values					Torque Values				
		Right		Left		p-value	Right		Left		p-value
		M	SD	M	SD		M	SD	M	SD	
U 1	60	4.88	0.70	4.88	0.65	0.954	13.52	2.81	13.56	2.82	0.546
U 2	60	8.27	0.71	8.29	0.68	0.240	8.14	1.76	8.20	1.74	0.063
U 3	60	12.02	1.38	11.95	1.40	0.669	-3.63	1.79	-3.65	1.80	0.580
U 4	60	0.10	0.40	0.10	0.45	0.877	-7.18	0.61	-7.13	0.68	0.187
U 5	60	0.10	0.40	0.12	0.43	0.233	-7.12	0.70	-7.06	0.78	0.257
U 6	60	0.03	0.65	0.01	0.69	0.268	-12.22	1.46	-12.18	1.52	0.385
U 7	60	0.03	1.10	-0.00	1.21	0.464	-12.25	1.76	-12.26	1.76	0.736
L 1	60	1.35	0.57	1.33	0.53	0.433	-1.05	0.64	-1.03	0.60	0.184
L 2	60	1.41	0.59	1.37	0.56	0.069	-1.20	0.80	-1.20	0.82	0.879
L 3	60	6.46	1.23	6.46	1.23	0.843	-10.24	1.87	-10.08	2.11	0.361
L 4	60	1.37	0.59	1.33	0.61	0.077	-16.44	1.93	-16.40	2.02	0.738
L 5	60	1.45	0.74	1.44	0.70	0.935	-20.28	1.91	-20.28	1.89	0.905
L 6	60	0.08	0.58	0.07	0.60	0.843	-28.09	3.56	-28.22	3.43	0.261
L 7	60	-0.11	1.32	-0.11	1.33	0.827	-28.59	3.46	-28.57	3.45	0.411

N: sample size; M: mean value; SD: standard deviation; U1: tooth abbreviation related to upper central incisor.

Table 3 Male and female comparison of the tip and torque.

Tooth	N	Tip Values					Torque Values				
		Male		Female		p-value	Male		Female		p-value
		M	SD	M	SD		M	SD	M	SD	
U 1	60	4.93	0.66	4.84	0.70	0.496	12.47	2.54	14.61	2.66	0.000*
U 2	60	8.20	0.66	8.37	0.71	0.170	7.82	1.94	8.52	1.45	0.026*
U 3	60	12.28	1.45	11.69	1.26	0.019*	-4.38	2.15	-2.91	0.85	0.000*
U 4	60	0.13	0.46	0.07	0.38	0.396	-7.09	0.61	-7.21	0.68	0.316
U 5	60	0.13	0.48	0.08	0.34	0.575	-7.00	0.73	-7.18	0.74	0.167
U 6	60	0.11	0.74	-0.06	0.58	0.140	-12.44	1.54	-11.96	1.40	0.078
U 7	60	-0.04	1.15	0.07	1.16	0.583	-12.52	1.93	-11.98	1.53	0.095
L 1	60	1.31	0.53	1.37	0.57	0.567	-1.07	0.61	-1.01	0.63	0.579
L 2	60	1.38	0.47	1.39	0.66	0.913	-1.28	0.80	-1.12	0.81	0.296
L 3	60	6.85	0.79	6.08	1.44	0.000*	-10.71	1.87	-9.62	1.97	0.002*
L 4	60	1.46	0.56	1.24	0.62	0.043*	-16.09	2.04	-16.73	1.85	0.071
L 5	60	1.50	0.67	1.39	0.76	0.378	-20.33	1.85	-20.23	1.95	0.767
L 6	60	0.12	0.62	0.03	0.57	0.428	-27.33	3.69	-28.99	3.08	0.009*
L 7	60	-0.06	1.38	-0.16	1.27	0.691	-27.89	3.45	-29.27	3.31	0.027*

N: sample size; M: mean value; SD: standard deviation; U1: tooth abbreviation related to upper central incisor; * the mean difference is significant at the 0.05 level.

(L2) between Saudi and Italians, for (U5) between Saudi and Japanese, and for (U2) and (U5) between Saudi and Indian.

4. Discussion

Advancement in civilization requires new inventions. Bestowed with the invention of a new orthodontic bracket system we found the essentiality of a bracket prescription. Developing the bracket prescription for the Saudi adult population mandated the determination of tip, torque, and prominence measurements (Bukhary et al., 2018).

In the present study, the torque angulation device (TAD) was used as an electronic protractor for the angular measurements of the tip and torque values directly from the dental models for Saudi adults. This was similar to the study of Jotikasthira et al. who used TAD to measure the torque and tip of

teeth for the Northern Thais (Jotikasthira et al., 2009). TAD was tested and found to be compact and simple to use with an accuracy of ±0.1° for repeated measurements (Sheffield, 2011). TAD was used to measure the tip and torque values for developing a future bracket prescription. However, the prominence values which are needed to complete the bracket prescription requires a different measuring technique using the same study samples in the near future.

Literature reveals that Andrews in the late (1979) used a protractor to manually measure from the dental models, the tip and torque values of North American whites (Andrews, 1979). In par, other researchers also used protractor to measure manually these values for Japanese with an accuracy of ±0.5° (Watanabe and Koga, 2001) and Indians (Currim and Wadkar, 2004; Doodamani et al., 2011). On the other hand, Tong et al. used the CBCT scans for measuring torque

Table 4 The combined right and left, male and female of Saudi data.

Tooth	N	Tip Values					Torque Values				
		M	SD	Min	Max	Range	M	SD	Min	Max	Range
U 1	120	4.89	0.68	2.00	6.50	4.50	13.43	2.65	6.10	17.30	11.20
U 2	120	8.29	0.70	6.00	9.50	3.50	8.13	1.68	3.20	10.70	7.50
U 3	120	11.99	1.39	8.50	14.50	6.00	-3.64	1.79	-8.80	-1.10	7.70
U 4	120	0.10	0.43	-0.50	1.50	2.00	-7.15	0.65	-8.70	-5.20	3.50
U 5	120	0.11	0.42	-0.50	2.00	2.50	-7.09	0.74	-9.30	-5.00	4.30
U 6	120	0.03	0.67	-2.50	2.00	4.50	-12.20	1.48	-14.80	-9.50	5.30
U 7	120	0.02	1.16	-4.00	2.50	6.50	-12.25	1.76	-16.70	-9.50	8.10
L 1	120	1.34	0.55	0.50	2.50	2.00	-1.04	0.62	-2.40	0.50	2.90
L 2	120	1.39	0.57	0.00	2.50	2.50	-1.21	0.81	-3.40	-0.10	3.30
L 3	120	6.46	1.22	2.50	8.50	6.00	-10.20	1.89	-13.80	-6.10	7.70
L 4	120	1.35	0.61	0.50	2.50	2.00	-16.41	1.97	-19.80	-12.20	7.60
L 5	120	1.45	0.61	0.00	2.50	2.50	-20.28	1.90	-23.90	-16.30	7.60
L 6	120	0.08	0.59	-1.50	1.50	3.00	-28.16	3.49	-33.70	-20.20	13.50
L 7	120	-0.11	1.32	-4.50	2.50	7.00	-28.58	3.44	-33.50	-20.60	12.90

N: sample size; M: mean value; SD: standard deviation; Min: minimum; Max: maximum; U1: tooth abbreviation related to upper central incisor.

Table 5 Comparison of the Saudi data with the published data.

	Tip Values											
	Saudi Data		Saudi-vs- N. American		Saudi-vs-Italian		Saudi-vs-African		Saudi-vs-Japanese		Saudi-vs-Indian	
	Mean	SD	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p
U1	4.89	0.68	3.59	S	4.53	S	3.68	S	3.11	S	5.00	S
U2	8.29	0.70	8.04	S	9.99	S	9.23	S	3.99	S	7.00	S
U3	11.99	1.39	8.4	S	9.96	S	8.23	S	7.73	S	7.00	S
U4	0.10	0.43	2.65	S	7.67	S	3.29	S	4.67	S	1.00	S
U5	0.11	0.42	2.82	S	9.64	S	5.96	S	5.20	S	1.00	S
U6	0.03	0.67	5.73	S	10.26	S	9.48	S	4.94	S	5.44	S
U7	0.02	1.16	0.39	S	-3.88	S	-3.06	S	4.09	S	5.00	S
L1	1.34	0.55	0.53	S	0.00	S	-1.13	S	1.98	NS	1.00	NS
L2	1.39	0.57	0.59	S	0.14	S	-0.26	S	2.28	S	1.00	NS
L3	6.46	1.22	2.48	S	5.91	S	3.47	S	5.40	S	3.00	S
L4	1.35	0.61	1.28	NS	6.06	S	2.95	S	3.80	S	2.00	S
L5	1.45	0.72	1.54	NS	6.90	S	3.60	S	3.91	S	2.00	S
L6	0.08	0.59	2.03	S	10.99	S	6.30	S	3.70	S	2.00	S
L7	-0.11	1.32	2.94	S	14.20	S	12.65	S	3.88	S	2.00	S
	Torque Values											
U1	13.43	2.65	6.11	S	7.41	S	11.41	S	12.82	S	16.68	S
U2	8.13	1.68	4.42	S	6.23	S	7.41	S	10.35	S	8.20	NS
U3	-3.64	1.79	-7.25	S	-3.35	NS	-2.03	S	-5.29	S	-7.62	S
U4	-7.15	0.65	-8.47	S	-5.35	S	-4.49	S	-6.00	S	-7.47	S
U5	-7.09	0.74	-8.78	S	-3.54	S	-4.00	S	-7.18	NS	-7.22	NS
U6	-12.20	1.48	-11.35	S	-6.26	S	-10.98	S	-9.75	S	-14.78	S
U7	-12.25	1.76	-8.01	S	-5.50	S	-12.79	S	-9.55	S	-14.67	S
L1	-1.04	0.62	-1.71	S	2.19	S	9.68	S	0.71	S	-6.65	S
L2	-1.21	0.81	-3.24	S	-1.36	NS	5.50	S	0.53	S	-6.48	S
L3	-10.20	1.89	-12.73	S	-9.01	S	-1.95	S	-11.13	S	-6.79	S
L4	-16.41	1.97	-18.95	S	-14.96	S	-9.23	S	-18.38	S	-12.51	S
L5	-20.28	1.90	-23.63	S	-17.43	S	-11.39	S	-21.81	S	-16.77	S
L6	-28.16	3.49	-30.67	S	-29.24	S	-23.50	S	-31.23	S	-20.59	S
L7	-28.58	3.44	-36.03	S	-33.26	S	-32.51	S	-32.90	S	-10.50	S

N: sample size; M: mean value; SD: standard deviation; U1: upper central incisor; P: t-test's p-value; S: The mean difference is significant at the 0.05 level; NS: The mean difference is non-significant at the 0.05 level.

and tip of teeth (Tong et al., 2012). Also, computerized digital models were used by Lombardo et al. (2015) and Ferrario et al. (2001), for the Italian and African study populations. However, the compromised accuracy of manual measurements from dental models, the exposure to radiation in CBCT scan give TAD the advantage to use for tip and torque measurements directly from dental models, with more accurate reading than the protractor.

Houston defined measurement errors as systematic and random (Houston, 1983). In the present study, the intra-examiner reliability and the consistency of the measurements were determined by repeated measurements obtained from 20 randomly selected sets of dental models within two-week intervals. Our error measurements were in agreement with earlier research findings of Jotikasthira et al. (2009), Nouri et al. (2014).

Prescription of the manufactured brackets are commonly presented as combined values without differences between right and left or gender as in Andrews straight wire bracket (SWA) (Andrews, 1979), Roth prescription (Roth, 1987), and MBT values (McLaughlin et al., 1997). In accordance, the present study combined the measurements of tip and torque values without any reported differences. Several earlier researchers reported a lack of any statistically significant difference between the right and left sides of the dental arch (Currim and Wadkar, 2004; Jotikasthira et al., 2009; Lombardo et al., 2015; Mestriner et al., 2006). Interestingly, the comparison between the right and left sides for the Saudi adult population showed no statistical differences in measurements of the tip and torque values.

In the current study, the tip values were higher in Saudi males when compared to females. The comparison of the torque between the male and female generally showed no statistical differences, except for the smaller torque values of maxillary central (U1), lateral incisors (U2), and mandibular first molar (L4) in male compared to female. In addition, higher torque values were also recorded for maxillary (U3) and mandibular canines (L3). However, this was in agreement with Ferrario et al. (2001), who found sexual dimorphism in dental tip and torque. Moreover, the difference between the male and female was also reported in the clinical crown height with a shorter clinical crown in the female than the male (Ferrario et al., 1999; Harris, 1997). The age of the male and female sample of the present study was not included, and it

was reported that teeth inclination change with age (Ferrario et al., 2001; Harris, 1997). Therefore, it is difficult to interpret the findings.

To facilitate the comparison with previously published literature, the measured data for the Saudi adults were combined and presented for upper and lower teeth. The combined data equates to a total of 120 teeth which is in proximity to Andrews study data (Andrews, 1979). Combining the data was in agreement with earlier studies who combined the right and left sides, the male and female data to be presented as upper and lower quadrant (Currim and Wadkar, 2004; Doodamani et al., 2011; Lombardo et al., 2015; Watanabe and Koga, 2001).

Comparison of the present study data to North American whites showed significant differences in all the measurements for the torque and tip values, except in the tip of lower premolars. Similarly, Doodamani and Lombardo (Doodamani et al., 2011; Lombardo et al., 2015) found significant differences between the North Americans and their study samples (Figs. 2 and 3). They reiterated the importance of considering the racial variations, in applying the bracket prescriptions. However, careful introspection of the collected data revealed that in comparison the torque values for the Saudi sample were more positive for the maxillary anterior teeth and premolars, also for the mandibular teeth, but had more lingual torque for the maxillary molars than North American Whites. In addition, the tip of the teeth for the Saudi sample generally was more upright especially for the molars in upper and lower arches.

Further, when the Saudi data variables were compared to the Italian data presented by Lombardo et al., there were statistical differences in all the teeth except in the torque values of the maxillary canines, and the mandibular lateral incisors (Lombardo et al., 2015). In general, the Saudi study population had a higher value for U3 and a lower torque value for L2 than Italians. On the other hand, the comparison between this study and the African values revealed that there were statistical differences in all the tip and torque values (Lombardo et al., 2015) (Figs. 2 and 3).

The comparison between Saudi and the Japanese data (Watanabe and Koga, 2001) revealed that there were statistical differences in most of the values of the tip and torque, except for the torque of the maxillary second premolars and the tip values of the mandibular central incisor. The Japanese have

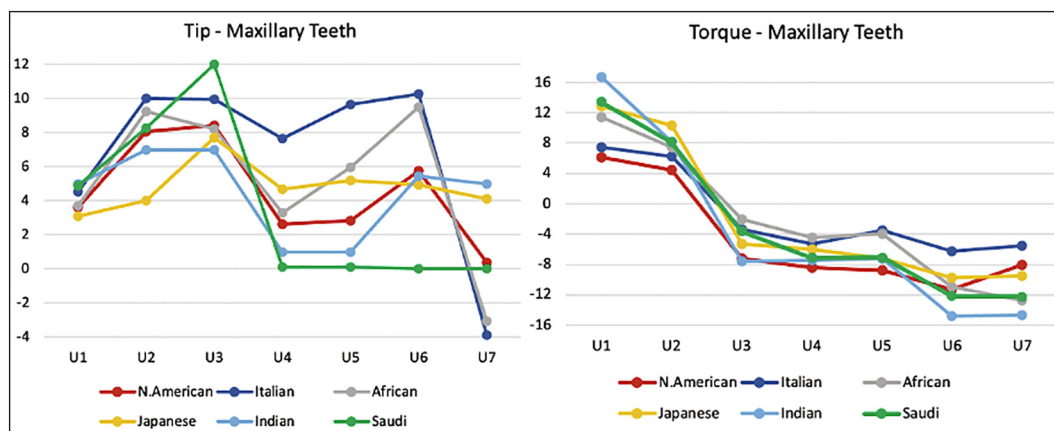


Fig. 2 Comparison of the mean tip and torque of the maxillary teeth obtained in this study with published data.

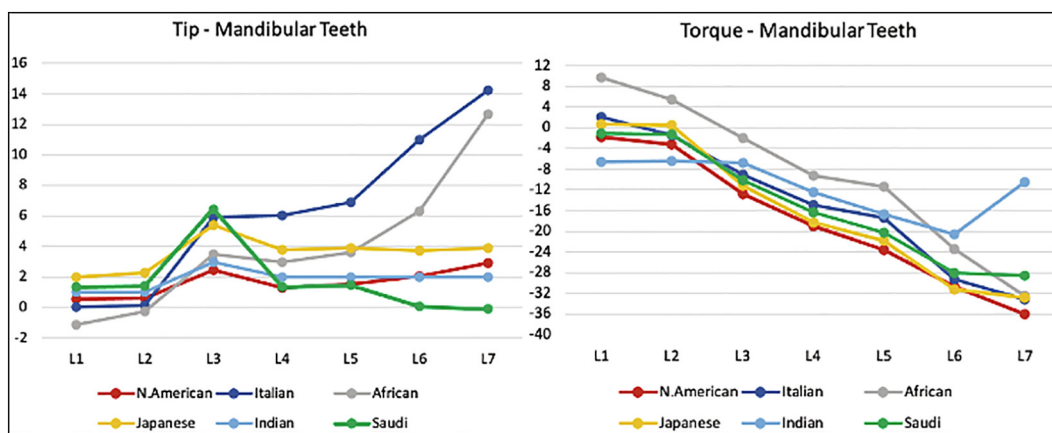


Fig. 3 Comparison of the mean tip and torque of the mandibular teeth obtained in this study with published data.

the most proclined U2 10.35° in comparison to the mentioned studies and higher than our measurement of 8.13° . On the other hand, the Japanese had higher tip values especially in the posterior teeth (Watanabe and Koga, 2001) (Table 5) (Figs. 2 and 3).

Comparing the Saudi data to the Indian bracket prescription values presented by Doodamani et al. showed statistical differences in most of the readings, with exceptions for the torque value of the maxillary lateral incisors (U2) and the second premolars (U5) and the tip of the mandibular incisors (L1). The Indian sample had higher torque values than Saudis (Doodamani et al., 2011).

The differences between the Saudi tip and torque values of the teeth and the other published data were generally significant (Table 5) (Figs. 2 and 3). Our comparative study results with other countries indicate the possible racial variations for Saudi Arabia. However, this study is the first of its type and suggests the need for more research in the Saudi Arabian population to validate the data for bracket prescriptions, either in Riyadh city or other provinces of Saudi Arabia.

5. Conclusion

Tip and torque values of bracket prescription for Saudi adult was determined and presented. Saudi data for the right and left sides and males and females were combined. Significant differences were found between the combined data of Saudi and North American whites' population. In addition, significant differences were also found between the tip and torque values of Saudis on par with the Italian, African, Japanese, and Indians. These differences could be due to morphological characteristics based on the racial background and the differences in method of measurement. The study thus enunciates the implication of racial differences while considering bracket prescriptions.

Ethical statement

Ethical approval was obtained from the Institutional Review Board (IRB) of King Saud University Medical City, project No. E-18-3072.

CRedit authorship contribution statement

Ferdous M.T. Bukhary: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Visualization. **Mohammed T. Bukhary:** Conceptualization, Writing - review & editing, Project administration. **Sahar F. Albarakati:** Methodology, Resources, Writing - review & editing, Supervision, Project administration.

Declaration of Competing Interest

F. Bukhary, M. Bukhary and S. Albarakati certify that there is no actual or potential conflict of interest in relation to this article.

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