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Three-dimensional measurement of tooth inclination: A longitudinal study

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ABSTRACT

Background: New tools have been introduced for tooth inclination measurement and assessment of its changes over time. This study aimed to measure the change in inclination of teeth after the periods of 2 and 4 years in adolescents with normal occlusion using three-dimensional (3D) software.
Materials and Methods: This retrospective longitudinal study was conducted on 54 pairs of dental casts of 24 adolescents between 9 and 13 years of age with normal occlusion. The inclination of teeth was determined by 3D measurements using OrthoAid software. After scanning the casts via stereophotogrammetric scanner, the mean and standard deviation of inclination of teeth were calculated at three time points. Change in these values was calculated after 2 and 4 years. The effect of sex, duration of follow-up, and the jaw (maxilla/mandible) on change of inclination was analyzed using the Mann–Whitney and Wilcoxon tests. $P < 0.05$ was considered statistically significant.
Results: Incisor teeth torque was positive in the maxilla (9.72 ± 8) and mandible (4.22 ± 6.09), but it was negative for the canine (–7.73 ± 6.3 for maxilla and –9.9 ± 5.22 for mandible), premolar (–10.35 ± 6.84 for maxilla and –26.51 ± 9.94 for mandible), and molar teeth (–13.23 ± 6.22 for maxilla and –39.78 ± 9.5 for mandible) in both jaws. Maxillary lateral incisor in boys showed the greatest change of inclination in both 2 and 4 years (about 7°) and the mandibular canine tooth in girls showed the least change of inclination in 4 years (4°).
Conclusion: Sex significantly affected the changes in the inclination of teeth throughout the period of study. The variation of changes in torque was considerable, and no consistent pattern was defined.

Key Words: Longitudinal, measurement, three dimensinal

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INTRODUCTION

The term "inclination of teeth" was described in the six keys of normal occlusion, and ideal norms were set for buccolingual inclinations. This calls for further research on the range of what might be considered acceptable regarding the buccolingual inclinations of teeth.[1] Enhancing smile attractiveness is a multifactorial process that can easily be achieved by proper positioning of the maxillary incisors. Both the inclination and the bodily position of these teeth should be favorable to ensure maximum facial harmony.[2]

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In the study of teeth inclination, a consistency does not seem to exist between professionals in the field of dentistry. When comparing the torque of incisors in simulated pictures, the orthodontists and prosthodontists prefer the labial inclination, but the dental students prefer the lingual inclination. In the meantime, the surgeons and laypeople prefer the normal inclination.[2] This indicates need for further studies on normal cases to better understand the range of normal torque of teeth.

Another aspect that has not been evaluated in many studies is the changes of inclination through time and based on gender. Ferrario *et al*.[3] reported an age-related decrease in facial axis of clinical crown inclination by comparing a group of adolescents with a group of adults. In a study on 20 elderly with many remaining teeth, Fukagawa *et al*.[4] found that tooth inclination indicated a progressive decrease from anterior to posterior. The decrease in mandibular teeth was more regular than maxillary teeth.

Furthermore, the methods of measuring the torque in the studies differ in many ways. The conventional tools used for the evaluation of tooth inclination are either based on lateral cephalograms, which limit the assessment to only central incisors, or measurements on dental models. Andrews measured tooth inclination by means of inclination protractor (TIP; MIB, Newport, United Kingdom). In the recent years, new methods have been introduced. Cone-beam computed tomography measures the inclination of all teeth based on 3D imaging using an X-ray beam.[5] However, requesting cone-beam computed tomography scans for all patients is invasive and unethical, especially for serial evaluation of changes in children. Brezniak[6] suggested to use the light reflection zone of the buccal surface of incisors as a clinical method to determine the inclination of incisors. Another recent modality suggested for tooth inclination evaluation is the 3D scanning of teeth and their surrounding tissues. This new modalities have introduced new virtual tools for the assessment of tooth inclination. Ferrario *et al*. used a computerized electromagnetic digitizer in his study,[3] but Fukagawa *et al*. used a 3D laser scanner and its related software.[4] The question is do the new tools confirm the results of older studies or they reveal new aspect considering the changes of torque. Therefore, due to small number of studies on longitudinal changes of torque and the new tools introduced for measuring them, the aim of our study was to measure the tooth inclination changes in two periods of 2 and 4 years in normal occlusion adolescents by means of these new tools to assess the changes based on sex and time on all teeth.

MATERIALS AND METHODS

This retrospective longitudinal study was conducted on dental casts of 9–13-year-old adolescents with normal occlusion (the sample is better introduced in our previous study)[7] in the city of Qazvin, Iran. Dental casts of 24 patients were collected and divided into two groups with 2 and 4 years duration of follow-up. 15–18 teeth in each category were evaluated with 2 years follow-up duration (from 1996 to 1998 or from 2000 to 2002) and another 9–16 teeth were evaluated with 4 years of follow-up (from 1998 to 2002 or from 1996 to 2000).[7] The overall number of casts evaluated was 54, 24 at the start of the study (T1). The reason for decrease in number of cases for some teeth was either the eruption time of the teeth evaluated or loss to follow-up.

Dental casts were scanned using a 3D scanner with structured light (Mastero 3D desktop Scanner, Pontedera, Italy), and data were saved in stereolithography format. The files were uploaded to the software by changing their extension to Polygon file format. These files were opened in OrthoAid 3D software in Windows 7 designed with C#.NET programming language.[8] The occlusal plane of the dental cast was then drawn by marking three points in the incisal edge of one central incisor and the mesiobuccal cusp of first molars, bilaterally. The respective tooth was selected and clinical bracket point (CBP) and its corresponding point in the occlusal or incisal surface and in the cervical surface (deepest point of attachment of gingival margin to the tooth) were marked. Using the marked points, the software drew a line tangent to the CBP and measured its angle relative to a line perpendicular to the occlusal plane as the inclination. Torque was calculated as such for all teeth [Figure 1].

All measurements were made on 3D casts by an experienced operator using the software. To assess the reliability of torque measurements by the operator, one cast was subjected to measurements for ten times within 10 days and the reliability of the measurements was calculated using intraclass correlation coefficient (ICC). This index usually used for inter- or intra-examiner reliability when there is one or two examining groups between two evaluation time or between each other. Furthermore, the torque

was measured twice on 15 casts, and the reliability of measurements was reported using ICC.

Next, the effect of sex, jaw (maxilla/mandible), and duration of follow-up on the change of inclination was analyzed using the Mann–Whitney and Wilcoxon tests. The inclination angle was measured at three-time points of baseline (T1 or onset of study), after 2 years (T2) and after 4 years (T3) and the mean and standard deviation (SD) of inclination value were calculated at each time point. Change at 2 and 4 years was calculated, and the mean and SD of change were reported using SPSS version 17 (IBM Corp., New York, US). $P < 0.05$ was considered statistically significant.

RESULTS

The reliability of measurements made on one cast for ten times was excellent with a coefficient of 0.99. The reliability of measurements made on 15 casts was also excellent (ICC = 0.9). These values indicated excellent reliability of measurements made by the examiner and her sufficient expertise in using the software.

After being sure about the examiner's competency in measuring tooth inclination, the teeth inclinations were calculated for all the casts. Tables 1-4 show the mean and SD of inclination of each tooth according to sex, jaw, and follow-up duration and its changes over 2 and 4 years. In the following section, the changes are reported based on the jaw, gender, and follow-up period for each type of tooth.

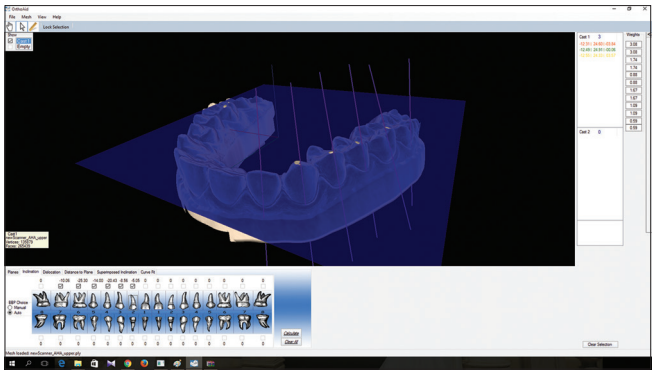

Figure 1: Measuring of teeth inclination related to occlusal plane.

Central incisors

- In both the maxilla and mandible, the degree of inclination was higher in boys as compared to that of girls [Table 1]
- Inclination was positive in all cases; in other words, the teeth had proinclination
- The change of inclination in both jaws of both males and females were greater during 4 years compared to 2 years.

Lateral incisors

- In both the maxilla and mandible, the degree of inclination was higher in boys as compared to that of girls [Table 1]
- The mean change in inclination in the mandible was greater in 4 years compared to 2 years
- In the maxilla, the mean change in inclination of teeth during 2 years was greater than that during 4 years, but no statistically significant difference was noted in this regard in boys.

Canines

- Inclination of canine teeth was negative

Table 1: The mean and standard deviation of inclination of central and lateral incisors (degree) according to jaw, sex, and follow-up duration and its changes over 2 and 4 years (the right and left side amounts have been summed up)

Jaw/ Tooth	Maxillary				Mandible			
	n	Female	*n*	Male	*n*	Female	*n*	Male
Central								
T1	18	7.82±4.86	14	13.04±5.87	18	1.26±5.81	14	8.76±7.61
T2	18	7.61±4.18	14	12.92±6.96	18	3.86±5.88	14	9.82±7.63
T3	16	7.21±5.40	10	8.38±7.30	14	3.59±7.08	10	8.68±9.43
2 years	18	2.77±2.64	14	4.07±2.69	18	3.80±3.02	14	2.78±2.10
4 years	16	4.42±5.54	10	6.40±5.40	14	3.92±5.46	10	4.35±3.35
Lateral								
T1	17	7.03±8.97	14	10.98±11.37	18	−1.16±6.24	14	8.03±4.44
T2	17	9.39±8.59	14	12.99±3.74	18	−3.16±7.32	14	7.22±5.35
T3	16	9.41±8.36	10	8.71±12.66	16	1.82±7.29	10	5.29±8.36
2 years	17	5.07±5.18	14	7.16±9.19	18	3.50±3.33	14	2.35±2.11
4 years	16	3.78±3.59	10	7.09±5.48	16	4.57±3.73	10	4.59±4.26

Table 2: The mean and standard deviation of inclination of canines (degree) according to jaw, sex and follow up duration and its changes over 2 and 4 years (the right and left side amounts have been summed up)

Canine	Maxillary				Mandible			
	n	Female	*n*	Male	*n*	Female	*n*	Male
T1	15	−11.28±6.22	12	−4.19±6.38	18	−11.57±4.00	14	−8.23±6.45
T2	15	−7.37±6.13	12	−3.90±7.10	18	−11.78±4.53	13	−4.41±10.26
T3	15	−6.21±10.49	10	−3.43±9.89	16	−9.14±3.89	10	−4.67±8.18
2 years	15	5.65±8.65	12	4.50±4.15	18	1.74±1.49	13	5.91±6.19
4 years	15	1.97±1.99	10	4.76±3.29	16	4.56±3.33	9	4.52±6.63

Table 3: The mean and standard deviation of inclination of first and second premolars (degree) according to jaw, sex, and follow-up duration and its changes over 2 and 4 years (the right and left side amounts have been summed up)

Jaw/ Tooth	Maxillary				Mandible			
	n	Female	*n*	Male	*n*	Female	*n*	Male
First premolar								
T1	16	−9.67±7.17	10	−7.59±5.80	18	−23.52±8.32	13	−19.64±6.79
T2	16	−8.09±6.76	10	−8.46±8.45	18	−21.22±6.24	12	−18.88±7.42
T3	16	−10.07±7.53	10	−6.60±6.23	16	−17.34±5.94	10	−16.07±5.96
2 years	16	4.36±3.77	10	3.70±2.13	18	3.15±5.10	12	4.53±2.83
4 years	16	4.73±5.91	8	5.70±5.30	16	4.37±6.93	10	3.47±2.78
Second premolar								
T1	15	−13.12±5.45	10	−11.15±8.23	18	−31.05±8.80	14	−31.43±10.52
T2	15	−12.08±5.55	10	−10.0±7.65	18	−30.31±6.01	12	−30.48±11.32
T3	15	−11.80±6.16	9	−12.96±5.89	16	−26.30±7.54	10	−24.56±4.90
2 years	15	4.24±2.62	10	4.99±4.29	18	4.93±3.91	12	5.40±4.60
4 years	15	5.18±2.77	8	5.94±4.41	16	5.12±5.67	10	6.63±6.89

Table 4: The mean and standard deviation of inclination of first molars (degree) according to jaw, sex and follow-up duration and its changes over 2 and 4 years (the right and left side amounts have been summed up)

First molar	Maxillary				Mandible			
	n	Female	*n*	Male	*n*	Female	*n*	Male
T1	18	−12.36±5.49	13	−14.11±6.96	18	−39.99±8.27	13	−39.58±10.73
T2	18	−13.10±5.65	13	−3.90±4.55	18	−37.25±6.14	14	−36.95±8.63
T3	16	−14.47±6.79	10	−14.81±5.97	16	−35.58±6.27	10	−32.19±8.65
2 years	18	5.23±3.92	13	5.53±5.25	18	5.85±3.80	13	5.09±4.94
4 years	16	5.02±4.63	10	4.52±5.39	16	5.79±4.01	10	4.40±3.61

in both jaws and in both males and females (retroinclination), but the degree of retroinclination was less in boys [Table 2]
- The greatest mean change in the mandible was noted in boys during 2 years (5.91 ± 6.19)
- The lowest mean change in the mandible was noted in girls during 2 years (1.74 ± 1.49)
- In all cases, canine tooth underwent proinclination over time.

First premolars

- The inclination of first premolar tooth was negative in both males and females and in both jaws (retroinclination) [Table 3]
- Inclination of first premolar tooth in the mandible was two times more negative than that in the maxilla (e.g., −23.52 ± 8.32 for mandibular versus −9.67 ± 7.17 for maxillary first premolars in females)
- First premolar teeth in the mandible of girls were slightly more retroclined than those in boys (−23.52 ± 8.32 for mandibular first premolars vs. −19.64 ± 6.79 for maxilla)
- The mean change in inclination during 2 and 4 years was not significantly different in girls [Table 5].

Second premolars

- Inclination of this tooth was negative in both

Table 5: Effect of sex and duration of follow-up on change of torque (degree)

Tooth	Girls' mean	Boys' mean	Mean difference of females	Mean difference of males	Sex	Follow-up period	Sex* follow-up
11	8.14	14.15	−4.42	−6.40	0.278	0.123	0.995
12	9.01	11.96	+3.78	−7.09	0.020$^{\Psi}$	0.588	0.610
13	−11.47	−1.27	+1.97	+4.76	0.527	0.562	0.304
14	−9.86	−8.04	−4.73	+5.70	0.881	0.308	0.704
15	−12.34	−9.63	+5.18	−5.94	0.383	0.417	0.677
16	−12.8	−14.47	−5.02	−4.52	0.522	0.675	0.904
21	7.51	11.92	−4.42	−6.40	0.351	0.479	0.563
22	5.27	10.00	+3.78	−7.09	0.727	0.418	0.947
23	−11.11	−7.11	+1.97	+4.76	0.824	0.371	0.438
24	−9.48	−7.14	−4.73	+5.70	0.951	0.828	0.589
25	−13.79	−12.66	+5.18	−5.94	0.862	0.669	0.453
26	−11.88	−13.80	−5.02	−4.52	0.635	0.836	0.791
31	1.48	9.41	+3.92	+4.35	0.827	0.265	0.815
32	−0.08	8.20	+4.57	−4.59	0.292	0.582	0.489
33	−10.52	−7.77	+4.56	+4.52	0.966	0.834	0.053$^{\Psi}$
34	−22.03	−19.99	+4.37	−3.47	0.660	0.687	0.202
35	−32.75	−31.04	+5.12	+6.63	0.438	0.936	0.740
36	−39.92	−42.42	+5.79	+4.40	0.719	0.603	0.628
41	1.03	8.11	+3.92	+4.35	0.852	0.849	0.374
42	−2.23	7.86	+4.57	−4.59	0.894	0.068	0.818
43	−12.61	−8.67	+4.56	+4.52	0.034$^{\Psi}$	0.624	0.619
44	−25.00	−19.33	+4.37	−3.47	0.434	0.694	0.771
45	−29.35	−31.82	+5.12	+6.63	0.936	0.464	0.886
46	−40.05	−36.27	+5.79	+4.40	0.052$^{\Psi}$	0.866	0.332

Two-way ANOVA, $P<0.05$ was considered statistically significant. $^{\Psi}$show significant difference in each column. *show interaction of sex and follow up period. It didn't indicate any statistical difference

jaws and in both males and females; in most cases, it shifted toward positive (proinclination) [Table 3]
- In total, this tooth in the mandible was more retroclined compared to that in the maxilla (about three times).

First molars

- Inclination of this tooth was negative in both jaws and in both males and females, but it was three times more negative (retroclined) in the mandible [Table 4]
- The difference in the mean change during 2 and 4 years was not significant (almost equal)
- No significant difference was noted between girls and boys [Table 5].

Table 5 shows the effect of sex and duration of follow-up on the change of torque in each tooth.

- The effect of sex on change of inclination was significant in the maxillary right lateral incisor and mandibular right canine and first molar teeth
- The interaction effect of sex and duration of follow-up on the change of inclination was statistically significant in the mandibular left canine tooth.

It was interesting to note that when the effect of gender was studied on the whole sample using ANOVA the effect was statistically significant (2 years $P < 0.041$ and 4 years $P < 0.021$). However, the tooth inclination changes did not have a significant difference between the upper and lower jaw [Table 6].

Table 7 shows the change of inclination in the maxillary and mandibular teeth during 2 and 4 years of follow-up. In the incisor teeth of both sides, the trend of change was highly variable during 2 and 4 years and was sometimes different from that on the other side. Thus, a specific pattern cannot be suggested for each tooth.

The torque of most canine teeth changed positively during 2 years of follow-up while during 4 years, the majority of teeth had a descending torque. Premolar teeth, similar to incisor teeth, had a highly variable and unpredictable trend of change. Mandibular first molars underwent increase or decrease of torque equally during 2 years of follow-up. It should be noted that 12.5% of teeth did not show any significant change in their inclination during this period. During 4 years, the torque of the majority of teeth became negative.

DISCUSSION

Many studies have measured the faciolingual inclination of teeth, but only a few have statistically analyzed the effect of gender and period of study on tooth inclination. Based on the results of these studies, a considerable variation exists in changes of faciolingual inclination of teeth during growth in individuals with normal occlusion. According to Andrews, this variability is within the biologic range. In contrast, Dellinger reported that this variability was high and there is no basis for allocating specific values to torque of crown in straight wire appliances.[9]

Introduction of preadjusted brackets or straight wire appliances resulted in treatment outcomes similar to or superior to standard brackets in terms of quality but with less wire bending and simpler mechanics. Andrews performed extensive measurements on major malocclusions and determined the moderate tip and torque of each tooth.[10,11] Racial differences,[12-14] facial profile,[15] facial type,[14] arch length,[16,17] size of jaws and contour of the labial surface of teeth[18,19] were among the variable factors in subjects with normal occlusion and thus, can affect normal angulation and inclination of teeth. As shown in the current study and previous ones,[9,13,20] relatively high SD values of each variable indicate extensive dispersion of torque values. On the other hand, individual variations in dental morphology are higher than the variation between different types of preadjusted appliances.[12] Thus, the use of same torque prescription built in preadjusted appliance may not be suitable for all orthodontic patients. Nevertheless, inaccurate placement of bracket, variability in dental structure and jaw relations and mechanical defects such as force diminution and play may prevent achieving the ideal position of the tooth using straight wire appliances.[21]

Thus, knowledge about the mean torque of teeth in the target population is particularly important for the use of a suitable appliance. In a cross-sectional study by Ferrario *et al.*,[3] significant differences exist in dental inclination between male and female adolescents and adults. On the other hand, our study showed that torque is subject to change over time. Since fixed orthodontic treatments take 18–24 months on an average, and it can increase to 30–42 months in case of conduction of growth modification, we evaluated the change during 2 and 4 years.

Ferrario *et al.*[3] evaluated the change in torque of teeth in 14.5 and 20 years old (5.5 years difference)

Table 6: The effect of jaw on teeth inclination changes based on follow-up period and gender

Jaw/ Follow up	Maxilla	Mandible	*P*	*P* total
2 years	4.75±5.00	4.02±3.92	0.191	0.421
4 years	4.76±4.60	4.71±4.81	0.526	
Female	4.36±4.60	4.21±4.18	0.994	0.050
Male	5.38±5.12	4.03±3.84	0.029	

Wilcoxon and Mann-Whitney tests, $P<0.05$ was considered statistically significant

Table 7: Tooth inclination changes during 2 and 4 years, represented as the percentage of total numbers of teeth in that category

Follow up period	Inclination changes	Tooth											
		16	15	14	13	12	11	21	22	23	24	25	26
2 years	Positive	43.75	53.9	35.8	57.2	33.3	50	31.3	31.3	71.5	50	87.5	50
	Zero	12.5	0	0	0	0	0	0	0	0	14.2	0	0
	Negative	43.75	46.1	64.2	42.8	66.7	50	68.7	68.7	28.5	35.8	12.5	50
4 years	Positive	22.2	25	25	50	70	40	40	30	33.3	77.7	44.4	50
	Zero	0	0	0	0	0	0	0	0	0	0	0	0
	Negative	77.8	75	75	50	30	60	60	70	66.7	22.3	55.6	50
Follow up period	**Inclination changes**	**36**	**35**	**34**	**33**	**32**	**31**	**41**	**42**	**43**	**44**	**45**	**46**
2 years	Positive	73.33	57.14	57.14	62.5	25	43.75	43.75	25	13.33	73.33	65.28	62.5
	Zero	6.66	7.14	14.28	12.5	37.5	18.75	6.25	6.25	20	6.66	7.14	6.25
	Negative	20	35.71	28.57	25	37.5	37.5	50	68.75	66.66	20	28.57	31.25
4 years	Positive	42.85	42.85	71.42	42.85	57.14	53.84	46.15	57.14	61.53	50	64.28	64.28
	Zero	14.28	14.28	7.14	14.28	14.28	7.69	7.69	0	0	14.28	14.28	0
	Negative	42.85	42.85	21.42	42.85	28.57	38.46	46.15	42.85	38.46	35.71	21.42	35.71

The values were considered positive if the torque was increased and negative if it decreased. If teeth inclination did not change then it was considered zero

in a cross-sectional study. In their study, the torque reported for all teeth in males and females were less than the values reported in our study. The main reason for this difference is selection of true sagittal and frontal planes as reference planes for the measurement of torque while in our study, the occlusal plane was chosen as the reference. In our study, reduction in torque was noted for maxillary central incisors of girls during the 4-year follow-up, whereas in the study by Ferrario *et al*., these changes were positive (increase in dental torque) during 5.5 years in females. Their study showed that the effect of age and sex and their interaction effect on the change of torque were significant for many teeth, whereas in our study, the effect of age, follow-up period and their interaction effect were not significant on the torque of most teeth (except for a few). Longitudinal design of our study had some advantages such as requiring a smaller sample size, showing individual differences and assessment of timing effect on growth changes, frequently encountered during growth and development of children and adolescents.

Another factor influencing variation of the results of the studies is the method of inclination measurement. It seems digital method for measurement of dental inclination, has less bias and human error.[22] However, some studies indicated that standard deviations obtained by digital methods were higher than those by the manual method described by Andrews, but the difference between the two methods was not statistically significant.[8,22] The study by Kodaka[22] had the highest similarity to our study. In their study, dental torque was measured manually and digitally (similar to our study), and the angles were measured relative to the occlusal plane (plane connecting the incisors to molars). However, they used tegmentum center of central incisors and center of the occlusal surface of maxillary or mandibular first molars as the reference points for drawing the occlusal plane, whereas in our study, the midline area and tip of mesiobuccal cup of first molars were used. This difference in the selection of reference points for the occlusal plane can cause differences in the results and explain the discrepancy between the results of the two studies. One major difference of our study with that of Uğur and Yukay,[9] was assessment of the angles relative to the functional occlusal plane instead of constructed occlusal plane. Vardimon and Lambertz[13] used manual and digital methods, despite the measurement of angles relative to the occlusal plane, a reference point at the middle of the buccal surface of the crown was visually selected as reference for measurements, which may be slightly different from the FA point and cause differences between measurements. The values obtained by Tong[5] were considerably different from our values; which is probably because they measured the torque of teeth radiographically and by use of root tip. The difference between our results and those of Verma is because they considered the actual horizon as the reference plane for measurement of torque.[21]

Measurement of tooth torque relative to the occlusal plane is influenced by several factors such as the change in circummaxillary sutures, development of alveolar bones, rotation of skeletal bases (internal and external), rotation of the cranial base, dental development (periodontal ligament and tooth eruption), and rotation of the occlusal plane. Since the change in each of the above-mentioned factors may be extensive and specific for each patient, change in torque may be highly variable and unpredictable between individuals and even in one individual between the right and left teeth. According to our previous study,[23] change in the occlusal plane angle of the maxilla was 2.65° ± 1.21° in the clockwise fashion during 2 years and 3.75° ± 0.57° during 4 years after superimposing the casts based on rugae. Thus, this change in the occlusal plane may be the factor for the increase in torque of maxillary incisors as much as 1.25° in girls and 2.95° in boys during 2 years. The torque decreased by 7.75° in girls and 10.5° in boys during 2 years. It is obvious that the torque of incisor teeth significantly affects esthetics as well as light reflection from the tooth surface and subsequent lightness of tooth. However, torque is not the only factor affecting dental esthetics, and the relative position of the tooth to the surrounding soft-tissue and facial growth pattern also play a role in this regard.[2]

CONCLUSION

Maxillary lateral incisor in boys showed the greatest change of inclination in both 2 and 4 years (about 7°) and the mandibular canine tooth in girls showed the least change of inclination in 4 years (4°). Our study indicated significant differences between changes of the teeth inclinations among adolescent males and females in the period of study. The variation of changes in torque was considerable, and no consistent pattern was defined. In addition, the pattern of changes was even different for the right and left side in the same individual through the period of study.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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