ACTA ODONTOLOGICA SCANDINAVICA
2023, VOL. 81, NO. 1, 73–78
https://doi.org/10.1080/00016357.2022.2084157

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Sex-specific reference values for the crown heights of permanent anterior teeth and canines for assessing tooth wear

Paula Roca-Obis[a], Ona Rius-Bonet[b], Carla Zamora-Olave[b,c], Eva Willaert[b,c] and Jordi Martinez-Gomis[b,c]

[a]Department of Oral Medicine, School of Dentistry, Faculty of Medicine and Health Sciences, University of Barcelona, Catalonia, Spain;
[b]Department of Prosthodontics, School of Dentistry, Faculty of Medicine and Health Sciences, University of Barcelona, Catalonia, Spain;
[c]Oral Health and Masticatory System Group (Bellvitge Biomedical Research Institute) IDIBELL, L'Hospitalet de Llobregat, Barcelona, Spain

ABSTRACT

Objective: We propose sex-specific reference values for the clinical crown height of anterior teeth and canines.

Material and methods: In this cross-sectional study, 1426 teeth were analysed from 169 undergraduate and postgraduate dental students (83 women and 86 men, median age 22 years). Teeth with worn or totally restored incisal edges, or gingival inflammation were excluded. Age, gender and body height were recorded and the degree of tooth wear was scored according to the quantification module of the Tooth Wear Evaluation System. The clinical crown heights of all anterior teeth and canines were measured from the gingival margin to the incisal edge with a digital calliper. Reference values for tooth groups were obtained at the percentiles 10, and expressed by sex if there was a significant difference between men and women.

Results: Mean crown heights were bigger in men than in women for each tooth group ($p = .028$). Clinical crown heights showed sexual dimorphism at the 10th percentiles for all tooth groups except for mandibular anterior teeth.

Conclusions: For assessing tooth wear, the sex-specific reference values for the clinical crown height of young adults Caucasoids range from 7.5 mm to 9.0 mm in women and from 7.5 mm to 9.5 in men.

ARTICLE HISTORY
Received 26 January 2022
Revised 11 May 2022
Accepted 24 May 2022

KEYWORDS
Tooth wear; clinical reference values; sexual dimorphism; crown height; human permanent tooth

Introduction

Tooth wear is the cumulative surface loss of mineralized tooth substance due to physical or chemo-physical processes. Typical causes are acid exposure (dental erosion), tooth-to-tooth contact (dental attrition) or wear by objects other than teeth (dental abrasion) [1]. The prevalence of severe tooth wear increases from 3% at the age of 20 years to 17% at the age of 70 years [2]. Because it will have irreversible effects on the dentition, it is important to detect tooth wear early and to implement prevention by counselling and monitoring so that restorative treatment can be avoided [3–5].

Diagnostic methods for tooth wear can be broadly classified into qualitative and quantitative categories [6]. Qualitative methods are based on the detection of clinical signs of mechanical or chemical wear. By contrast, quantitative methods are used to determine the amount of loss of dental tissue by objectively grading or scoring parameters such as groove depth, facet areas or crown heights. Any quantitative method should be simple to use, have clear scoring criteria and be reproducible [7]. Commonly used evaluation methods for tooth wear are Eccle's method [8], the Tooth Wear Index [9], Lussi's method [10] and the Basic Erosive Wear Examination (BEWE) [11]. However, variations in these evaluation methods make difficult to compare the results of different studies [12,13].

In 2016, Wetselaar and Lobbezoo developed the Tooth Wear Evaluation System (TWES) clinical guideline to assess tooth wear systematically across several modules [14]. One diagnostic module is to compare the clinical crown height of anterior teeth and canines against reference values [15]. However, this module could be improved in three aspects. First, the proposed technique measures from the incisal edge towards the cementoenamel junction (CEJ) using a periodontal probe. Taking the gingival margin as a reference in cases when the CEJ is not visible could allow the use of a calliper instead of a probe, which could improve measurement precision [16–18]. Second, the existing reference values do not differentiate measurements by gender despite knowledge that sexual dimorphism in tooth dimension has been reported [17,19–21]. Moreover, other factors could be related to clinical crown height, such as body height or laterality [22–26]. Third, when seeking to detect extreme values, reference values expressed as percentiles could be of more use than average values [27]. Although percentile distribution has been reported for mesiodistal crown size [27,28], overall maxillary central incisor height [29] and canine inclination [30], no percentile distributions are available for crown height.

CONTACT Jordi Martinez-Gomis jmartinezgomis@ub.edu L'Hospitalet de Llobregat, Campus de Bellvitge, C/Feixa llarga s/n, Barcelona, 08907 Catalonia, Spain

Figure 1. Clinical crown height measurement from gingival margin to incisal edge with a digital calliper.

The validity of the clinical crown height module could be improved if reference values are defined by tooth group (using the recommended clinical technique), if they are expressed as percentiles and if the factors related to crown height are considered. The primary aim of this study was to establish reference values for the clinical crown height of anterior teeth and canines, as measured using a clinical technique and expressed as percentiles and by sexual dimorphism. This study also aimed to determine whether the body height and the side affected the reference values for the clinical crown heights of each tooth group.

Material and methods

Study design and subject selection

We invited 195 undergraduate and postgraduate dental students at the University of Barcelona to participate in this cross-sectional study if they were Caucasoids, aged 18–40 years and had a natural dentition. Efforts were made to enrol similar numbers of men and women. Permanent anterior teeth and canines that were totally restored or worn incisal edges, or teeth with gingival inflammation were not included in the analysis. All participants provided informed consent, and the study was approved by the Ethics Committee of Barcelona University Dental Hospital (Code 2019-48). Recruitment took place from February to November 2020 in accordance with the principles of the Helsinki Declaration and the study was reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [31].

Clinical procedures and data collection

On the day of measurement, age, gender, body height and details of whether the participant had any anterior tooth restorations were obtained by interview-based questionnaire at the Barcelona University School of Dentistry (Catalonia, Spain). Anterior tooth restorations were assessed by intraoral examination and incisal wear was assessed and scored according to an 8-point ordinal scale of the finer-grained quantification module [14]. Briefly, incisal tooth wear was graded on a tooth-by-tooth basis as grade 0 as no visible wear; grade 1a, 1 b or 1c as minimal wear, facets or noticeable flattening of incisal edges, within the enamel, grade 2, 3a, 3 b and 4 as wear with dentine exposure and loss of clinical crown height $\leq$1/3, 1/3-1/2, 1/2-2/3, $>$2/3, respectively. In the same session, one researcher (P R-O) measured the clinical crown height from incisal edge to the most apical curvature of the gingival margin, for each permanent anterior tooth and canine. Measurement was performed using the external edges of a digital calliper and recorded to the nearest 0.01 mm (Figure 1). We excluded restored anterior teeth for which the actual height could not be determined. Teeth scoring $\geq$ 2, indicating wear with dentine exposure, or teeth on which enamel wear could have reduced crown height were considered worn and excluded from the analysis. In this study, six tooth groups were considered, i.e. central incisors, lateral incisors and canines in the maxillary and mandibular arch.

Table 1. Test–retest reliability and the smallest detectable differences (SDD) of clinical crown height by tooth group.

Group of teeth	*n*	ICC (CI 95%)	*p* Value	SDD*
Right maxillary canine	17	0.98 (0.95 – 0.99)	<.001	0.16
Right maxillary lateral incisor	17	0.98 (0.96 – 0.99)	<.001	0.15
Right maxillary central incisor	15	0.96 (0.89 – 0.99)	<.001	0.19
Left maxillary central incisor	16	0.93 (0.80 – 0.98)	<.001	0.26
Left maxillary lateral incisor	16	0.97 (0.89 – 0.99)	<.001	0.26
Left maxillary canine	16	0.98 (0.94 – 0.99)	<.001	0.21
Left mandibular canine	17	0.96 (0.89 – 0.99)	<.001	0.28
Left mandibular lateral incisor	17	0.89 (0.70 – 0.96)	<.001	0.40
Left mandibular central incisor	17	0.96 (0.90 – 0.99)	<.001	0.23
Right mandibular central incisor	17	0.97 (0.92 – 0.99)	<.001	0.24
Right mandibular lateral incisor	17	0.96 (0.90 – 0.99)	<.001	0.31
Right mandibular canine	17	0.96 (0.88 – 0.98)	<.001	0.21

ICC: intraclass correlation coefficient ICC – 2-way random, absolute agreement for average measurements; CI: confidence interval. * in mm.

Data analysis

The sample size was determined by considering a type I error of 0.05, a power of 0.8 and an estimated standard deviation of 0.9 mm to find a between-group difference of 0.4 mm in clinical crown height of maxillary central incisors [15,32]. A 15% dropout rate was estimated. To evaluate the reproducibility of the main study parameter, measures of clinical crown height were repeated in 17 participants one week apart. Reliability was assessed by the intraclass correlation coefficient (ICC) for average measurements, using a two-way random effects model and absolute agreement. The smallest detectable difference (SDD) was determined as the measure of agreement between sessions, calculated as 1.96 $\times$ ($\sqrt{2}$) $\times$ standard error of the measurement [33]. The ICC and SDD values ranged from 0.89 and 0.40 mm for left mandibular lateral incisor to 0.98 and 0.15 mm for right maxillary lateral incisor, respectively (Table 1).

The normality of clinical crown height measurements for each tooth was confirmed by Shapiro–Wilk's test and visual analysis of Q–Q and box plots. Clinical crown height percentiles (3rd, 5th, 10th, 25th, 50th, and 75th) were calculated by sex. Independent student *t*-tests were used to assess mean differences between males and females and paired *t*-test

Table 2. Number of teeth excluded by group and reason.

	MAXILLARY DENTITION		
	CANINES	LATERAL INCISOR	CENTRAL INCISOR
Restored/absence/deciduous	6	18	20
Worn tooth	141	37	34
TOTAL teeth excluded	147	55	54
INCLUDED	191	283	284
	MANDIBULAR DENTITION		
	CANINES	LATERAL INCISOR	CENTRAL INCISOR
Restored/absence/deciduous	3	5	7
Worn tooth	149	88	94
TOTAL teeth excluded	152	93	101
INCLUDED	186	245	237

were used to assess intra-subject mean differences in clinical height by right or left sided tooth location. Bivariate correlations between quantitative parameters were assessed using Pearson correlation coefficient.

Multiple linear regression models were conducted using a stepwise forward method to establish if gender and body height were significantly associated with the clinical crown height of each tooth group. Reference values for each tooth group were obtained as the 10th percentile and expressed by sex when sex differences were detected at this level. The use of the 10th crown height percentile of unworn teeth implies a specificity of around 90%. Sex differences at the 10th percentile were analysed after dichotomizing the clinical crown variable according to the cut-off value at this percentile and applying the chi-square (or Fisher's Exact Test) between this dichotomized variable and sex. All values were rounded to the nearest 0.5 mm. p-values of $< .05$ were considered statistically significant, and all the analysis were conducted using IBM SPSS Version 27 (IBM Corp., Armonk, NY, USA).

Results

Of the 195 people invited to participate in this study, 25 did not attend on the day of study and 1 refused to participate, leaving a final sample of 169 people with a median age of 22 years (range = 18–40). Of them, 86 were male (50.9%; mean body height 177 ± 7 cm) and 83 were women (49.1%; mean body height 166 ± 6 cm). A further 602 teeth were excluded because of either an inability to measure the clinical crown height (56 restored, 3 absents) or tooth wear ($n = 543$) (Table 2). Therefore, 1426 teeth were included for analysis.

Central tendency data for the clinical crown heights by tooth group and gender are shown in Table 3. Regardless of the group of teeth, gender or side, clinical crown values ranged from 5.69 mm to 13.05 mm. Significantly bigger height values were observed for males than for females by each tooth group ($p = .028$; independent t-test), but not by laterality ($p > .05$; paired t-test). Thus, teeth from the right and left sides were pooled for each tooth group.

The body height had a significant correlation with clinical crown heights of maxillary and mandibular canines (Pearson correlation coefficient $r = 0.294$; $p < .001$ and $r = 0.383$; $p < .001$, respectively) and maxillary lateral and central incisors ($r = 0.208$; $p = .007$ and $r = 0.206$; $p = .008$, respectively), but not with crown heights of mandibular lateral and central incisors ($r = 0.122$; $p = .115$ and $r = 0.055$; $p = .482$, respectively) (Figure 2). However, men were an average of 11.4 cm taller than women (95% confidence, 9.4–13.4 cm; independent t-test), and stepwise multiple regression analysis showed that only gender was significantly related to the crown height of each tooth group, except for mandibular central incisors (adjusted R^2 = ranged from 0.03 to 0.23; $p < .05$).

Table 4 shows the 3rd, 5th, 10th, 25th, 50th and 75th percentiles for clinical crown height by tooth group and sex. Sexual dimorphism was detected in all two maxillary anterior tooth types and in maxillary and mandibular canines. Reference values for the clinical crown heights of unworn teeth measured from gingival margin to incisal edge are shown in Figure 3, where they are expressed as 10th percentiles, rounded to the nearest 0.5 mm and grouped by sex. Reference values were 7.5 mm for mandibular central and lateral incisors in both sexes and maxillary lateral incisor for women, 8.0 mm for maxillary lateral incisor in men, 8.5 mm for maxillary canine in women, 9.0 mm for maxillary central incisor and mandibular canine in women and maxillary canine in men and 9.5 mm for maxillary central incisor and mandibular canine in men.

Discussion

In this study, we have proposed reference values for clinical crown height by permanent anterior tooth group and gender, expressed as the 10th percentile of values measured using a clinical technique. The values, which ranged from 7.5 mm to 9.5 mm, can be useful for detecting and quantifying anterior tooth wear. Despite being 1.5–3 mm below the TWES reference values [14,15], the relative differences in crown height between different anterior tooth groups are similar in both. Discrepancies between the reference values are probably due to the measurement techniques, the use of a 10th percentile instead of an average value (mean) and the populations studied.

It is important that the reference values in this study were obtained using a clinical protocol. Moreover, the main advantages of using the gingival margin instead of the CEJ as the reference point are that it is more comfortable for the patient and easier for the clinician to locate. It also allows a calliper to be used for measurement, which is more sensitive than a periodontal probe for measuring anterior intraoral distances. An inconvenience of using the gingival margin is that the location can vary with gingival inflammation or overgrowth. In cases of incisal recession or periodontal surgery where the CEJ may be visible, this could be used as a reference point for the calliper. Other studies measuring clinical crown height from the gingival margin to the incisal edge with a digital calliper have reported data with differences of less than 1 mm [17,18].

Regardless of gender, the median clinical height of maxillary central incisors in the present study (10.3 mm) was comparable to that of other studies measuring the distance from the gingival margin and using a calliper either intraorally (9.6

Table 3. Clinical crown heights (mm) of anterior teeth and canines by sex and laterality.

	MAXILLARY DENTITION					
	CANINES ($n = 191$)		LATERAL INCISOR ($n = 283$)		CENTRAL INCISOR ($n = 284$)	
SIDE	Female ($n = 113$)	Male ($n = 78$)	Female ($n = 144$)	Male ($n = 139$)	Female ($n = 151$)	Male ($n = 133$)
Right	9.59 (9.37:9.82)	10.52 (10.18:10.87)	8.35 (8.16:8.54)	8.86 (8.65:9.07)	10.06 (9.89:10.24)	10.85 (10.63:11.07)
Left	9.74 (9.51:9.97)	10.78 (10.45:11.11)	8.52 (8.34:8.69)	8.94 (8.73:9.14)	10.07 (9.88: 10.26)	10.67 (10.46:10.88)
TOTAL	9.67 (9.51:9.82)	10.65*** (10.41:10.88)	8.43 (8.30:8.56)	8.90*** (8.75:9.04)	10.07 (9.94:10.20)	10.76*** (10.61:10.91)
	MANDIBULAR DENTITION					
	CANINES ($n = 186$)		LATERAL INCISOR ($n = 245$)		CENTRAL INCISOR ($n = 237$)	
SIDE	Female ($n = 108$)	Male ($n = 78$)	Female ($n = 131$)	Male ($n = 114$)	Female ($n = 122$)	Male ($n = 115$)
Right	9.88 (9.64:10.12)	11.00 (10.72:11.28)	8.46 (8.29:8.62)	8.90 (8.63:9.16)	8.30 (8.13:8.48)	8.62 (8.35:8.89)
Left	9.90 (9.69:10.11)	10.86 (10.50:11.22)	8.49 (8.30:8.69)	8.81 (8.54:9.08)	8.37 (8.18:8.55)	8.53 (8.30:8.77)
TOTAL	9.89 (9.73:10.05)	10.93*** (10.71:11.15)	8.48 (8.35:8.60)	8.85*** (8.67:9.04)	8.33 (8.21:8.46)	8.58* (8.40:8.75)

Mean (95% confidence interval) of clinical crown height expressed in mm. *$p < .05$; ***$p < .001$ between sexes, independent t-test.

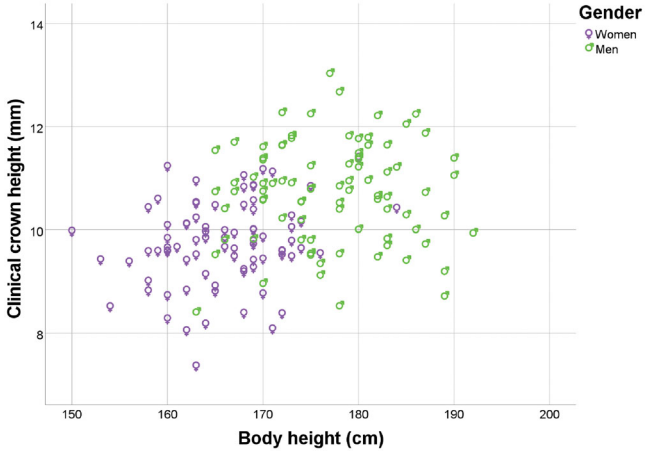

Figure 2. Scatterplot showing clinical crown height (mm) for the mandibular canine and body height (cm) by gender.

Table 4. Clinical crown height (mm) percentiles by tooth group and sex.

	MAXILLARY DENTITION								
	Canines			Lateral Incisors			Central Incisors		
Percentile	Female	Male	Total	Female	Male	Total	Female	Male	Total
N	*113*	*78*	*191*	*144*	*139*	*283*	*151*	*133*	*284*
3rd	8.1	8.5	8.2	7.1	7.3	7.2	8.5	9.3	8.8
5th	8.2	8.8	8.3	7.3	7.5	7.4	8.8	9.4	8.9
10th	8.5	9.1**	8.7	7.4	7.8**	7.6	9.1	9.6***	9.3
25th	9.0	10.0	9.3	7.9	8.3	8.0	9.5	10.1	9.7
50th	9.7	10.6	10.1	8.4	9.0	8.6	10.1	10.7	10.3
75th	10.4	11.5	10.8	9.0	9.5	9.3	10.6	11.5	11.1
	MANDIBULAR DENTITION								
	Canines			Lateral Incisors			Central Incisors		
Percentile	Female	Male	Total	Female	Male	Total	Female	Male	Total
n	*108*	*78*	*186*	*131*	*114*	*245*	*122*	*115*	*237*
3rd	8.0	9.0	8.3	7.1	6.4	6.9	6.9	6.8	6.9
5th	8.3	9.3	8.8	7.3	7.0	7.3	7.3	7.1	7.1
10th	8.9	9.6**	9.0	7.5	7.6	7.5	7.5	7.4	7.5
25th	9.4	10.3	9.6	8.1	8.3	8.2	7.8	8.0	7.9
50th	9.9	11.1	10.3	8.4	8.8	8.6	8.3	8.4	8.4
75th	10.4	11.5	11.1	8.9	9.7	9.3	8.8	9.3	9.1

**$p < .01$; ***$p < .001$; Sex differences in 10th percentile of clinical crown height, Fisher's Exact Test.

and 9.8 mm) [17,18], in dental casts (9.8 mm) [21] or on digital photographs (10.7 mm) [34]. When using the CEJ as a reference, values were higher on extracted incisors (10.9 mm and 11.7 mm) [15,35] and dental cone-beam computed tomography scan (10.7 mm) [36]. Regardless the population and measurement technique, it appears that a difference of approximately 0.5 mm could be expected between CEJ or gingival margin measurements of the clinical crown height of permanent anterior teeth and canines.

The average sex differences in this study are consistent with those found in a Portuguese population in which the canines and lateral incisors had the highest absolute and relative sex differences [23]. Furthermore, this study found that the 10th percentiles showed sexual dimorphism in crown height for all two maxillary anterior teeth and maxillary and mandibular canines. By contrast, no crown height asymmetry was found by any tooth group in this study. Although individual body height was positively related to clinical crown height of some types of teeth [26], this bivariate relationship became insignificant after controlling for gender, as reported elsewhere [21]. Therefore, reference values for clinical crown height are better expressed by sex than by individual body height or tooth laterality.

This is the first study to provide clinical crown height percentiles for men and women by anterior teeth and canines. The 10th percentile of crown height of unworn teeth can be used as sex-specific reference threshold values for detecting tooth wear and considering early preventive interventions. The use of the 10th crown height percentile of unworn teeth implies a specificity of around 90% (1 in 10 individuals without tooth wear would be considered to have tooth wear; a false positive). However, tooth wear could be discarded in these individuals by simple oral examination for clinical signs and a brief interview of symptoms related to tooth wear. Using a lower percentile, such as the 3rd or 5th percentile, would increase the specificity at the cost of decreased sensitivity (potentially leading to missed diagnoses). Future research in a population with worn teeth could clarify the sensitivity of these threshold values.

Combining the reference values and measurement technique described in this study could improve the validity of the clinical crown height diagnostic module in an updated version of the TWES. Interestingly, version 2.0 of the TWES was recently published and did not upgrade this quantification module and considered it optional in the assessment of tooth wear status, probably due to the lack of recent studies on this topic [37]. A suggestion that could complement this

MAXILLARY DENTITION					
CANINES		LATERAL INCISOR		CENTRAL INCISOR	
Female	Male	Female	Male	Female	Male
8.5 mm	**9.0 mm**	**7.5 mm**	**8.0 mm**	**9.0 mm**	**9.5 mm**
9.0 mm	**9.5 mm**	**7.5 mm**	**7.5 mm**	**7.5 mm**	**7.5 mm**
Female	Male	Female	Male	Female	Male
CANINES		LATERAL INCISOR		CENTRAL INCISOR	
MANDIBULAR DENTITION					

Data are expressed for the 10th percentile of unworn teeth, as measured from the gingival margin to the incisal edge, rounded to 0.5 mm.

Figure 3. Reference values for clinical crown height by tooth group and sex.

module in the TWES protocol might be to perform screening by measuring the crown height of only one maxillary central incisor and/or a mandibular canine, with a positive result prompting the clinician to measure other teeth and conduct a more comprehensive clinical evaluation of tooth wear [4]. Future research using an appropriate design could validate this screening approach. Moreover, the mean reference values in this study could be used, together with other clinical data, to determine the final position of the gingival margin in aesthetic crown lengthening and prosthodontic rehabilitation.

A strength of this study is the inclusion of 1426 unworn teeth from 169 of young adults, which should have given a sufficiently large sample size to establish threshold values for clinical crown height by sex and type of tooth. Moreover, the test–retest results showed not only high reliability of the clinical crown height measurements but also that this technique could detect differences higher than 0.4 mm [17,38]. Given a clinically insignificant reduction in tooth size of $<$0.5 mm [33], reference values were rounded to 0.5 mm. However, this study also has important limitations. First, the use of a convenience sample may have resulted in a sample that was not representative of the general population. Extrapolating the results to populations other than Caucasoids will need to be done with caution because the average height of natural teeth may vary between different population groups [39]. More studies are needed to consider if reference values need to be reported by population or ethnic group. Second, since the position of the gingival margin may vary with age, the use of these reference values should be done with caution in a population over 40 years of age.

Conclusions

Reference values of clinical crown height for central and lateral incisors and canine of women are 9.0, 7.5 and 8.5 mm in the maxillary arch and 7.5, 7.5 and 9.0 mm in the mandibular arch, respectively. Reference values of clinical crown height for central and lateral incisors and canine of men are 9.5, 8.0 and 9.0 mm in the maxillary arch and 7.5, 7.5 and 9.5 in the mandibular arch, respectively. Reference values for clinical crown height are better expressed by sex than by individual body height or tooth laterality. These reference threshold values might be used for detecting tooth wear in a young adult Caucasoid population and considering early preventive interventions.

Acknowledgments

The authors thank Michael Maudsley for editing the text.

Disclosure statement

The authors report there are no competing interests to declare.

Data availability statement

The data sets used and/or analysed during the current study are available from the corresponding author on reasonable request.

References

[1] Schlueter N, Amaechi BT, Bartlett D, et al. Terminology of erosive tooth wear: consensus report of a workshop organized by the ORCA and the cariology research group of the IADR. Caries Res. 2020;54(1):2–6.
[2] Van't Spijker A, Rodriguez JM, Kreulen CM, et al. Prevalence of tooth wear in adults. Int J Prosthodont. 2009;22(1):35–42.
[3] Muts EJ, van Pelt H, Edelhoff D, et al. Tooth wear: a systematic review of treatment options. J Prosthet Dent. 2014;112(4):752–759.
[4] Carvalho TS, Colon P, Ganss C, et al. Consensus report of the European Federation of Conservative Dentistry: erosive tooth wear-diagnosis and management. Clin Oral Investig. 2015;19(7):1557–1561.
[5] Loomans B, Opdam N, Attin T, et al. Severe tooth wear: European consensus statement on management guidelines. J Adhes Dent. 2017;19:111–119.
[6] Ganss C, Lussi A. Diagnosis of erosive tooth wear. Monogr Oral Sci. 2014;25:22–31.
[7] Bardsley PF. The evolution of tooth wear indices. Clin Oral Investig. 2008;12 Suppl 1:S15–S19.
[8] Eccles JD. Dental erosion of nonindustrial origin. A clinical survey and classification. J Prosthet Dent. 1979;42(6):649–653.
[9] Smith BG, Knight JK. An index for measuring the wear of teeth. Br Dent J. 1984;156(12):435–438.
[10] Lussi A, Schaffner M, Hotz P, et al. Dental erosion in a population of Swiss adults. Community Dent Oral Epidemiol. 1991;19(5):286–290.
[11] Bartlett D, Ganss C, Lussi A. Basic erosive wear examination (BEWE): a new scoring system for scientific and clinical needs. Clin Oral Investig. 2008;12 Suppl 1:S65–S68.
[12] Wetselaar P, Faris A, Lobbezoo F. A plea for the development of an universally accepted modular tooth wear evaluation system. BMC Oral Health. 2016;16(1):115.
[13] Schlueter N, Luka B. Erosive tooth wear - a review on global prevalence and on its prevalence in risk groups. Br Dent J. 2018;224(5):364–370.
[14] Wetselaar P, Lobbezoo F. The tooth wear evaluation system: a modular clinical guideline for the diagnosis and management planning of worn dentitions. J Oral Rehabil. 2016;43(1):69–80.
[15] Magne P, Gallucci GO, Belser UC. Anatomic crown width/length ratios of unworn and worn maxillary teeth in white subjects. J Prosthet Dent. 2003;89(5):453–461.
[16] Volchansky A, Cleaton-Jones P. Clinical crown height (length)-a review of published measurements. J Clin Periodontol. 2001;28(12):1085–1090.
[17] Al-Jabrah O, Al-Shammout R, El-Naji W, et al. Gender differences in the amount of gingival display during smiling using two intraoral dental biometric measurements. J Prosthodont. 2010;19(4):286–293.
[18] Köseoğlu M, Yanikoğlu N. Investigation of anterior tooth dimensions and color distribution of young patients of turkish society. Oral Health Dent Manag. 2019;18:1–7.

[19] Işcan MY, Kedici PS. Sexual variation in bucco-lingual dimensions in Turkish dentition. Forensic Sci Int. 2003;137(2-3):160–164.
[20] Viciano J, Tanga C, D'Anastasio R, et al. Sex estimation by odontometrics of nonadult human remains from a contemporary Italian sample. Am J Phys Anthropol. 2021;175(1):59–80.
[21] Sterrett JD, Oliver T, Robinson F, et al. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. J Clin Periodontol. 1999;26(3):153–157.
[22] Martinez-Gomis J, Lujan-Climent M, Palau S, et al. Relationship between chewing side preference and handedness and lateral asymmetry of peripheral factors. Arch Oral Biol. 2009;54(2):101–107.
[23] Pereira C, Bernardo M, Pestana D, et al. Contribution of teeth in human forensic identification–discriminant function sexing odontometrical techniques in Portuguese population. J Forensic Leg Med. 2010;17(2):105–110.
[24] Abeleira MT, Outumuro M, Ramos I, et al. Dimensions of central incisors, canines, and first molars in subjects with down syndrome measured on cone-beam computed tomographs. Am J Orthod Dentofacial Orthop. 2014;146(6):765–775.
[25] Rovira-Lastra B, Flores-Orozco EI, Ayuso-Montero R, et al. Peripheral, functional and postural asymmetries related to the preferred chewing side in adults with natural dentition. J Oral Rehabil. 2016;43(4):279–285.
[26] Hossain MZ, Munawar KM, Rahim ZH, et al. Can stature be estimated from tooth crown dimensions? A study in a sample of South-East Asians. Arch Oral Biol. 2016;64:85–91.
[27] Paulino V, Paredes V, Cibrian R, et al. Tooth size changes with age in a Spanish population: percentile tables. Med Oral Patol Oral Cir Bucal. 2011;16(6):e840–e844.
[28] Sanin C, Savara BS. An analysis of permanent mesiodistal crown size. Am J Orthod. 1971;59(5):488–500.
[29] Bjorndal AM, Henderson WG, Skidmore AE, et al. Anatomic measurements of human teeth extracted from males between the ages of 17 and 21 years. Oral Surg Oral Med Oral Pathol. 1974;38(5):791–803.
[30] Alessandri Bonetti G, Zanarini M, Danesi M, et al. Percentiles relative to maxillary permanent canine inclination by age: a radiologic study. Am J Orthod Dentofacial Orthop. 2009;136:486e1–486e6.
[31] von Elm E, Altman DG, Egger M, STROBE Initiative, et al. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ. 2007;335(7624):806–808.
[32] de Vet HC, Terwee CB, Knol DL, et al. When to use agreement versus reliability measures. J Clin Epidemiol. 2006;59(10):1033–1039.
[33] Walker SC, Mattick CR, Hobson RS, et al. Abnormal tooth size and morphology in subjects with cleft lip and/or palate in the North of England. Eur J Orthod. 2009;31(1):68–75.
[34] Wolfart S, Quaas AC, Freitag S, et al. Subjective and objective perception of upper incisors. J Oral Rehabil. 2006;33(7):489–495.
[35] Lazos JP, Senn LF, Brunotto MN. Characterization of maxillary Central incisor: novel crown-root relationships. Clin Oral Investig. 2014;18(6):1561–1567.
[36] Hikita Y, Yamaguchi T, Tomita D, et al. Growth hormone receptor gene is related to root length and tooth length in human teeth. Angle Orthod. 2018;88(5):575–581.
[37] Wetselaar P, Wetselaar-Glas MJM, Katzer LD, et al. Diagnosing tooth wear, a new taxonomy based on the revised version of the tooth wear evaluation system (TWES 2.0). J Oral Rehabil. 2020;47(6):703–712.
[38] Kieser JA, Groeneveld HT, McKee J, et al. Measurement error in human dental mensuration. Ann Hum Biol. 1990;17(6):523–528.
[39] Peraire M, Rustullet O, Anglada JM, et al. Limitations in the use of attachments in a mediterranean population. Quintessence Int. 1996;27:469–471.