JUSTIFICATION OF USE OF FIXED RETAINERS BASED ON THE ANALYSIS OF SIZE OF THE INCISOR AND CANINE CROWNS

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Anatomical features of the teeth should be accounted for dental treatment plans. The need for constant monitoring of changes in the dentition system determines the relevance of this research. The study aimed to establish the size of anterior teeth with the help of odontometry. We made bi-layer single stage impressions and cast diagnostic models of the anterior teeth of 50 male and 50 female participants aged 18–24 years. The absolute sizes of crowns of incisors and canines were established. To assess the reduction of lateral incisors, we calculated the interincisor index (Ii) of teeth 22 and 21; sexual dimorphism was determined using the Garn–Lewis formula. It was discovered that there are no differences in the mesiodistal widths of crowns of contralateral teeth on the right and left sides ($p > 0.05$). The mesiodistal width of crowns of anterior teeth decreases (significant changes) in the following order: maxillary central incisors → maxillary canines → mandibular canines and maxillary lateral incisors → mandibular lateral incisors → mandibular central incisors. The degree of reduction of lateral incisors is low (Ii = 74.9) and more prominent in males than in females. In the examined patients, the greatest mean length of crowns of anterior teeth is that of upper central incisors and lower canines, while upper canines are shorter in length and upper lateral incisors, lower central and lateral incisors have the shortest mean crown length. Males have longer (mean length) crowns of lower canines, upper incisors and canines than females, the difference being significant ($p < 0.001$). The parameters of the crowns determined in this study showed that they have sufficient height and mesiodistal width, which, together with the low degree of reduction of the lateral incisors, justifies the possibility of direct fabrication of orthodontic fixed retainers. The data can also be used at the stage of dental treatment planning.

Keywords: teeth anatomy, odontometry, teeth crowns mesiodistal dimensions, teeth crowns height, dental treatment planning, orthodontic retainer

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ОБОСНОВАНИЕ ИСПОЛЬЗОВАНИЯ НЕСЪЕМНЫХ РЕТЕЙНЕРОВ НА ОСНОВАНИИ АНАЛИЗА РАЗМЕРОВ КОРОНОК РЕЗЦОВ И КЛЫКОВ

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При планировании стоматологического лечения необходимо учитывать анатомические особенности зубов. Необходимость постоянного мониторинга изменчивости зубочелюстной системы определяет актуальность данной работы. Целью работы было оценить размеры коронок фронтальной группы зубов с помощью одонтометрии. Получены двухслойные одноэтапные оттиски и отлиты диагностические модели переднего участка челюстей у 50 мужчин и 50 женщин в возрасте 18–24 лет. Определены абсолютные значения размеров коронок резцов и клыков. Для оценки редукции латеральных резцов вычислен межрезцовый индекс (Ii) по зубам 22 и 21, половой диморфизм определен по формуле Garn–Lewis. Установлено, что различия мезиодистальных размеров коронок одноименных зубов правой и левой стороны отсутствуют ($p > 0,05$). Мезиодистальные размеры коронок статистически значимо убывают в ряду: верхние центральные резцы → верхние клыки → нижние клыки и верхние латеральные резцы → нижние латеральные резцы → нижние центральные резцы. Степень выраженности редукции латеральных резцов низка (Ii = 74,9) и более выражена у мужчин, чем у женщин. У обследованных пациентов среди передних зубов наибольшая высота коронки свойственна верхним центральным резцам и нижним клыкам, меньшая — верхним клыкам, а наименьшая — верхним латеральным резцам, нижним центральным и латеральным резцам. У мужчин высота коронок нижних клыков, верхних резцов и клыков статистически значимо ($p < 0,001$) больше, чем у женщин. Полученные параметры коронок свидетельствуют об их достаточной высоте и мезиодистальных размерах, что в совокупности с низкой степенью выраженности редукции латеральных резцов обосновывает возможность изготовления несъемных ретейнеров прямым методом. Данные могут быть использованы и на этапе планирования стоматологического лечения.

Ключевые слова: анатомия зубов, одонтометрия, мезиодистальные размеры коронок зубов, высота коронок зубов, планирование стоматологического лечения, ретейнер

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Retention is an integral stage of orthodontic treatment. It is defined as preservation of the optimal aesthetic and functional position of teeth once the active phase of orthodontic treatment is over [1].

After active orthodontic treatment, teeth do not become stable, they situation should be considered as dynamic and constantly changing. Therefore, there arises a need for permanent retention to ensure stability of the position of teeth post-treatment. There is a number of biological goals that should be considered when choosing a retainer, such as maintenance of the good condition of periodontal tissues, ensuring optimal oral hygiene, maintaining optimal functional loads on teeth [2, 3].

The reasons behind a potential recurrence of problems addressed with orthodontic treatment may be associated with prolonged remodeling of periodontal tissues, muscle imbalance, changes caused by growth and aging [4]. Long-term studies reveal that in 90% of cases the said problems reappear within 10 to 20 years after the end of the retention phase of treatment [5]. Since only a certain part of dentition needs retention, a term "differential retention" was introduced to stress the special attention paid to the section most prone to recurrence in each orthodontic case [3].

Retainers can be fixed and removable. As the name implies, removable retainers can be removed, which simplifies oral hygiene procedures and allows patients to wear them only through a part of the day, if necessary. However, in some situations retainers should remain in the oral cavity 24 hours a day in order to reduce the chance of recurrence; typically, such conditions call for a fixed retainer [6, 7].

Removable retainers were the retention appliances of choice for many years. In the 1970s, fixed retainers were suggested as a solution preventing recurrence of the treated orthodontic problems around mandibular incisors [8]. A study published in 2002 reported that a third of orthodontists prefer fixed lingual retainers for the mandible and 5% choose fixed retainers for the maxilla [9]. A 2011 publication has shown a shift in opinions: fixed retainers were selected by 42% of orthodontists for the lower jaw and by 11% for the upper jaw [10].

There ways of retaining treatment results preferred by the orthodontists vary greatly region to region. For example, in Norway and the Netherlands, both fixed and removable retainers are often prescribed for the maxilla and fixed retainers for the mandible. In Switzerland, a combination of two types of retainers is often used in cases of maxillary extractions and jaw expansions. Orthodontists practicing in the US, Saudi Arabia and Australia usually opt for removable retainers for the upper jaw and fixed retainers for the lower jaw. In most studies, vacuum formed retainers are the preferred type of a removable retainer [11, 12].

In terms of retainer wear duration, less than 20% of orthodontists in Norway, 52% in Saudi Arabia, approximately 80% in Australia, the US and the UK and 90% in Germany prescribe permanent retention. These differences in the approaches practiced by the orthodontists underscore the importance of having a clear understanding of the relative advantages of each type of retention [11].

In recent years, the list of situation when fixed retainers are prescribed has expanded significantly [13]:

– diastema closure;
– tremas between anterior teeth;
– potential post-orthodontic tooth migration in adult patients;
– loss of teeth or large tremas in maxillary dentition before orthodontic treatment;
– treatment involving extraction of mandibular incisors;
– severe tortoanomaly of maxillary incisors before orthodontic treatment;
– corrected palatal impaction of the canines.

The advantages of fixed retainers are: easy adaptation (usually the adaptation period lasts no more than a week); no active involvement of the patient in the retention process; constant action on the teeth, which reduces both the retention period and the risk of recurrence; virtual invisibility during conversations; minimal effect on articulation [14].

There are direct and indirect methods of fixed retainer fabrication. The choice of the splinting method depends on the anatomy of anterior teeth [15, 16].

Odontometry and odontoscopy provide a scientific basis for selection of the splinting method. The features of dentition and jaws system tend to change in the population, therefore, these studies must be carried out dynamically [17–19]. Odontometry yields results for the following criteria.

1. *Crown anatomy*. Anatomy of the crown drives selection of a tooth to be extracted for orthodontic reasons. This choice is the subject of ongoing debate among orthodontic schools. Some of the schools recommend extraction of a specific (not any) tooth in each case when there is a need for extra space; this approach is largely justified by the anatomy of crowns of teeth. For example, in the upper jaw it is common to extract the second premolar and not the first one. The idea behind this concept is that extraction of the first premolar can cause imbalance as well as aesthetic and functional mismatch of the dental arches. Odontometry is also an integral part of the dental treatment planning process (aesthetic restorations, dental

Table 1. Mesiodistal widths of crowns of incisors and canines

Tooth	Mesiodistal width, mm	*U* value	*p* value
13	7.30 (6.86–7.77)	835	0.903
23	7.27 (6.93–7.63)		
12	6.10 (5.72–6.65)	4753	0.547
22	6.07 (5.71–6.52)		
11	8.08 (7.77–8.43)	4931	0.964
21	8.07 (7.75–8.48)		
31	5.12 (4.84–5.42)	4802	0.807
41	5.12 (4.85–5.38)		
32	5.51 (5.27–5.81)	4694	0.455
42	5.51 (5.20–5.73)		
33	6.31 (6.07–6.72)	4935	0.874
43	6.39 (6.03–6.70)		

Table 2. Z value (lower left corner) and *p* error, pairwise comparisons of the groups of teeth formed by mesiodistal distance of the crown

Teeth	*z* and *p* values					
	13 + 23	12 + 22	11 + 21	31 + 41	32 + 42	33 + 43
13 + 23	–	< 0.001	0.002	< 0.001	< 0.001	< 0.001
12 + 22	10.31	–	< 0.001	< 0.001	< 0.001	0.012
11 + 21	4.64	14.94	–	< 0.001	< 0.001	< 0.001
31 + 41	20.71	10.42	25.31	–	< 0.001	< 0.001
32 + 42	16.96	6.65	21.58	3.79	–	< 0.001
33 + 43	7.79	2.53	12.42	12.94	9.18	–

Note: here and hereafter, the cells where *p* < pcrit are highlighted in gray.

prosthetics) and a feasible study in the context of diagnosing increased tooth wear and their subsequent restoration [20, 21].

2. *Root anatomy*. In the orthodontic literature, the importance of root anatomy in orthodontic treatment is conveyed via the concept of anchorage. Anchorage is resistance to undesirable displacement of teeth [22].

A specific anchorage value is selected for each tooth based on various criteria: root surface; capability of periodontal ligament to resist displacement regardless of its direction; root length, i.e. a longer root is considered to be fixed deeper. The most preferred method of anchorage calculation involves assessment of the root volume, which represents the three-dimensional integrity of root and alveolar bone [20].

3. *Anatomy of the entire tooth*. In some clinical situations, the anatomy of the entire tooth shapes the treatment plan. One of such cases, for example, is transposition of the lateral incisor and maxillary canine. Currently, the advancements of restorative and orthopedic dentistry allow changing the shape of the tooth crown (coronoplasty), a popular solution for a lateral incisor implying shaping it as a canine [20].

It should be noted that the last odontometric studies in the Republic of Belarus were conducted over 10 years ago, which, together with the need for constant monitoring of the variability of the dentition [23], establishes the relevance of this work.

This study aimed to establish the size of crowns of incisors and canines in the population of the Republic of Belarus and substantiate the possibility of using fixed retainers.

METHODS

Using disposable plastic spoons and C-silicone from the Zetaplus L TrialKit (Zhermack Spa; Italy), two-layer one-stage impressions of the anterior teeth of 100 volunteering participants (50 male, 50 female) were made and studied. The inclusion criteria were: age from 18 to 24; permanent residence in the Republic of Belarus. The exclusion criteria were: refusal to participate in the study, restorations or prosthetics on the upper and lower incisors and canines.

We cast diagnostic models EliteModel (Zhermack SpA) supergypsum and, using them, established mesiodistal dimensions (distance between the protruding points of the mesial and distal edges of a crown) and height of crowns of incisors and canines with an electronic caliper DR6003 (Dr.Iron; China) with resolution of 0.01 mm and accuracy of ±0.01 mm. The results of sizing 797 incisors (including 199 upper central, 200 upper lateral, 200 lower central, 198 lower lateral) and 400 canines (including 200 upper, 200 lower canines) were recorded in the study card.

To assess the reduction of lateral incisors, we calculated the interincisor index (Ii) for teeth 22 and 21 [24, 25]; sexual dimorphism was determined using the Garn–Lewis formula, median values [26].

Statistical processing of the obtained results was enabled by the Past 3.0 software [27]. The quantitative variables as a median, lower and upper quantiles Me (Q_1–Q_3) were described.

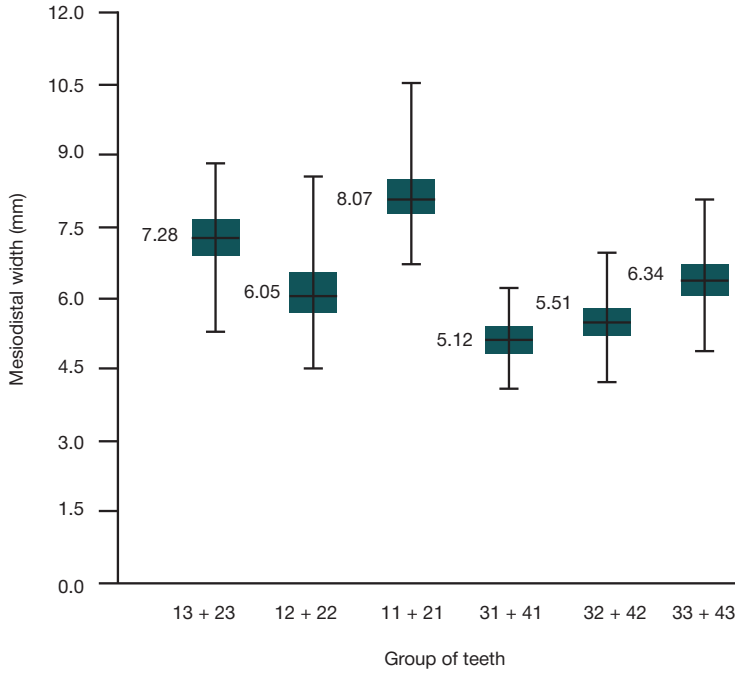

Fig. 1. Comparison of mesiodistal widths of crowns, individual groups of teeth

Table 3. Mesiodistal widths of anterior teeth crowns in men and women

Teeth	Sex	Mesiodistal width, mm	*U* value	*p* value	Sexual dimorphism
Maxillary canines	male	7.26 (6.92–7.63)	4371	0.125	–1.6
	female	7.38 (6.95–7.80)			
Maxillary lateral incisors	male	5.92 (5.38–6.35)	3161	<0.001	–6.3
	female	6.32 (5.94–6.66)			
Maxillary central incisors	male	7.99 (7.59–8.40)	4256	0.088	–1.8
	female	8.14 (7.81–8.51)			
Mandibular central incisors	male	5.09 (4.81–5.37)	4455	0.27	–1.5
	female	5.17 (4.89–5.42)			
Mandibular lateral incisors	male	5.45 (5.10–5.69)	3907	0.008	–1.4
	female	5.53 (5.33–5.86)			
Mandibular canines	male	6.37 (6.03–6.72)	4852	0.718	1
	female	6.31 (6.06–6.68)			

The degree of variation intensity was determined with the coefficient of variation (*V*).

The significance of differences between two independent groups was determined by the U (Mann-Whitney) and χ^2 (Pearson) tests with a critical level of significance for statistical hypotheses at 0.05. The significance of differences in multiple comparisons was determined by the *H* test (Kruskal–Wallis, with a critical significance level of 0.05), in post hoc comparisons - by the Dunn's test (z value) with the Bonferroni correction (with a critical significance level of 0.0034 (six compared groups)) [28, 29].

RESULTS

The median age of the examined patients was 21.0 (20.0–22.0); we did not discover significant differences in the age of men (21.0 (20.0–22.3) and women (21.0 (21.0–21.3)) (U = 1116; $p > 0.05$). Table 1 presents the mesiodistal width of the anterior teeth crowns.

It was noticed that there are no differences in the mesiodistal widths of crowns of contralateral teeth on the right and left sides, which allowed grouping them. Multiple comparisons of the formed groups of teeth revealed significant differences between them (H = 937.0; $p < 0.001$), post hoc comparisons (Table 2) showed significant differences between all groups (except for the comparison of lower canines and upper lateral incisors).

The mesiodistal widths of crowns (Fig. 1) decrease in the following order: upper central incisors (8.07 (7.77–8.46 mm)) → upper canines (7.28 (6.93–7.69) mm) → lower canines (6.34 (6.05–6.70) mm) and upper lateral incisors (6.05 (5.71–6.58) mm) → lower lateral incisors (5.51 (5.23–5.77)) mm) → lower central incisors (5.12 (4.85–5.39) mm). It should be noted that these data are consistent with the results reported in previous studies [23].

Comparing the mesiodistal widths of the anterior teeth crowns of male and female participants (Table 3), we discovered significant differences in cases of maxilla lateral incisors (5.92 (5.38–6.35) mm and 6.32 (5.94–6.66) mm, respectively) and mandible lateral incisors (5.45 (5.10–5.69) mm and 5.53 (5.33–5.86) mm, respectively). A noteworthy observation is that the highest degree of sexual dimorphism was characteristic of the upper lateral incisors (the value of the Gang–Lewis index was –6.3).

The Ii value for all examined patients was 74.9 (70.8–80.8), which indicates a low degree of lateral incisor reduction. It was found that the degree of intensity of variation of Ii is low (V = 9.62), and only in 21% of cases its value was below 70.

Females had the interincisal index value at 76.3 (73.1–82.0), which is significantly (U = 855; $p < 0.01$), by 4.0% greater that registered in men (73.4 (67, 8–78.1). Males (n = 17; 34.0%) had the value of this index below 70 4.3 times more often (χ^2 = 10.2; $p < 0.01$) than females (n = 4; 8.0%), which suggests a conclusion that, in the population of the Republic of Belarus,

Table 4. Height of crowns of incisors and canines

Tooth	Crown height, mm	*U* value	*p* value
13	9.29 (8.59–9.99)	4701	0.247
23	9.18 (8.54–9.84)		
12	8.14 (7.47–8.77)	4695	0.456
22	8.25 (7.65–8.69)		
11	9.60 (8.91–10.27)	4917	0.936
21	9.58 (9.01–10.26)		
31	7.91 (7.30–8.70)	4645	0.526
41	7.88 (7.22–8.60)		
32	8.28 (7.62–8.94)	4867	0.746
42	8.19 (7.61–8.91)		
33	9.53 (8.81–10.24)	4953	0.906
43	9.51 (8.78–10.24)		

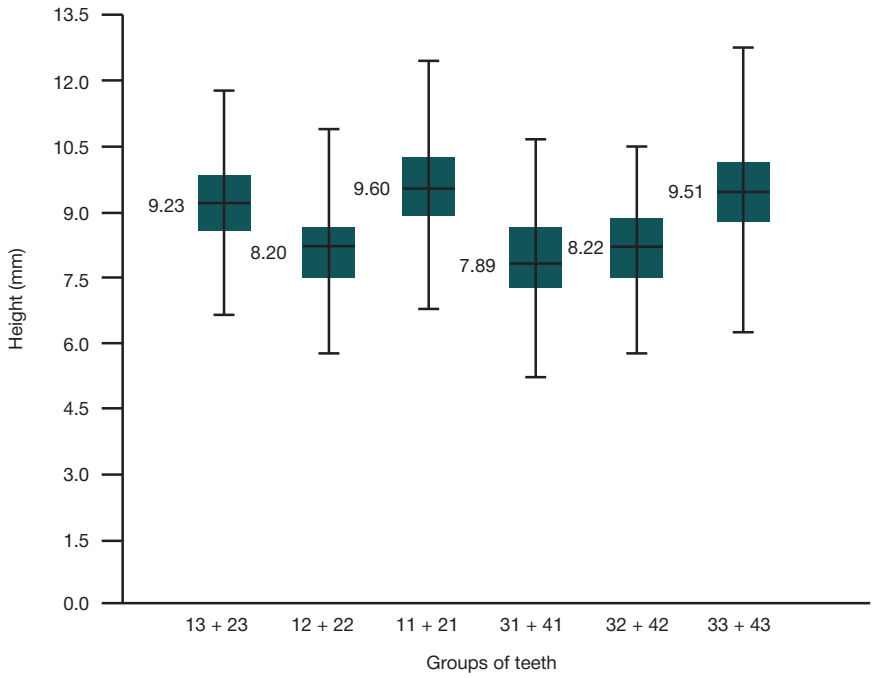

Fig. 2. Comparison of the crown height of individual groups of teeth

there is a more pronounced reduction of lateral incisors in males.

Table 4 presents data on the height of anterior teeth crowns.

It was discovered that there are no differences in height of crowns of contralateral teeth on the right and left sides ($p > 0.05$), which allowed grouping them (Fig. 2). Multiple comparison of the formed groups of teeth yielded the Kruskal–Wallis test value of 371.2, which indicates significant differences between them ($p < 0.001$).

The longest crowns were those of the upper central incisors (9.60 (8.96–10.27) mm), lower canines (9.51 (8.81–10.24) mm) and upper canines (9.23 (8.96–10.24) mm). .55–9.90) mm), and the smallest — of the upper lateral incisors (8.20 (7.54–8.72) mm), lower central and lateral incisors (7.89 (7.23–8.63) and 8.22 (7.62 – 8.91) mm, respectively).

The results of post hoc comparisons are given in Table 5. We found significant differences between all groups (with the exception of comparisons of upper canines and lower canines, upper lateral incisors and lower incisors, upper central incisors and The mesiodistal width of crowns of anterior teeth decrease (significant changes) in the following order: maxillary central incisors — maxillary canines — mandibular canines and maxillary lateral incisors — mandibular lateral incisors — mandibular central incisors, lower canines).

It was established that males have longer crowns of the lower canines, upper central and lateral incisors and canines (Table 6), the difference with females being significant (the values of the Gang–Lewis index for this attribute were 8.4, 6.8, 7.3, and 4.7).

DISCUSSION

The study established that the mesiodistal widths of crowns (Fig. 1) in the population of the Republic of Belarus decrease in the following order: upper central incisors (8.07 (7.77–8.46 mm)) → upper canines (7.28 (6.93–7.69) mm) → lower canines (6.34 (6.05–6.70) mm) and upper lateral incisors (6.05 (5.71–6.58) mm) → lower lateral incisors (5.51 (5.23–5.77)) mm) → lower central incisors (5.12 (4.85–5.39) mm). These data are consistent with the results of a study completed in 2009 [23]. The crowns of the maxillary and mandibular lateral incisors of females are larger in mesiodistal width than those in males.

The severity of reduction of lateral incisors was found to be low (Ii = 74.9 (70.8 – 80.8)). Males in the Republic of Belarus have more pronounced reduction of lateral incisors (Ii = 73.4 (67.8–78.1)) than females (Ii = 76.3 (73.1–82.0)). This conclusion is consistent with the results of a study that found the prevalence of reduction of lateral incisors in men [30].

In the examined patients, the longest crowns in the anterior segment were those of upper central incisors (9.60 (8.96–10.27) mm) and lower canines (9.51 (8.81–10.24) mm), while upper canines were smaller in length (9.23 (8.55–9.90) mm) and upper lateral incisors (8.20 (7.54–8.72) mm), lower central and lateral incisors (7.89 (7.23–8.63) and 8.22 (7.62–8.91) mm, respectively) the smallest. It was demonstrated that males have longer crowns of the lower canines, upper incisors and canines than females, the difference being significant ($p < 0.001$).

Table 5. Z value (lower left corner) and p error, pairwise comparisons of the groups of teeth formed by crown height

Teeth	*z* and *p* values					
	13 + 23	12 + 22	11 + 21	31 + 41	32 + 42	33 + 43
13 + 23	–	< 0.001	0.002	< 0.001	< 0.001	0.037
12 + 22	8.89	–	< 0.001	0.109	0.438	< 0.001
11 + 21	3.13	12	–	< 0.001	< 0.001	0.295
31 + 41	10.47	1.61	13.57	–	0.017	< 0.001
32 + 42	8.11	0.78	11.23	2.38	–	< 0.001
33 + 43	2.08	10.97	1.05	12.54	10.19	–

Table 6. Crown height of anterior teeth crowns in men and women

Teeth	Sex	Height, mm	*U* value	*p* value	Sexual dimorphism
Maxillary canines	male	9.52 (9.09–10.23)	3094	< 0.001	4.7
	female	8.90 (7.87–9.52)			
Maxillary lateral incisors	male	8.42 (8.02–9.02)	3061	< 0.001	7.3
	female	7.85 (7.10–8.45)			
Maxillary central incisors	male	9.99 (9.21–10.40)	3029	< 0.001	6.8
	female	9.35 (8.43–9.90)			
Mandibular central incisors	male	7.94 (7.43–8.66)	4414	0.228	0.8
	female	7.88 (7.13–8.60)			
Mandibular lateral incisors	male	8.33 (7.66–9.07)	4315	0.094	2.8
	female	8.10 (7.56–8.79)			
Mandibular canines	male	9.93 (9.18–10.74)	2845	< 0.001	8.4
	female	9.16 (8.44–9.88)			

CONCLUSIONS

Thus, the size parameters of incisors and canines determined in this study show that these teeth have sufficient crown length and mesiodistal width, which, together with the low degree of reduction of lateral incisors, justifies the possibility of direct fabrication of orthodontic fixed retainers. The data from this study can also be used at the stage of dental treatment planning (aesthetic restorations, orthopedics and orthodontics).

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