Original Article

Dental features and treatment findings of impacted maxillary central incisors: A multicenter study

ABSTRACT

Background: Impacted upper central incisors substantially affect esthetics, function, and the self-esteem of patients. This retrospective multicenter study was designed to assess and compare the demographic and radiographic features and treatment findings for patients with impacted upper central incisors in three different countries.

Materials and Methods: Diagnostic and treatment records, panoramic radiographs, and lateral cephalograms were retrieved for 74 (32 female) patients (11.24 ± 2.9 years old), with impacted upper central incisors from the USA, Germany, and Colombia, according to the preset eligibility criteria. Sagittal and vertical angulation and location of the upper impacted central incisors, type of radiographic skeletal malocclusion, surgical procedures, and duration of treatment were investigated.

Results: Statistically significant differences between the three groups were found for age ($P = 0.003$), duration of treatment ($P = 0.001$), and location of the impacted upper central incisors ($P = 0.015$). The angulation was significantly bigger for the impacted central incisors compared to the respective normal incisors ($P < 0.0001$). The age of the patients did not influence the treatment time. The regression model showed that higher height of impaction was associated with a closed surgical procedure ($P = 0.046$).

Conclusions: Patients with impacted incisor treated in three different centers showed differences in terms of age, gender, treatment time, and type of surgical treatment. The surgical access with closed surgery has a direct relationship with a more apical location of the impacted incisor.

Keywords: Impacted tooth, incisors, multicenter study, orthodontics

INTRODUCTION

Eruption of teeth is a dynamic process, and its failure is a multifaceted phenomenon which encompasses local (i.e., dental trauma, mesiodens, or other supernumerary teeth,[1] dilacerations,[2] odontoma, or other atypical dental structure, dentigerous cyst, premature loss or prolonged retention of a deciduous tooth, dental crowding, dense mucoperiosteum, abnormal inclination, germ malposition, alveolar cleft) and systemic (i.e., endocrine deficiencies, radiation therapy, cleidocranial dysostosis, and amelogenesis imperfecta) factors.[3,4] Apart from individual components, further aspects such as race, ethnicity, and gender can also affect eruption and therefore should be considered when the nature of normal eruption is discussed.[5,6] Impaction of teeth is regarded as a frequent phenomenon with much variation of its prevalence and distribution in the different regions of the jaw.[7] Detailed assessment of the location, angulation, and orientation of the impacted tooth is important for

Eleni N Katsikogianni, Sarah H Abu Arqub[1], Taranpreet Chandhoke[2], Nikolaos Nikitas Giannakopoulos[3], Diana M Barbosa-Liz[4]

Department of Orthodontics, Faculty of Medicine, Heidelberg University, Heidelberg, Germany, [1]UCONN Fellow, Associate Orthodontist, Sunna Orthodontic Center, Amman, Jordan, Abu Dhabi, UAE, [2]Assistant Professor, Division of Orthodontics, University of Connecticut School of Dental Medicine, Connecticut, USA, [3]Department of Prosthodontics, Faculty of Medicine, University of Würzburg, Würzburg, Germany, [4]Gionorto Research Group, Faculty of Dentistry, University of Antioquia, Medellín, Colombia

Address for correspondence: Dr. Diana M Barbosa-Liz, Gionorto Research Group, Department of Orthodontics, University of Antioquia, Calle 70 # 52-21, Medellìn, Antioquia, Colombia. E-mail: dimabarbosa@gmail.com

Access this article online	
Website: www.orthodrehab.org	Quick Response Code
DOI: 10.4103/ijor.ijor_5_19	

How to cite this article: Katsikogianni EN, Arqub SH, Chandhoke T, Giannakopoulos NN, Barbosa-Liz DM. Dental features and treatment findings of impacted maxillary central incisors: A multicenter study. Int J Orthod Rehabil 2019;10:1-9.

orthodontic treatment planning.[8,9] For this purpose, a variety of imaging methods have been advocated through the years, including use of panoramic, occlusal, cephalometric, or periapical radiographs.[10] Recently, to overcome the shortcomings of two-dimensional (2D) imaging, cone-beam computed tomography (CBCT) has been introduced for three-dimensional evaluation and location of impacted teeth.[11-13]

The prevalence of impacted teeth in different populations and ethnic groups has been the subject of several studies.[14] Impaction of maxillary central incisors occurs with a prevalence of 0.06%–0.2%.[15] Their low incidence, however, contradicts the high clinical importance of this disorder, as maxillary incisors are the most prominent teeth in an individual's smile. Thus, their normal eruption, position, and morphology are crucial to facial esthetics and phonetics.[8] Moreover, the great clinical relevance of this situation is well reflected by the number of published case reports focusing on the different treatment options for impacted central incisors.[10] Periodontal and orthodontic management of impacted maxillary central incisors poses several substantial challenges, particularly because of the position within an esthetically important region. Careful soft-tissue management is required to ensure a successful long-term esthetic outcome. Treatment of impacted incisors requires an interdisciplinary approach. The two main alternatives are either surgical exposure (open or close) with orthodontic traction and alignment or extraction and subsequent prosthetic replacement.[16] Early diagnosis is considered to be of pivotal importance as far as the success of the orthodontic treatment is concerned.[17] Sun *et al*.[18] also found that early treatment could promote better morphology of root apex reducing the risk of alveolar bone loss.

Understanding the developmental process, morphogenic diversity, and variations in treatment outcomes for impacted incisors contributes to an amelioration of the conditions of a multidisciplinary treatment approach.[19,20] Sociodemographic, clinical, and other findings from larger samples of patients with impacted upper central incisors could contribute to a more profound knowledge of this pathology. Regarding the relative low prevalence of this condition, larger samples are not easy to find. This condition could be studied in multicenter and thus multicultural studies. The differences between patient samples from different countries with impacted incisors are yet unknown.

In this context, the current study is the first attempt to specify the main features as well as treatment patterns for impacted maxillary central incisors in a multicentric and multicultural setting. The main objectives of this study were as follows:

1. Description, evaluation, and comparison of demographic and radiographic findings, for subjects with impacted central incisors from different centers located in different countries
2. Description of the performed surgical procedure and evaluation of the success and duration of the orthodontic treatment
3. Outline of specific demographic and radiographic findings, which may influence the type of surgical treatment and the duration of the treatment at patients with impacted maxillary incisors.

MATERIALS AND METHODS

Study design

This investigation was designed as a multicenter, retrospective study. The participants were enrolled from the patient registries of the Orthodontic Department of three different university clinics: (i) University of Connecticut, Connecticut, USA; (ii) University of Antioquia, Medellin, Colombia; and (iii) Ruprecht-Karls-University, Heidelberg, Germany.

Selection and description of participants

Eligible patients were children and adolescents without any age limitation. Inclusion criteria were as follows: (i) at least one unilateral or bilateral impacted central incisor; (ii) treated by combined orthodontic and surgical procedures, (iii) complete diagnostic and treatment records, and (iv) availability of pretreatment panoramic radiographs and lateral cephalograms. Participants with all types of malocclusions were included in the study. Patients with a history of trauma in the anterior region or ankylosed maxillary central incisors, cleft lip, and/or other craniofacial anomalies were excluded from the study. Cases for which panoramic radiographs or lateral cephalograms were of inadequate quality, precluding their correct evaluation, were not included in our study sample. Due to the study design and the low prevalence of the condition, no sample size calculation was performed in advance. Seventy-four patients conformed to our eligibility criteria and were finally included in the study.

Ethics

The methods adhered to the tenets of the Declaration of Helsinki for the use of human participants in biomedical research. The study protocol was approved by the respective institutional review boards and ethics committees, separately in each participating country (reference numbers: 14-075-3 for USA; minute no. 4, 18-06-2014 for Colombia; and S-048/2014 for Germany).

Examiners and procedures

Patients' records were retrieved to obtain general information about country of residence, age at the first visit, sex, affected side, treatment time, and type of surgical procedure. The radiographic analysis was performed by one of the authors (SAA) who was unaware of the patient's identity, the surgical technique used, and the clinical outcome. To enable high final reliability, a two-phase calibration was conducted before the main radiographic analysis (intraclass correlation coefficient: 0.84, excellent).

Both panoramic radiographs and lateral cephalograms were analyzed for each patient to detect the presence of root dilaceration, anodontia, other impactations, malformation or supernumerary teeth (i.e., mesiodens), to measure the vertical position of the impacted maxillary central incisor, and its inclination relative to the occlusal plane, and to assess the radiographic patient's skeletal pattern (Class I, II, or III malocclusion according to the ANB angle).

The description of all radiographic variables measured is presented in Table 1. The evaluation of the position and angulation of the impacted incisor of panoramic radiographs was based on the modified analysis presented for impacted canines by Novak *et al*.[21] using angles and sectors. The vertical position of the impacted central incisor was evaluated based on four different zones and depended on the occlusal position of the incisal edge of the impacted maxillary central incisor relative to the root of the contralateral normally erupted central incisor [Figures 1-3].

To determine the inclination of the crown and the root of the impacted maxillary central incisors, lateral cephalograms were analyzed by use of the procedure described by Ho and Liao[12] [Figures 4 and 5].

In cases of bilateral impaction, the position of the impacted maxillary central zone was assessed in relation to the adjacent normally erupted lateral incisor. The surgical procedure conducted (open or closed) and duration of treatment for alignment of the impacted central incisor/s were evaluated. The type of orthodontic traction treatment

Table 1: Description of the radiographic variables evaluated in the X-rays

Variable	Definition
Panoramic radiograph	
Angle A	Angle between the long axis of the impacted tooth and the maxillary vertical midline, which passes through the nasal septum
Angle B	Angle between the long axis of the impacted tooth and the perpendicular to the occlusal plane
Zone 1	Impacted incisor located apical to the apex of the contralateral incisor
Zone 2	Impacted incisor located on the apical third of the root of the contralateral incisor
Zone 3	Impacted incisor located on the middle third of the root of the contralateral incisor
Zone 4	Impacted incisor located on the coronal third of the contralateral incisor
Lateral cephalogram	
CIAi	Angle between the long axis of the crown of the impacted tooth and the palatal plane
CIAI	Angle between long axis of the crown of the normally erupted maxillary central incisor and the palatal plane
UIAi	Angle between long axis of the impacted tooth and the palatal plane
UIAI	Angle between long axis of the normally erupted maxillary central incisor and the palatal plane
Angle SNA	Sella-Nasion Angle A
Angle SNB	Sella-Nasion Angle B
Angle ANB	Angle A minus Angle B

CIAi: Impacted upper incisor crown angulation, CIAI: Normal upper incisor crown angulation, UIAi: Impacted upper incisor angulation, UIAI: Upper incisor normal angulation

Figure 1: Depiction of the angulation of impacted maxillary incisor (Angle A)

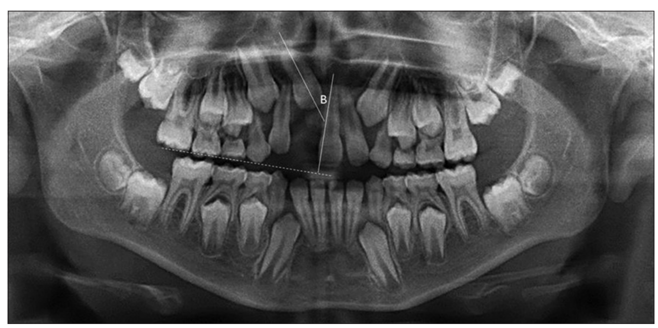

Figure 2: Depiction of the angulation of impacted maxillary incisor (Angle B)

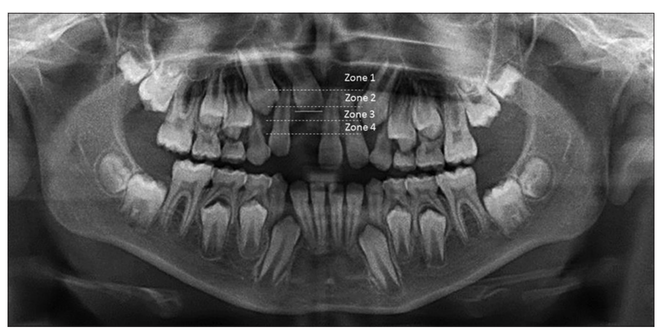

Figure 3: Location of the impacted maxillary incisors on the basis of zone distribution

Figure 4: Angulation of impacted and normal long axis (UIAi and UIAI, respectively). UIAi: impacted upper incisor angulation, UIAI: Normal upper incisor angulation

Figure 5: Angulation of impacted and normal crown incisor axis (CIAi and CIAI, respectively). CIAi: Impacted upper incisor crown angulation, CIAI: normal upper incisor crown angulation

(e.g., 4 × 2 appliance traction with elastic chain, 4 × 2 appliance with NiTi wire, removable appliance, full orthodontic appliance, lower anchorage traction, Nance appliance anchorage traction, and others) was also registered.

Statistical analysis

Data analysis was performed with SPPS® 23.0 (IBM Corp., Armonk, NY, USA). The significance level was $P \leq 0.05$. Normality of data distribution was examined by use of the Kolmogorov–Smirnov test. For descriptive analysis, qualitative variables were expressed as percentages, whereas quantitative measurements were presented as mean values with standard deviation. A multivariate regression model was calculated with the type of surgical procedure and a simple linear regression model was calculated with the duration of the treatment as dependent variable.

RESULTS

Demographic data

The final convenience sample consisted of 74 patients, 33 from Colombia, 23 from the USA, and 18 from Germany; the mean age was 11.2 ± 2.9 years. The detailed demographic distribution and general information about the participants are presented in Table 2. The USA sample was significantly older than each of the other (Kruskal–Wallis one-way analysis of variance on ranks $P = 0.003$).

Radiographic findings

Additional radiographic dental anomalies were indicative of the high comorbidity of such findings as anodontia, dilaceration, other impactions, or supernumerary teeth [Table 2]. With regard to gender, the prevalence of supernumerary or missing teeth was 16.7% for males and 12.5% for females. The frequency of malformed teeth (2.4% vs. 12.5%) and other impactions (16.7% vs. 28.1%) was greater for females than for males, but not significantly.

Radiographic measurements

Table 3 summarizes the measurements obtained from the panoramic radiographs. In almost 50% of the cases, the impacted central incisors were located in the third zone (i.e., the medium third of the contralateral central incisor root). Regarding the radiographic data assessed from the panoramic radiographs, Kruskal–Wallis one-way analysis of variance on ranks (*post hoc* comparison with Bonferroni correction) revealed overall significantly different ($P = 0.015$) location of the impacted tooth, according to the zone, due to the higher percentage in Zones 3 and 4 of the German sample compared to the USA sample. Mean angles A and B did not differ significantly between the different countries.

The crown angulation of the impacted teeth, evaluated on cephalograms, showed a significantly higher variance from that of one of the normally erupted incisors [Table 4]. Moreover, the angles of the long axis of the incisor (UIA) or the long axis of the crown (CIA) and the palatal plane were both significantly bigger for the impacted central incisors compared to the respective normal incisors (related samples Wilcoxon-signed rank test, $P < 0.001$). Furthermore, our results revealed no significant differences for the crown or tooth angulations of the impacted central incisors among the three different country groups (Kruskal–Wallis one-way analysis of variance on ranks, $P > 0.05$).

Surgical procedure and orthodontic treatment

The specific and general characteristics of the treatment in our sample are summarized in Table 5. The closed surgical

Table 2: Summary of patients' demographic and radiographic characteristics according to country (n=74)

Variable	Colombia	Germany	USA	Total	P (Kruskal-Wallis)
Age years, mean±SD	10.57±1.8	10.01±1.4	13.14±3.9	11.24±2.9	0.003*
Gender, n (%)					
Male	23 (69.7)	9 (50.0)	10 (43.5)	42 (56.8)	
Female	10 (30.3)	9 (50.0)	13 (56.5)	32 (43.2)	
Side of impaction, n (%)					
Left	17 (51.5)	5 (27.8)	8 (34.8)	30 (40.5)	
Right	16 (48.5)	7 (38.9)	12 (52.2)	35 (47.3)	
Bilateral		6 (33.3)	1 (4.3)	7 (9.5)	
Missing			2 (8.7)	2 (2.7)	
Skeletal relationship, n (%)					
Class I	18 (54.5)	3 (16.7)	9 (39.1)	30 (40.5)	
Class II	11 (33.3)	9 (50.0)	7 (30.4)	27 (36.5)	
Class III	1 (3.0)	6 (33.3)	6 (26.1)	13 (17.6)	
Missing	3 (9.1)		1 (4.3)	4 (5.4)	
Anomalies, n (%)					
None	13 (39.4)	9 (50.0)	11 (47.8)	33 (44.6)	
Other impacted	5 (15.2)	3 (16.7)	8 (34.8)	16 (21.6)	
Supernumerary or agenesis	7 (21.2)	2 (11.1)	2 (8.7)	11 (14.9)	
Malformation	3 (9.1)	1 (5.6)	1 (4.3)	5 (6.8)	
Combination	3 (9.1)	3 (16.7)	1 (4.3)	7 (9.5)	
Missing	2 (6.1)			2 (2.7)	
Total, n (%)	33 (44.6)	18 (24.3)	23 (31.0)	74 (100)	

*Statistically significant difference, P<0.05. SD: Standard deviation

Table 3: Summarized measurements in panoramic radiographs

Variable	Colombia (n=33)	Germany (n=18)	USA (n=23)	Total (n=74)	Significance Kruskal-Wallis one-way analysis of variance on ranks (P)
Angle A, mean±SD	15.7±31.2	9.9±22.1	33.9±41.3	19.1±33.4	0.134
Angle B, mean±SD	27.1±32.0	26.2±25.5	36.1±33.9	29.3±30.4	0.449
Zone, number of cases (%)					
1	1 (3.0)		6 (26.1)	7 (9.5)	0.015*
2	10 (30.3)	1 (5.6)£	5 (21.7)£	16 (21.6)	
3	19 (57.6)	11 (61.1)	7 (30.4)	37 (50.0)	
4	3 (9.1)	6 (33.3)	5 (21.7)	14 (18.9)	

*Statistically significant difference, P<0.05, £Pairwise comparisons: USA-Colombia, P>0.05; Germany-Colombia, P=0.052; USA-Germany, P=0.019 (Bonferroni correction for multiple tests). SD: Standard deviation

Table 4: Descriptive statistics of the angular measurements on lateral cephalograms

Measurement (°)	Country			Total (n=74)	Significance (P)
	Colombia (n=33), mean±SD	Germany (n=18), mean±SD	USA (n=23), mean±SD		
Impacted crown CIAi	121±20	114±30	123±35	120±28	<0.001*
Normal crown CIAI	114±7	113±12	112±10	113±9	
Impacted incisor UIAi	123±19	116±28	122±32	121±26	<0.001*
Normal incisor UIAI	118±6	114±9	117±9	117±8	

*Statistically significant difference, P<0.05. Wilcoxon-signed rank test. CIAi: Impacted upper incisor crown angulation, CIAI: Normal upper incisor crown angulation, UIAi: Impacted upper incisor angulation, UIAI: Upper incisor normal angulation, SD: Standard deviation

technique was the preferred (67.6%) type of interventional tooth exposure procedure. When evaluating the type of surgical procedure according to the cephalometric malocclusion classification, most of the Class II (81.5%) and all Class III malocclusion cases were treated with a closed surgical procedure. Regarding the treatment time, the mean treatment duration was 14.6 ± 9.1 months. A significantly different (P = 0.037) duration of treatment among the three

Table 5: Distribution of the type of surgical procedure and duration of treatment according to the country group

Variable	Colombia (n=33)	Germany (n=18)	USA (n=23)	Total (n=74)	Significance (P)
Surgical procedure, n (%)					
Open	7 (21.2)	3 (16.7)	7 (30.4)	17 (23.0)	-
Closed	21 (63.6)	15 (83.3)	14 (60.9)	50 (67.6)	-
Missing records	5 (15.2)		2 (8.7)	7 (9.5)	-
Duration of treatment (months), mean±SD	18.8$^{£}$±11.0	11.8±5.2	10.7±5.7	14.6±9.1	<0.0001*

*Statistically significant difference, P<0.05. Kruskal-Wallis. Bonferroni correction for pairwise comparisons. $^{£}$Pairwise comparisons: USA-Colombia, P=0.001; Germany-Colombia, P=0.013; USA-Germany, P>0.05. SD: Standard deviation

samples was found; the longest duration of treatment was observed for the Colombian sample. Kruskal–Wallis one-way analysis of variance on ranks (with Dunn's method for *post hoc* pairwise comparisons) revealed that the difference between the USA and Colombian groups was significant.

A great variability was found in the type of orthodontic treatment performed and there was no predominant form of traction treatment. All forms of orthodontic traction of the upper impacted incisor employed were successful.

A logistic regression analysis was performed to ascertain the effects of sample origin, age, gender, cephalometric skeletal relationship, side of impaction, simultaneous presence of other anomalies, zone of impaction, and radiographic angles (CIA, UIA) on the likelihood that a closed surgical procedure will be chosen. Participants with Angle Class III malocclusion were more likely to receive a closed surgical procedure (P = 0.021). Higher height of impaction was associated with an increased likelihood (P = 0.046) of choice of a closed surgical procedure.

Likewise, to find which factor could influence the treatment time, a simple linear regression model, with duration of treatment concerning the traction and alignment of the upper central incisor/s as dependent variable, was calculated to enable comparison of our results with those from previous studies. No correlation between the treatment time and the age of the patients was found. In addition, when 10 years of age was used as a cutoff, no significant differences were observed, regarding the radiographic findings and the variables sex, radiographic skeletal malocclusion, height and side of impaction, and surgical procedure.

DISCUSSION

The current prevalence of impacted maxillary central incisors has a rate of 0.06–0.2 according to the available literature;[3,5] hence, only some studies have reported on a slightly larger sample.[12,18,22] To study such a rare condition, multicenter studies could be needed. To the best of our knowledge, our study is the first to report a multicenter and multicultural sample summarizing demographic and radiographic findings of impacted maxillary incisors regarding also aspects concerning the surgical procedures and the orthodontic treatment.

Adequate knowledge of the timing and pattern of permanent tooth emergence is essential for diagnosis and treatment planning in pediatric dentistry and orthodontics. Normal eruption of the central incisors typically occurs between 8 and 10 years of age.[4] As a result of their location alone, impacted maxillary central incisors pose a disturbing esthetic dilemma to the parents of a child. Careful supervision of the developing dentition and early diagnosis of aberrations in eruption are essential for early intervention and correction.[8,23] In this study, we considered the age of the patient at the beginning of the traction treatment.[24]

According to the results of our study, there was no difference between the prevalence of impacted incisors and supernumerary teeth in males and females. In contrast, some authors[17,25] found that females have more impacted incisors than males. The possible effect of ethnicity on these findings should be investigated.[26] Van Buggenhout and Bailleul-Forestier suggested, moreover, that supernumerary teeth affect males approximately twice as frequently as females.[2] One reason for these differences could be the low prevalence of supernumerary anomalies in our population; this fact could also indicate a regional or ethnic effect.

Numerous but nonsignificant associations between different dental anomalies have also been revealed in cases of impacted maxillary central incisors, including other impactions, supernumeraries, and malformed and missing teeth.[23,27] The high variability of additional dental radiographic findings among the groups involved in this work may imply that ethnic factors could affect the prevalence of these conditions.

In our study, we included patients with panoramic radiographs because the diagnostic information obtained is sufficient for overview and prediction of tooth eruption, root resorption, and treatment results. However, despite its much higher availability, panoramic radiography has some limitations.[28] CBCT has the benefit of enabling evaluation of tissue dimensions more precisely[29,30] and has been used for applications in orthodontics, although its high radiation dose is a major concern. Panoramic radiography, in contrast, uses a lower dose of radiation and provides comprehensive information about complete dentition, jaws, and the surrounding structures.[3] Several factors can affect 2D image quality and accuracy, for example, patient positioning errors and distortion effects inherent in the radiological technique used.[28] To reduce these crucial limitations, high-quality procedures are required. All three orthodontic departments involved in this work have similar long experience and established standard radiological procedures, and they all use a comparable radiation process. Despite this, the limitation of the 2D imaging method used in our study still applies, without affecting, though, our investigation.

The results obtained reveal high variability of the initial angulation of the impacted maxillary incisor in the different country groups. No specific pattern of position was, therefore, observed in our study similar to the findings made by Ho and Liao.[12] The angulation of the crown and the long axis of impacted maxillary incisor and the palatal plane (CIAi and UIAi) were significantly bigger for the impacted central incisors compared to the respective normal incisors. This finding may be further examined and quantified, in order to be able to predict a potential impaction of a tooth in a primary stage. This situation suggests an increase in the complexity of the orthodontic treatment, since not only the impacting should be corrected but also the wrong angulation of the impacted tooth.

The surgical–orthodontic traction treatment of all incisors included in our study was successful, similar to the findings reported by Shi *et al*.[31] Three main types of surgical procedure are used to uncover and extrude impacted maxillary central incisors: open, apically repositioned flap, and closed (primary full flap closure) eruption.[32] Studies have revealed the closed eruption method results in less recession, better bone support, and superior periodontal characteristics.[4] This surgical procedure was also preferred by the clinics involved in our study. This could be explained by the fact that the higher the impaction of the tooth, the best prognosis concerning the long-term periodontal health of the tooth could be noticed.[31]

The duration of the orthodontic treatment according to the available literature is multifaceted and may depend on the number of treatment phases, pretreatment skeletal patterns, location of impacted teeth, oral hygiene, patient's compliance, etc.[9,12] In our study, we defined treatment time as not only the traction of the teeth but also its alignment, i.e., from the time of the application of the traction device until the correct position of the impacted teeth in the dental arch. In the literature, it is suggested an average time for traction and alignment of impacted canines of 18–30 months[1,21] and for impacted incisors of 21.6 ± 8 months.[22] Our mean treatment time may have been somehow shorter than these findings, which could be explained by not including the time of the complete orthodontic treatment, just the time to achieve the correct incisor alignment.

Regarding radiographic findings, the results of our study are in accordance with the conclusions of Laganà *et al*.[27] but not with those of Ho and Liao,[12] who established a significant relationship between impacted incisor treatment time and dilacerations.

Ho and Liao found a positive relation between age of patients and treatment duration of impacted maxillary central incisors having 10 years old as cutoff point.[12] However, the study of Stewart *et al*.,[33] for retained canines, indicated an inverse age treatment duration, which may be explained by the fact that in this study treatment duration considered the correction of the skeletal pattern and the traction and alignment of the impacted tooth. If we analyze the correlation between age and treatment duration by splitting our sample in subgroups, according to the main origin of the patients, we found out the American sample with the oldest patients presented the smallest treatment duration, whereas the Colombian sample with younger patients revealed a significantly longer orthodontic treatment time. Chaushu *et al*.[22] found treatment duration was influenced by the height of the impacted incisor, but in our study, we could not find any relation between these two variables. On the other hand, the types of orthodontic traction treatments were very diverse, and this aspect also may have affected the treatment time. This could underline the fact that treatment duration is a multifactorial phenomenon and depends not only on the age of the patients[12] but also on the height of the impacted incisor.[22] Other parameters as, for example, their access to the health system, the variability in traction technique, and in general, the health-care setting of each country, among others, could influence treatment time.

When 10 years of age was used as a cutoff (the age for completion of root formation in maxillary central incisors), no significant differences were observed, in disagreement with the results of Ho and Liao.[12] This finding shows that for our sample, age does not play a role for the duration of treatment, which as mentioned before could be affected by multiple other factors and thus was not the focus of this study.

The rather plausible finding of our study by the regression model was the correlation of the surgical treatment choice (close or open) with the height of impaction and the skeletal relationship, which is for the first time reported in the literature, to our best knowledge. Since impacted central incisors are commonly located above the mucogingival junction, use of the closed eruption approach might ensure adequate keratinized tissue and better gingival contours when the incisor has been aligned.[21,30] In addition, according to our findings, Class III patients are more likely to have a closed surgical access which may be related to some vertical maxillary deficiency, a very common feature in Class III malocclusion.[34] This finding should be confirmed in further studies.

Although differences were found in the groups according to the country, in relation to the age of the patients, the position of the impacted incisor, and the treatment time, it is not possible to affirm that these differences were attributable only to the ethnic differences. Other factors can probably affect these aspects. The impacted incisor treatment decision should, however, be evidence-based and further multicenter studies should be conducted to determine the benefits of early or late treatment. Specific surgical management of an impacted tooth is of crucial importance to achieving desirable esthetic results.

CONCLUSIONS

Participants with retained upper incisors from different countries showed different demographic and radiographic characteristics, as well as treatment time and type of surgical procedure.

The closed eruption method was the most common surgical procedure, and all methods of orthodontic traction treatment were successful.

The more apical location of the impacted incisor has a direct relationship with the surgical access with closed surgery. Within such a diverse sample, treatment duration may not be affected only by the age.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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