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Original Article

Crown and Root Lengths of Impacted Maxillary Central Incisors and Contralateral Teeth Evaluated with Cone Beam Computed Tomography

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Abstract

Objective: To assess and compare the crown and root lengths of impacted maxillary central incisors with contralateral teeth, using cone-beam computed tomography (CBCT). **Material and Methods:** Sample comprised twenty-six patients (15 males, 11 females), ranging from seven to 14 years old, with unilateral impaction of maxillary central incisors. Landmarks demarcation was performed (I) at the root apex, (II) at the incisal edge, and (III) at the midpoint between the buccal and lingual cementoenamel junction (CEJ). Linear measures were taken alongside teeth long axis, with the aid of the software tools. Crown length was considered the distance between the incisal edge and CEJ; and root length was the distance between CEJ and the root apex. Crown and root length measures were obtained in cone beam computed tomography images using the In Vivo® Software. Measurements were compared between the impacted maxillary central incisors and contralateral teeth using paired t-test. **Results:** Crown and root lengths were statistically shorter (0.56 mm and 3.22 mm, respectively) in the impacted maxillary central incisors when compared to their contralateral teeth ($p<0.001$). This trend with regard the root length was observed in 25 out of 26 subjects, as well as in 21 subjects with regard the crown length. **Conclusion:** Decision-making process on the treatment plan for impacted maxillary central incisors must consider that these teeth have in average the crown lengths five per cent shorter and the root lengths 25 per cent shorter than their contralateral teeth.

Keywords: Tooth, Impacted; Incisor; Cone-Beam Computed Tomography.

Introduction

Impaction of maxillary central incisors requires accurate diagnostics and timely treatment plan executed by a multidisciplinary team. Impacted maxillary incisors are associated to diastemas, tooth transposition and root resorptions [1,2]. Furthermore, absent maxillary central incisors cause unesthetic smile that embarrass both children and parents. Main etiologies of impaction of maxillary central incisors are trauma on deciduous teeth, the presence of supernumerary teeth, odontoma or cysts, and systemic disorders, syndromes or cleft lip or palate [3-7].

Many treatment alternatives for impacted central incisor has been cited [1-3]. Tooth extraction is recommended when the impacted tooth has a poor long-term prognosis. Other treatment alternatives with some limitations in regard to function and esthetics can also be considered, such as replacement of maxillary central incisors by mesial relocation of lateral incisors, premolar auto transplantation, prosthetic fixed bridge, or implant [8-12]. However, the best alternative of treatment consists in the orthodontically induced eruption. Relocation of natural teeth favors the achievement of function, once the downward movement of the teeth promotes alveolar bone growth, improved dental aesthetics and functional occlusion [3,8].

The dimensions and developmental stages of an impacted maxillary central incisors have a strong influence in the treatment plan development [1,2,13-15]. In order to establish a more accurate long-term prognostic and diagnosis, cone-beam computed tomography (CBCT) is considered as the gold-standard method for impaction assessments [13,14].

The aim of the present study was to assess and compare crown and root lengths of impacted maxillary central incisors and their contralaterals using CBCT scans. The null hypothesis was that there are no differences between impacted and contralateral teeth dimensions.

Material and Methods

Study Design and Sample

This observational study gathered all patients with impacted maxillary central incisors, treated at the Orthodontics Department of PUCRS. Inclusion criteria were: (I) healthy individuals with diagnosis of unilateral impaction of a maxillary central incisor; (II) with erupted contralateral incisor at Nolla development stage 9 (complete-formed root) or stage 10 (closed-root-apex); (III) availability of pre-treatment CBCT images, intra and extra-oral photos, cephalometric study, panoramic radiograph, and study models. Exclusion criteria were individuals with craniofacial syndromes, cleft lip or palate, bilateral impaction of maxillary central incisors, angle of crown-root dilaceration beyond 60 degrees, and erupted contralateral incisor at Nolla stage 8 or less.

Twenty-six patients (15 males, 11 females, mean age of 9.5 years - ranging from seven to 14 years old), met the inclusion criteria. The aetiology of the impaction of the maxillary central incisors was investigated through the dental and medical history, and CBCT assessments. The sample size allowed detecting differences of 1 mm in the root length between impacted maxillary central incisors

and contralateral teeth (12.30 ± 1.55 mm), with a power of 90 per cent and a bilateral alpha level of five per cent (Statistical Solutions, LLC Systems, Cottage Grove, WI, USA).

Data Collection

CBCT scans were taken with I-Cat scanner (International Imaging Sciences, Hatfield, PA, USA), at 120 kV, 8 mA, 40 seconds of exposure, and 0.3 mm voxel dimension. The exams were recorded in DICOM (Digital Imaging and Communications in Medicine) format and stored on CD-ROM. Thereafter, the 52 images (26 impacted maxillary central incisors and 26 contralateral teeth) were randomly assessed by the observer (P.R.), using the In Vivo® Software (version 5.0, Anatomage, San Jose, CA, USA).

In each assessment, the head position was reoriented until image could display the maxillary central incisors long-axis in a sagittal view (Figure 1). Landmarks demarcation was performed (I) at the root apex, (II) at the incisal edge, and (III) at the midpoint between the buccal and lingual cementoenamel junction (CEJ). Linear measures were taken alongside teeth long axis, with the aid of the software tools. Dilacerated roots were measured in three straight segments, following the root canal. Crown length was considered the distance between the incisal edge and CEJ; and root length was the distance between CEJ and the root apex (Figure 1).

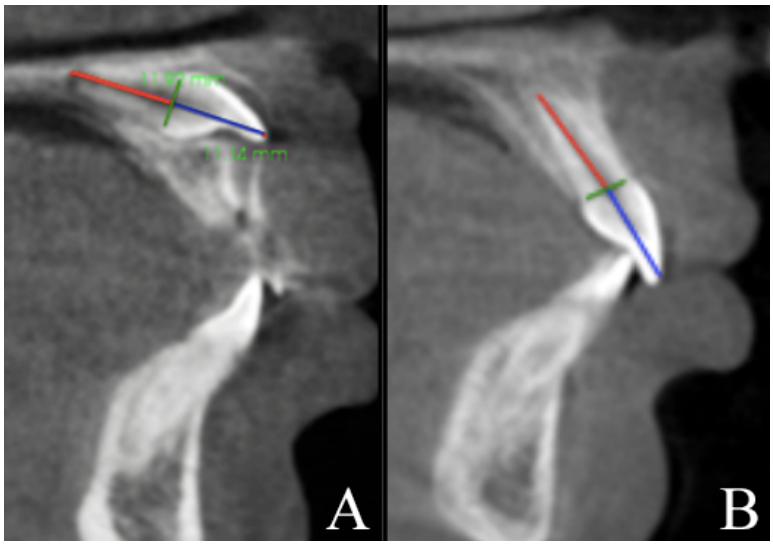

Figure 1. Sagittal view of the impacted maxillary central incisor long-axis (A), and its contralateral tooth (B). Linear measures of the crown length (blue), and the root length (red).

In each CBCT, the impacted maxillary central incisor and its contralateral were compared to each other, measuring crown and root lengths. Reproducibility was checked through repeated measurements in ten cases, by the same observer (P.R.), after a ten-day interval.

Statistical Analysis

Intraobserver agreement between repeated measures was calculated with intraclass correlation coefficient (ICC), based on a two-way mixed Analysis of Variance (ANOVA). The

Kolmogorov-Smirnov test assured normal distribution of the data. Paired t-test was used to compare crown and root lengths of the impacted maxillary central incisors and contralateral teeth. Analysis of the data was performed with SPSS statistical software (version 18.0, IBM, Armonk, NY, USA). Significance level was set at five per cent.

Ethical Aspects

This study was approved by the Ethics and Research Committee of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), under Protocol No. 0016/12. The objectives of this research were explained to all patients' parents or guardians, and those who agreed to participate signed written consent forms.

Results

Intraobserver agreement between repeated measures was excellent (ICC = 0.81 - 0.92). The aetiology of maxillary central incisors impaction was correlated to supernumerary teeth in nine cases (35 per cent), dental trauma in eight cases (31 per cent), odontoma in six cases (23 per cent), and root dilaceration due to ectopic germ position in three cases (11 per cent).

Table 1 reveals that crown and root lengths were statistically shorter in the impacted maxillary central incisors than in its contralateral teeth ($p < 0.001$). Figure 2 depicts 21 out of 26 impacted maxillary central incisors with a shorter crown length (80 per cent of the sample).

Table 1. Mean crown and root lengths between impacted maxillary central incisors and contralaterals (n = 26).

Variables	Maxillary Central Incisor	Mean ± SD	Mean Difference	p-value
Crown Length (mm)	Impacted	10.02 ± 1.31	0.56	0.006*
	Contralateral	10.58 ± 1.08		
Root Length (mm)	Impacted	9.21 ± 1.70	3.22	<0.001**
	Contralateral	12.42 ± 1.53		

Paired t-test; mm = millimeters; SD = Standard deviation; **p≤0.01

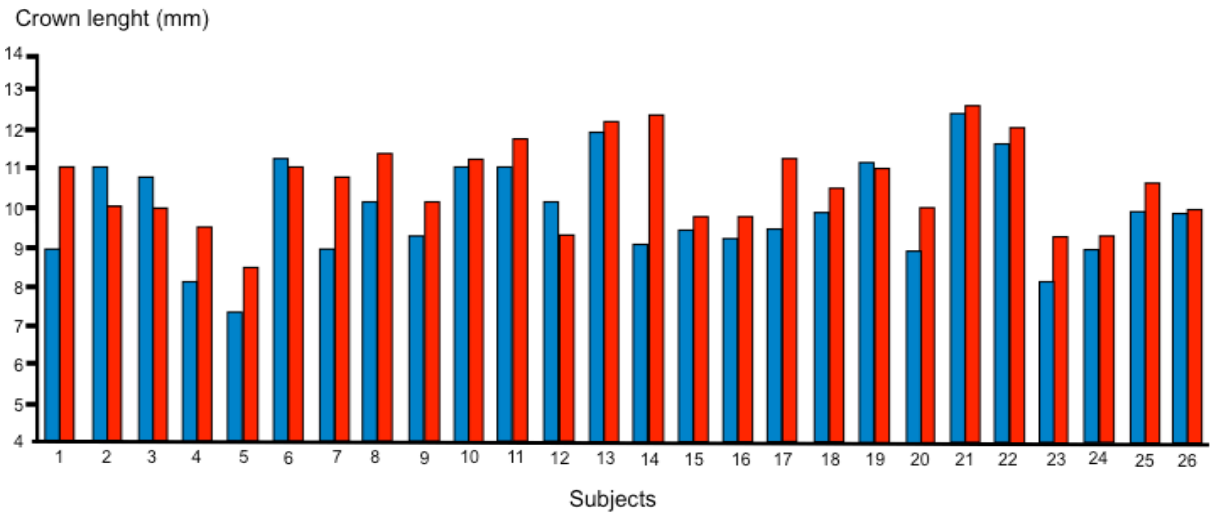

Figure 2. Bar chart showing the crown lengths of impacted maxillary central incisors (blue) and contralateral teeth (red), in all individuals.

Figure 3 shows that the root lengths of the impacted maxillary central incisors were shorter in 25 out of 26 subjects (96 per cent of the sample).

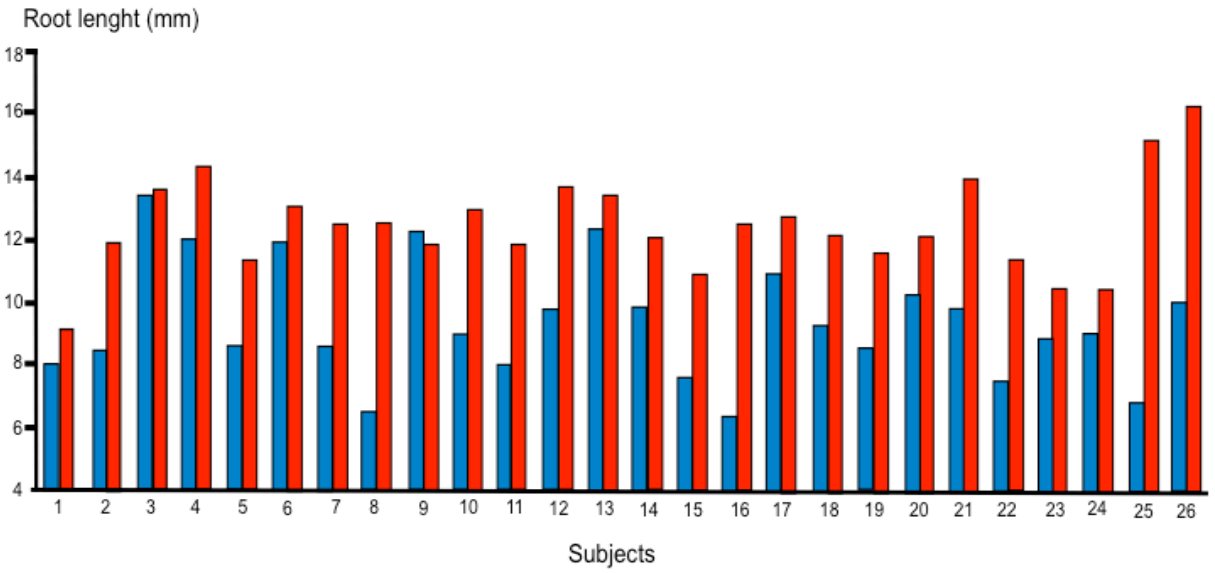

Figure 3. Bar chart showing the root lengths of impacted maxillary central incisors (blue) and contralateral teeth (red) in all individuals.

Discussion

Clinical examination, dental and medical past history are still essencial tools for tooth impaction diagnosis and aetiology establishment. However, accuracy in impacted tooth dimensions and position can be easily achieved by CBCT images [2]. Also, these 3D assessments may reproduce teeth measurement with high accuracy, due to a 1:1 ratio image relationship [13,14].

The higher prevalence of maxillary central incisor impaction in this study was related to the presence supernumerary teeth, followed by dental trauma, presence of odontoma and root dilaceration. This findings is in agreement with other studies [16,17], that reported supernumerary teeth, odontoma and trauma as the most common causes of maxillary incisors impaction.

The aetiology of underdeveloped roots of the impacted maxillary central incisors is still unclear. It may be due to a possible traumatic injury to the tooth germ during odontogenesis. Furthermore, it may be related to an ectopic position of tooth germ, and an anatomical confinement that hinders complete development of Hertwig's epithelial root sheath [2].

Maxillary central incisor impaction is not a common finding, since it affects 0,06-0,2% of population [3]. In this sample, the mean differences in crown and root lengths of impacted teeth in comparison to their contralateral were 0.56 mm and 3.22 mm, respectively. Within the impacted group, a general trend about tooth dimension was perceived. Crown length of impacted teeth were smaller than 1.5 mm in 85 per cent of the sample, although one case showed a impacted crown 3 mm shorter than its contralateral. The statistically significant difference between groups indicated the trend of impacted teeth to have shorter crown lengths than their contralaterals. When related to root dimensions, 25 out of the 26 subjects showed shorter root lengths in the impacted central

incisor when compared to contralaterals. In eleven individuals (42 per cent of the sample), the root length of the impacted incisor was more than 3 mm shorter.

In the present study, we found that root length of four impacted incisors (15 per cent of the whole sample) was around 6 mm shorter than the contralateral. Regardless of the prognosis, the best treatment alternative still consists in orthodontic induced eruption. The orthodontically induced eruption has already been proved as a succesfull and reliable procedure [18-21]. This procedure best advantage is the possibility to promote alveolar bone growth and maintenance of the gingival morphology, allowing an eventual tooth loss and better aesthetic reconstruction [8].

Optimal timing of intervention is still an issue in impaction cases. Early interventions are strongly recommended, in order to eliminate the etiological factor and create space for full root development of the impacted teeth [12]. However, it must start in an appropriated timepoint, such as (I) after a six-month delay in the eruption of a maxillary incisor compared to the contralateral tooth; (II) after one-year delay in the eruption of both maxillary central incisors compared to the lower incisors; or (III) in cases of abnormal sequence of eruption. On the other hand, late treatment may deal with several complications, as dental midline shift, loss of alveolar bone crest, and migration of adjacent teeth [22].

The inclusion criteria adopted in the present study comprised a uniform sample of children with unilateral impacted maxillary central incisors. Since this clinical situation shows low prevalence in population, the results of our sample mostly followed a general trend and can be considered clinically significant. Nevertheless, the influence of the several etiological factors on teeth impaction were not yet deeply investigated. Lastly, we wonder if the shorter immature roots of impacted maxillary central incisors could promote a temporary delay in the teeth development and eruption. Further studies might enrich the current knowledge on the aetiology, early diagnosis and treatment of impacted teeth.

Conclusions

Assessments of CBCT images revealed:

1) Impacted maxillary central incisors had crown lengths five per cent shorter than its contralateral teeth;

2) Impacted maxillary central incisors had root lengths 25 per cent shorter than its contralateral teeth;

3) Shorter roots of impacted incisor are a relevant finding for a more accurate and efficient treatment plan.

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