

## Original Article

# Evaluation of Teeth Development in Unilateral Cleft Lip and Palate Patients in Mixed Dentition by Using Medical Image Control Systems

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### ABSTRACT

**Objectives:** The aim of this study was to evaluate the crown and root development in patients with cleft lip and palate using medical software programmes. **Materials and Methods:** In our study, 25 patients with mixed dentition unilateral cleft lip and palate were examined with cone-beam computed tomography (CBCT). The tomography images obtained as high resolution medical images on the computer control system (MIMICS 15.0, Materialise, Leuven, Belgium and SOLIDWORKS 2014 Premium, Concord, Massachusetts) were converted to three-dimensional volumetric images. These three-dimensional images of the cleft on the sides of the teeth in the crown and root growth were measured by mesiodistal length and crown/root rate with volume and area. These measurements were compared with a control group of healthy individuals. **Results:** There were no statistically significant differences in the volume, surface area and MD size, crown/root ratio of central incisor, canine, first premolar and second premolar teeth within defect, and healthy teeth. However, it was found that there was a significant difference between the volume, surface area and MD size, and crown/root ratio of the lateral teeth in each group. **Conclusion:** In particular, among patients with cleft lip and palate, on obtaining a solid model of the tooth structure by using these programs, tooth development can be examined in more detail, diagnosis can be made more reliable, as well as in treatment planning. We believe that these programs can be used to resolve certain limitations such as a lack of an application to be used in routine dental treatment and in particular the need to do more study.

**KEYWORDS:** CBCT, cleft lip and palate, medical software programmes

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## INTRODUCTION

Cleft lip and palate deformities occur between the 4<sup>th</sup> and 8<sup>th</sup> week of the intrauterine period because of a defect in the formation and growth of facial structures.<sup>[1]</sup> Orofacial cleft is one of the most common craniofacial deformities, constituting 15% of all congenital abnormalities.<sup>[2]</sup> Consanguineous marriage also increases the incidence of orofacial clefts.<sup>[3]</sup> In addition to these factors, use of tobacco, alcohol, and corticosteroids; folic acid deficiency; zinc deficiency; and maternal grief also increase the risk.<sup>[4]</sup> The craniofacial growth of children with cleft palate differs from that of healthy children. These differences manifest during the examination of a morphogenetic model and the lip/palate location.<sup>[5]</sup> The teeth ride irregularly on a cleft palate, and the

esthetics and phonation are malformed. When surgical interventions are not performed early enough or if they fail, psychological problems are encountered in children.<sup>[6]</sup> The prevalence of dental abnormalities, especially on the cleft side, is common in patients with cleft lip or palate.<sup>[7]</sup> Morphological defects such as hypoplasia of the permanent central incisor, congenitally missing tooth, and surface corruptions have been reported in individuals with cleft lip/palate during periods of mixed and primary dentition.<sup>[8]</sup>

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## MATERIALS AND METHODS

In our study, dental tomographic images of 25 patients (14 boys and 11 girls; age range, 8–12 years) with unilateral cleft palate and lip in the mixed dentition period were examined. New tomographic images were not acquired from these patients, and prior images of dental computed tomography (CT) acquired before the cleft palate/lip surgery were examined. The sectional thickness of these images was 0.5 mm; the images were acquired in the Department of Radiology of Selcuk University and obtained from the Department of Plastic Surgery of Selcuk University.

Volumetric three-dimensional (3D) images were obtained by transferring the CT images in a DICOM format to a medical imaging control system (Mimics 15.0, Materialise, Leuven, Belgium ve Solidworks 2014 Premium, Concord, Massachusetts) in a computer with a high-definition screen. The volumes, surface areas, mesiodistal (MD) sizes, and the crown/root ratios of 25 permanent central incisors, canines, the 1st and 2nd premolar teeth on the defective and nondefective sides, and the crown and root growth of 8 permanent lateral incisors were measured. From these measurements, the volumetric measurements and surface areas of the crown/root growth of these teeth located on both the defective and nondefective sides (as control) were compared.

### Transfer of the computed tomographic images to the Mimics software

Biomodells of the images obtained from CT scans were collected using a series of commands via the Mimics software. These commands were given to transfer the images to the software in DICOM format, mask the images with the selected color and proper values, and to obtain 3D models with 3D analysis.

To obtain the 3D models of bone data in DICOM format, the borders of the teeth in the bone to be measured were determined using the bone (CT) and Hounsfield unit (HU) values of the software. The HU value in the software was predefined and was in the range of 226–3072. The borders of the teeth were observed by determining the HU values within these ranges according to the resolution of the CT scans [Figure 1]. After determining the HU values, the software automatically assigns a mask to the determined region. Different masks could be assigned by selecting different colors for different sites. The teeth undergoing evaluation were demarcated from each other by assigning yellow, green, and purple-colored masks [Figure 2]. Subsequently, the borders were set and the masking process was terminated. After these procedures, the obtained images were transformed into 3D images [Figure 3].

The MD crown sizes and crown/root measurements of teeth on the cleft and nondefective sides were obtained via 3D images generated by the Mimics software.

### Transfer of the three-dimensional images obtained using the Mimics software to the Solidworks package

To obtain biomechanical models, the 3D images obtained using the Mimics software were transferred in to the Solidworks package as a point cloud [Figure 4]. These images had irregular surfaces when transferred into the Solidworks package. Quality of these irregular surfaces were rendered with a remeshing model using triangular sections.

The open surfaces obtained after the mesh preparation command were closed by using the surface cover (sewing) command. The point cloud was rendered to close space with this procedure. Finally, all the mesh surfaces were combined using surface detailing [Figure 5].

Using triangular modes, the quality of the images was improved, and the images were transformed into formats that were supported by the selected computer-aided design (CAD) software. The triangular surface was transformed into qualified surfaces in the CAD software, and biomechanical models were formed before the analysis [Figure 6]. Surface arrangements were performed on the obtained bone models using the smoothing command by removing the protrusions and cavities of the surface without changing their volumes and surface areas.

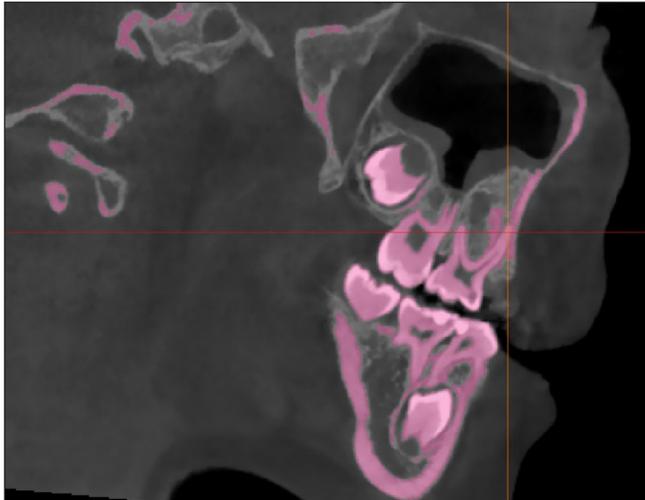
Finally, the volumes and surface areas of the teeth included in the present study were recorded via the biomechanical bone models obtained using the Solidworks package by selecting the “mass specification” segment from the “evaluate” tab of the program. Teeth on both the defective and nondefective sides were compared.

### Statistical analysis of the data

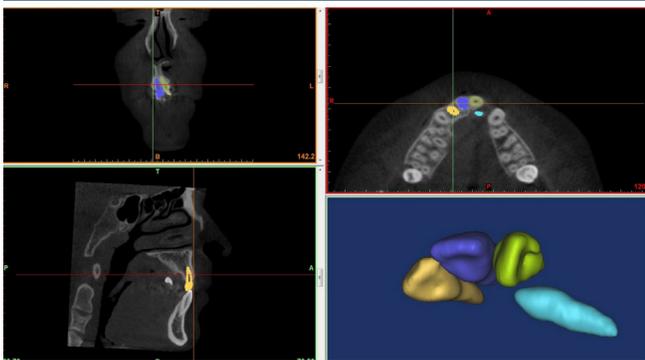
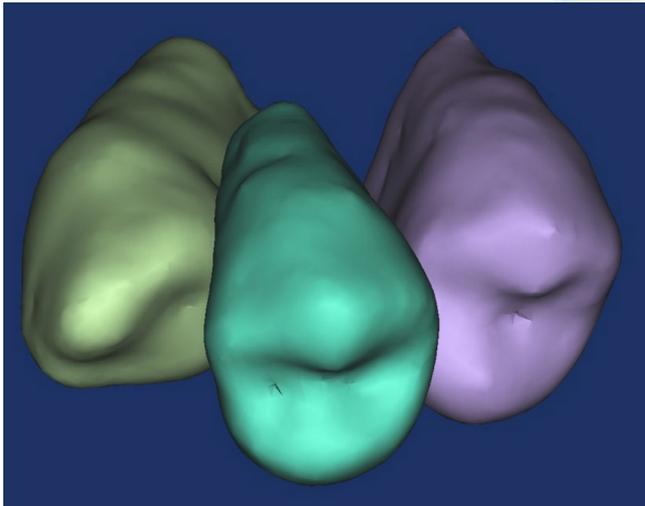
Data obtained from our study were recorded into Microsoft Office Excel 2010 suite. Statistical analysis of the recorded data was performed using the Statistical Package for the Social Sciences software, version 20.0 (SPSS Inc. Chicago, USA). The Kolmogorov–Smirnov test was employed to determine whether the data showed normal distribution. Independent samples *t*-test (a parametric test) was used for the analysis of data showing normal distribution according to the Kolmogorov–Smirnov test, and Mann–Whitney U test (a nonparametric test) was used for the analysis of data that did not follow normal distribution. Finally, the relations between the data were analyzed using the Pearson correlation test.

## RESULTS

No statistically significant difference was detected between the volumes of the central incisors, canine, and the 1st and 2nd premolar teeth on both the defective and nondefective sides ( $P > 0.05$ ). After the evaluation of



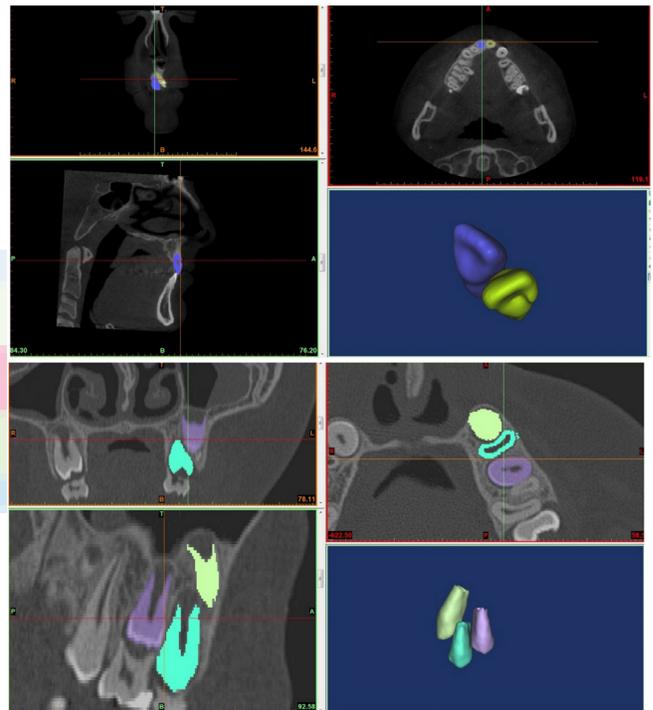
**Figure 1:** The borders of the teeth were observed by determining the Hounsfield unit values



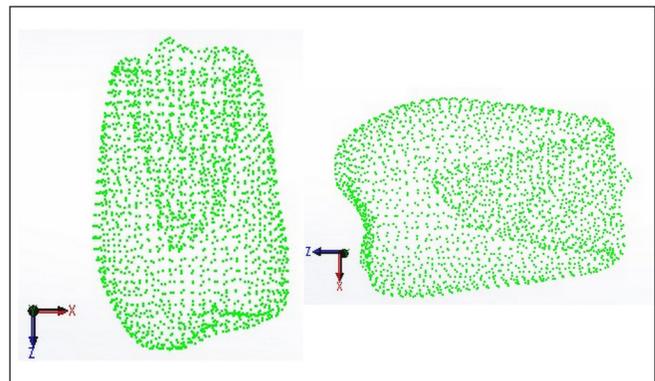
**Figure 3:** After the borders were set and the masking process was terminated, the obtained images were transformed into three-dimensional images

the CT images, it was observed that the lateral incisors were congenitally missing in 17 out of the 25 patients (68%). Volumetric and surface area measurements of the teeth of the remaining 8 patients were performed using the CT images. There was a statistically significant difference between the volumes of the lateral incisors on the defective and nondefective sides ( $P < 0.05$ ). A decrease of 47% was determined in the volume of the lateral incisor on the defective side compared to that on the nondefective side.

No statistically significant difference was detected between the surface area values of the central incisors, canine, and the 1st and 2nd premolar teeth on both the defective and nondefective sides ( $P >$



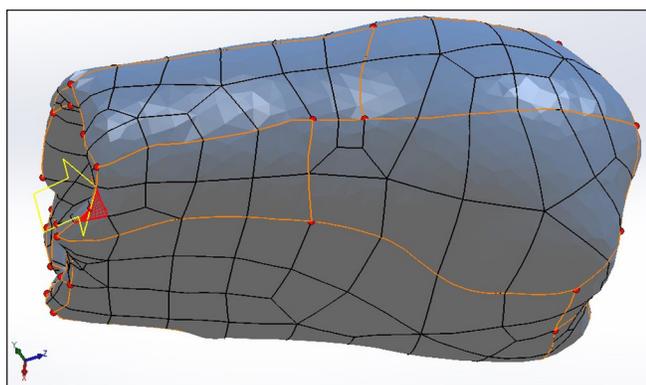
**Figure 2:** The teeth undergoing evaluation are demarcated from each other by assigning yellow, green, and purple colored masks



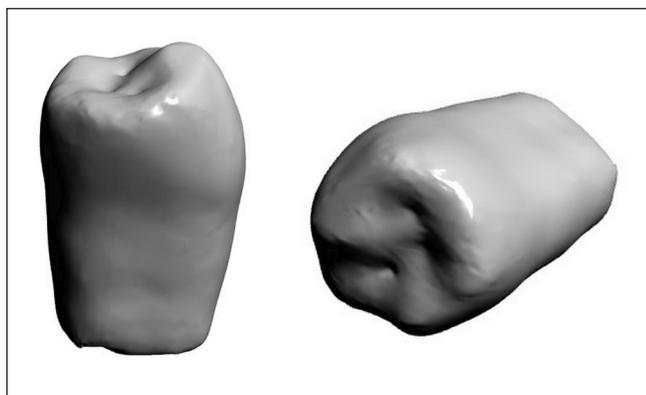
**Figure 4:** The three-dimensional images obtained using the Mimics software were transferred into the Solidworks package as a point cloud

**Table 1: Analysis of mean volume, surface area, mesiodistal size, and crown/root ratio of teeth, and the P values**

			Central incisor	Lateral incisor	Canine	1st premolar	2nd premolar
Volume		Defect +	542.51±71.29	49.90±64.80	545.06±22.91	483.31±16.71	450.59±18.55
		Defect -	575.33±82.27	496.37±19.18	532.97±23.57	474.59±15.13	469.37±19.18
		P value	0.186	0.000*	0.900	0.662	0.357
Surface area		Defect +	462.53±48.16	260.57±55.16	443.12±13.01	408.94±14.10	376.57±13.05
		Defect -	490.16±45.07	408.64±45.96	433.13±13.49	399.84±11.62	391.56±15.59
		P value	0.069	0.000*	0.930	0.992	0.337
MD size		Defect +	8.01±0.59	5.56±0.33	7.48±1.08	7.11±0.84	7.46±0.90
		Defect -	8.27±.041	6.87±0.35	7.42±0.81	7.30±0.70	7.31±0.93
		P value	0.111	0.000*	0.233	0.456	0.890
Crown/Root ratio		Defect +	1.46±0.40	0.68±0.06	1.08±0.67	0.97±0.71	1.39±1.76
		Defect -	1.31±0.38	0.81±0.08	1.12±0.71	1.01±0.70	1.42±1.87
		P value	0.237	0.000*	0.760	0.884	0.955



**Figure 5:** All the mesh surfaces were combined by surface detailing



**Figure 6:** Biomechanical models were created before the analysis

0.05). There was a statistically significant difference between the surface area values of the lateral incisors on the defective and nondefective sides ( $P < 0.05$ ). A decrease of 36% was observed in the surface area of the lateral incisor on the defective side as compared to that on the nondefective side.

No statistically significant difference was detected between the MD sizes and crown/root ratios of the central incisors, canine, and the 1st and 2nd premolar teeth in both the defective and nondefective sides ( $P > 0.05$ ). There was a statistical significant difference between the MD sizes and crown/root ratios of the lateral incisors on the defective and nondefective sides ( $P < 0.05$ ) [Table 1].

## DISCUSSION

Tortora *et al.*<sup>[9]</sup> reported that higher dental abnormalities were observed in children with a cleft lip and palate than that in the general population. These abnormalities included supernumerary teeth, ectopic teeth, and defects involving dental morphology.<sup>[10-12]</sup> Pegelow *et al.*<sup>[8]</sup> reported that morphological defects, such as hypoplasia of the permanent central incisor, congenitally missing tooth, and surface corrosions, were observed in individuals with cleft lip/palate during periods of mixed and primary dentition. Eerens *et al.*,<sup>[13]</sup> in their study regarding congenital tooth deficiency and teeth formation in patients with cleft palate and lip, reported that congenital tooth deficiency and teeth asymmetry were frequently observed in permanent teeth located on the cleft side.

Radiological examination plays an important role in dentistry, especially in the treatment and diagnosis of patients with cleft palate and lip.<sup>[14-16]</sup> Intraoral radiography was first introduced by Roentgen in 1895. Cephalometric roentgens used for extraoral radiography were developed in the subsequent years. Panoramic radiography was introduced in the mid-twentieth century.<sup>[17]</sup> On reviewing retrospective studies, it was observed that because of the proliferation of 3D imaging techniques, two-dimensional (2D) radiography is being used frequently.<sup>[18-20]</sup> Adequate

measurements of the shape and size of malformations, such as cleft palate and lip, which require combined treatment, could not be obtained from 2D images. Thus, additional cephalometric drawings and photo images of the patients are required along with the 2D images. After the introduction of tomography, 3D images could be obtained; therefore, adequate measurements could be obtained due to enrichment of the details.<sup>[21]</sup> Although ectopic teeth and formations on the surrounding structures could be detected using 2D radiography, resorption in the ectopic site could be better detected in 3D tomographic images.<sup>[22]</sup>

Cone beam computed tomography (CBCT) has enabled dentists to obtain 3D volumetric data using a single rotation movement and very low radiation dose.<sup>[23]</sup> The measurements of the maxillofacial structures obtained by this method could be exported with minimum dimensional changes.<sup>[14,24]</sup>

Compared to 3D tomography, CBCT has a shorter radiation duration and lasts <30 s in many devices. This is because a single rotation of the beam source is sufficient to acquire the image of the object. CBCT imaging provides clinicians with sub-millimeter spatial resolution images of high diagnostic quality with relatively short scanning times, as well as a reported radiation dose equivalent to that needed for 15 CT images.<sup>[14]</sup> A study that involved performing and comparing the measurements obtained using conventional cephalometric radiographs to those obtained using 3D constructed models of human skulls derived from CBCT reported a clinically relevant difference between the two imaging techniques; reliability and accuracy of CBCT was higher than that of the conventional technique.<sup>[25]</sup> Nervina<sup>[26]</sup> reported that 2D images were not adequate for the detection of defective sites, monitoring the growth, and in treatment planning of the patients with cleft palate/lip, and CBCT provided close to real images and precise information. CBCT provides more detailed imaging of the cleft site than CT. This feature of CBCT plays an important role in both preoperative and postoperative diagnosis and treatment of patients with cleft palate/lip.<sup>[27]</sup>

Recently, software packages into which CBCT images are transferred are commonly used in the medical field. However, such usage in dentistry is not popular in our country. After advancement in computer technology, modeling and production methods such as CAD, computer-aided production (CAP), computer-aided engineering (CAE), and reverse engineering (RE) have become popular.<sup>[28,29]</sup> One of these fields is the generation of 3D images by using radiographs obtained from devices such as CT machines as well as the transfer of the images to an analysis software package.<sup>[30,31]</sup> Using such medical analysis software packages, 3D models

of bone structures can be generated and a simulation or design of the bone implants can be obtained.<sup>[32,33]</sup>

Although a detailed literature review and many studies have examined the relationship between dentition and cleft palate/lip, no study monitoring the dentition using a medical analysis software package have been conducted.

According to the reviews, most researchers observed that the prevalence of dental abnormalities is increased in cases of cleft palate or lip.<sup>[13,34,35]</sup>

Dewinter *et al.*<sup>[35]</sup> observed hypodontia of the lateral incisor in more than 50% of the patients on the cleft side. Akcam *et al.*<sup>[36]</sup> in a study involving examination of dental abnormalities in patients with cleft palate/lip, observed that a congenital deficiency of permanent teeth on the cleft side, with a prevalence of 70.8%, was the most frequently encountered dental abnormality. Ribiero *et al.*<sup>[7]</sup> in a study involving examination of the dental abnormalities of lateral incisors in patients with cleft palate/lip, observed that a congenital deficiency was found in 49.8% of the patients on the cleft side. Tortora *et al.*<sup>[9]</sup> in a study regarding the dental abnormalities in patients with unilateral and bilateral cleft palate and lip reported that 45% of the patients had a congenital deficiency of the lateral incisor on the cleft side. When tomographic images were examined in the present study, it was observed that 68% of the patients had congenital deficiency of the lateral incisor on the cleft side.

Shapira *et al.*<sup>[37]</sup> in their study regarding congenital deficiency in patients with cleft palate/lip, reported that 77% of the patients had congenital deficiency of the lateral incisor on the cleft side. Dewinter *et al.*<sup>[35]</sup> investigated the dental abnormalities in patients with unilateral cleft palate and lip and reported that 58.6% of the patients had hypodontia involving the anterior teeth, 32% had crown malformation, and 10.6% had root malformations. Pegelow *et al.*<sup>[8]</sup> examined the dental characteristics of the cleft side and reported that 10% of the patients had microdontia with hypoplasia and 38% had congenital deficiency.

Akcam *et al.*<sup>[36]</sup> compared the difference between the MD sizes of the teeth in patients without defects to those of patients with unilateral cleft palate/lip, emphasizing that there was a statistically significant difference between the MD sizes of the teeth of both the groups. In a study performed by Maciel *et al.*,<sup>[38]</sup> enamel changes in the teeth on the cleft side were investigated, and the presence of hypoplasia or opacity was detected in 48.1% of the participants. Our results regarding lateral incisors were similar to the results of the aforementioned studies. In this study, a statistically significant difference was observed between the volume and surface area values of

the lateral incisors located on both the cleft and healthy sides. Moreover, it was detected that the average volume and surface area of teeth on the cleft side were lower than those on the healthy side by 47% and 36%, respectively.

Although dental abnormalities were observed in the teeth on the cleft side in previous studies, no data are available regarding the source of these abnormalities.

Tortora *et al.*<sup>[9]</sup> examined the dental abnormalities in patients with uni- and bilateral cleft palate/lip and indicated that the dental abnormalities on the cleft side were caused by the defects in the enamel structure created during surgical operations; these observations corresponded with the results of the present study. In a study performed by Lucas *et al.*,<sup>[39]</sup> it was observed that enamel defects are more prevalent on the cleft side. They also stated that this prevalence was related to the surgical operation performed on the cleft side.

Hunter<sup>[40]</sup> compared the crown–root length of the teeth on the cleft and healthy regions of the participants; no statistically significant difference was observed between the two groups. In addition, no statistically significant difference between the healthy and cleft side was detected in the volume and surface area measurements of the central incisor, canine, and the 1st and 2nd premolar teeth; however, a high positive correlation was observed between the volume and surface area values in our study. Furthermore, no statistically significant difference with regard to MD size and crown/root ratio measurements was observed between the teeth located in both the segments.

Based on these results, we suggest that the dentition of the lateral incisor located on the cleft side is influenced by the defects on the cleft side and the dentition of teeth located on the healthy side is not influenced by the defects due to their location. Meanwhile, dimensional changes were observed in the teeth on the cleft side. We do not think that dentition disorders are caused by prior surgical operations due to unavailable malformations. In addition, in prior studies, a 2D radiography method was usually used and the evaluation was performed using a single dimension measurement. Reflecting on these results, we think that the volumes and surface areas of teeth were not evaluated accurately in prior studies.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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