Biomedical Imaging for Tooth Size Measurements in a Sample of Romanian Subjects

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Abstract: - Biomedical imaging has become a major tool in large population studies since it enables rapid visualization and accurate quantitative assessment. The current technological developments allowed us to obtain digital study models. These can be saved electronically, viewed three-dimensionally and measured precise on a computer with dedicated software. For a specific population tooth size measurements, ratios and equations should be updated each 30 years. The aim of this paper was to obtain the average mesiodistal sizes of permanent teeth in a sample of Romanian subjects. We also determined, using the advantages of digital tools, the Bolton ratios and we tested the accuracy of Tanaka and Johnston’s equations for males and females. The new developed tooth size tables and regression equations are more accurate for dimensional characterization of teeth and orthodontic diagnosis.

Key-Words: - digital models, biomedical imaging, digital tools, tooth size tables, Bolton ratio, Tanaka and Johnston’s equations, orthodontic diagnosis

1 Introduction

The three-dimensional (3D) biomedical imaging progressed considerably in recent years with numerous applications in dental medicine. Medical imaging has become a major tool in almost every aspect of orthodontic practice, research, manufacturing and education as previously published [1, 2, 3, 4, 5, and 6].

Today the evolution of digital technology has changed computers from having a limited, supporting role mainly in managing databases to one being indispensable in orthodontic treatment [2].

Biomedical imaging has become a major tool in large population studies since it enables rapid visualization and accurate quantitative assessment, facilitating statistical analysis.

The current technological developments allowed us to obtain digital study models. These can be saved electronically, viewed three-dimensionally and measured precise on a computer with dedicated software.

The virtual study model analysis is a viable alternative approach to the traditional plaster model analysis being part of the same paradigm: Computer-Aided Diagnosis (CAD) [7].

2 Problem Formulation

Study model analysis is a time consuming procedure but extremely valuable in the diagnosis and development of an orthodontic treatment plan.

Standard values for the growth and development of the stomatognathic system are important for the dental practitioner because he bases his conclusions, diagnosis and treatment on them. They must be accurate, current and should characterize the examined population [8].

These standards have a maximum validity of 30 years and for the Romanian population they were not updated.
For a specific population tooth size measurements, ratios and equations should be updated each 30 years [8].

The aim of this paper was to obtain the average mesiodistal sizes of permanent teeth in a sample of Romanian subjects. We also determined, using the advantages of digital tools, the Bolton ratios and we tested the accuracy of Tanaka and Johnston’s equations for males and females.

3 Problem Solution

The introduction of digital models has provided the orthodontist with a viable alternative to plaster models with the added advantages of electronic storage of data, minimal storage space required, simple and accurate cataloguing and a rapid transmission of records for consultation [9].

For this study we scanned a total number of 150 models using an optical three-dimensional scanner, Activity 101 developed by the Firma Smart Optics Sensorentechnik GmbH, Germany.

For scanning the model is fixed on a swivel arm that moves in front of the scanning device.

In the first stage a 2D photo of the model is taken. Then the doctor marks the region he wants to scan, in our case the complete dental arcade. It follows the proper 3D scanning process lasting 2-3 minutes. The result is the first version of the digital model that features a series of goals where there was an uneven scanning pattern (Fig.1)

With dedicated tools provided by the software the fixed model turns on all sides and the deficient areas are scanned again. The newly scanned areas appear in pink. Finally all the intermediate scans are fitted together and the final 3D model results.

The matching process takes 3-4 minutes. All the scanning process of a model, depending of the number of intermediate scanning’s lasts 10-12 minutes.

The 3D model will be exported as a .stl file, generally with large dimensions of 13-14MO. They can be opened and measured only by dedicated programs. In our study we used the OnyxCeph™ software developed by the Firma Smart Optics Sensorentechnik GmbH Germany (Fig.2) [10].

We used the built-in magnifying tool for the enlargement of the models on screen for better placement of the odontometric landmarks (Fig.3).

Placement of the landmarks that define the maximum diameter of the teeth and dento-alveolar arches is a thorough procedure of utmost importance that requires experience and allows full use of advantages of digital models.

The user-friendly interface of the software allows multiple relocations of the landmarks signaling this at every second time by changing the color from red to blue (Fig.4)
When placing the landmarks generally the posterior teeth were measured from occlusal view and the anterior from facial view. But, especially in cases with rotated or malpositioned teeth this approach has generated a number of artifacts (Fig.5, 6).

To avoid this we recommend rotating the biomedical images of the digital model on screen in order to check the position of the landmark in all three planes. Only then we can speak about a correct odontometric evaluation.

The OnyxCeph™ software enables beside enlargement also an assembly of 3 or 4 images of the same teeth from different angles facilitating the checking of the landmark position (Fig.7).

The results of the digital model analysis are exported as a table in which is listed the calculated and standard values from international literature (Fig.9).

We conducted a cross-sectional study on a sample of 150 digital study models, acquired from patients aged between 14 and 25 years, from which 59 were males and 91 were females (Fig.10).
The selection criteria were: study models of children and young adults with permanent dentitions, without any severe malocclusion, with complete dental arches, without proximal carious lesions, proximal restorations or crowns.

All the values of mesiodistal tooth dimensions acquired for each permanent tooth on the study models were collected in a large Excel Database (Fig.11).

Because of their importance in the clinical practice of orthodontics, we determined the mean values for the sum of upper incisors (SI) and the sum of lower incisors (si), the standard deviation (SD), the minimum and maximum value (Min, Max) (Fig.13).

We compared the mean dimension of each tooth between genders and we reached the conclusion that the permanent teeth are larger in boys then in girls (Fig.14).
Fig. 14 Mean mesio-distal dimensions for each tooth in females and males

We also determined the Bolton Index, calculating the anterior ratio (Bolton 6) and the overall ratio (Bolton 12). The mean value for the anterior ratio was 78.59% and the mean value for overall ratio was 91.23%, for our sample (Fig. 15, 16).

We determined Bolton Ratio for each gender as well and we compared then the results obtained between the two genders, using the unpaired t test. The differences were not significant for both ratios (p=0.819, for Bolton 6 and p=0.463, for Bolton12).

We tested the accuracy of Tanaka and Johnston’s equations for males and females. We used a paired t test in order to compare the determined sizes of canines and premolars (345) according to well known and largely used equations and the measured sizes of the same teeth. The comparisons were made for males and females and for upper and lower teeth. The sum of the lower incisors, used in the formula was calculated by adding the mesio-distal dimensions of the 4 lower incisors.

We determined significant differences for boys and girls, for both the maxilla and the mandible. New regression equations were developed.

Between the values of si and 345 in the maxilla, we established a linear, significant, direct and low correlation, for girls (Fig. 17).

![Fig. 14 Mean mesio-distal dimensions for each tooth in females and males](image)

![Fig. 15 The mean value for anterior ratio](image)

![Fig. 16 The mean value for overall ratio](image)

![Fig. 17 The correlation established for girls in the maxilla](image)
Between the values of si and 345 in the mandible, we established a linear, significant, direct and medium correlation, for girls (Fig.18).

Between the values of si and 345 in the maxilla, we established a linear, significant, direct and medium correlation, for boys (Fig.19).

Between the values of si and 345 in the mandible, we established a linear, significant, direct and medium correlation, for boys (Fig.20).

4 Conclusion

Using of biomedical imaging had a positive effect in determining the current odontometric data of a population from Romania allowing rapid and accurate evaluation of large amounts of information.

The cross-sectional study represents a quick and easy way for determining the odontometric data and ratios that result from this data and for testing some equations.

These kinds of studies have the advantage of being noninvasive, which is the main demand from bioethical reasons.

Because the large number of values acquired, a good management of the data is needed, which requires computerized databases.

The mesiodistal tooth dimensions are among the characteristic features of one population. Romanian boys have larger teeth than girls and there are some differences between the same teeth on the left side to that on the right side. The differences were significant for molars and premolars on both jaws and for the canines and lateral incisors in the maxilla.

The mean value determined for the upper incisors sum was 30.95 mm and for the lower incisors sum was 22.97 mm. These sums are important in predictions of arch widths (Pont Index) and for the prediction of the dimensions of an erupted tooth in the mixed dentition space analysis (Tanaka and Johnston equations).

The mean values for Bolton ratios were 78.59% and 91.23% and the differences are not significant between genders.

The prediction equations were not as accurate as expected, but a linear correlation was found between the two parameters and four new equations were developed.

The new developed tooth size tables and regression equations are more accurate for dimensional characterization of teeth from the actual Romanian population and orthodontic diagnosis.

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