Inter-Operator Reliability of Dental Morphometric Measurements

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ABSTRACT

Background: Measurement-based studies are prone to measurement errors, which occur at the same operator or between different operators during repeated measurements of the same sample. **Aim of the study:** To assess the inter-operator reliability of morphometric measurements using a bidimensional image analysis method. **Material and methods:** Eight study models have been selected, images of teeth and models were taken from vestibular and occlusal view. The following parameters were measured individually by three, previously trained operators: mesio-distal, occluso-gingival, and vestibulo-oral dimensions, vestibular and occlusal area, depth of palatal arch, arch breadth, arch circumference, and arch length. Intraclass correlation coefficients were calculated for each measurement. **Results:** The reliability of the measurements showed high degrees, all values being higher than 0.8. **Conclusions:** Dental morphometric measurements done by 2D image analysis can be performed by multiple operators with an excellent reliability.

Keywords: inter-operator reliability, morphometric measurements, 2D image analysis

INTRODUCTION

Measurement-based studies are prone to measurement errors. They originate from technical errors of the same operator or of different operators during the measurement of the same specimen more than once. Quantitative measurements are considered to have a high degree of reliability when the result of different measurements of the same specimen are identical or similar. Precision and accuracy of measurements are important factors in determining reliability, which refers to reproducibility and repeatability.[1]

In case of dental morphometric measurements on study models, there are many possible factors that influence reliability: the operator; the procedure of making the stone cast; the image capturing procedure; calibration and measurement technique. Repeating the same measurements for the same samples may

not yield the exact same result due to the variability of the measurement processes.[2]

The purpose of the present study was to assess the inter-operator reliability of a bidimensional image analysis method used for dental morphometric measurements.

MATERIAL AND METHODS

The study was conducted after receiving approval from the local ethics committee (Research Ethics Committee of the University of Medicine, Pharmacy, Sciences and Technology of Tîrgu Mureş) and after obtaining written informed consent from the analyzed subjects.

Dental stone (FujiRock, GC) models were obtained from alginate impressions (Ypeen Premium, SpofaDental) taken from volunteers aged 16–24 years. Eight study casts have been selected for the inter-operator reliability study. Inclusion criteria were: the presence of fully erupted permanent teeth on the dental arches, without fillings or lesions.

Dental casts were captured from occlusal and palatal view; images from selected teeth were taken individually from the vestibular and occlusal views, with the use of a digital photographic equipment (Nikon D3100, Nikon Corporation, Japan), with a 90 mm macro lens (Tamron SP AF-S 90 mm f/2.8) and a cable shutter (Nikon MC-DC2). Pictures were transferred using the ViewNX2 (Nikon Corporation, Japan) software and morphometric measurements were completed using the Image Pro Insight 8.0 software (Media Cybernetics, USA), with a ten-millimeter scale for subsequent calibration of the picture.

The following measurements were performed for the inter-operator reliability study:

- mesio-distal (MD) distance from vestibular view: the highest length between the mesial and distal sides of the analyzed tooth;
- occluso-gingival (OG) length from vestibular view: the distance between the occlusal and incisal surface and gingiva, perpendicular to the mesio-distal line;
- vestibular area;
- vestibulo-oral (VO) distance from occlusal view: the greatest length between the vestibular and oral sides;
- occlusal area;
- depth of the palatal arch: the deepest point of the arch (vault) was assessed visually and marked with a black pen; the model was positioned perpendicular on the stand and captured this way. The most palatal cervical points of first molars were connected and a perpendicular was drawn on that line to the black point (Figure 1);
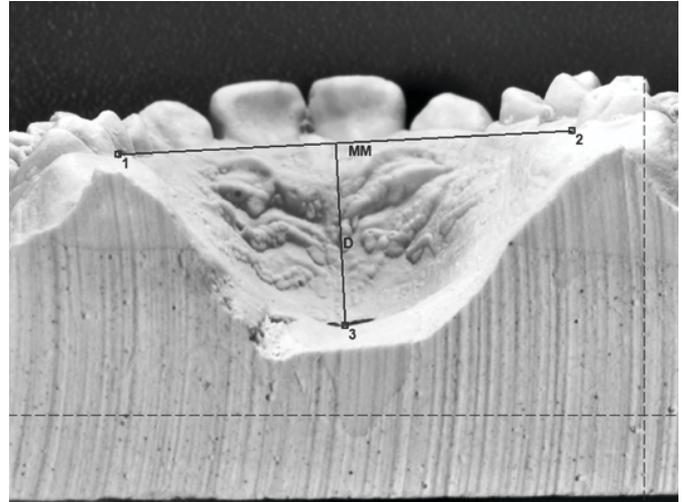

FIGURE 1. Measurement of the depth (D) of palatal arch

- arch breadth: (1) intermolar width: two different measurements were done: one between the central grooves, and another between the most vestibular cervical point (used as landmarks); (2) intercanine width: the distance between the cuspal tips of the canines;
- arch circumference: a polyline drawn through the mesial and distal contact points of teeth from the distal side of the first molar on one side of the arch, to the distal surface of the opposite first molar;
- arch length: the distance between the contact points of central incisors and a line drawn through the most mesial surface of the first molar.

The following teeth were included for measurements: upper arch – first incisor, canine, second premolar, and first molar; lower arch – second incisor, canine, first premolar, and first molar.

All procedures, including image capturing, calibration, and measuring, were carried out by three different, previously trained operators. The operators worked independently, at different occasions.

Statistical analysis was carried out using the SPSS 22 software (IBM Corp.). Intraclass correlation coefficients were defined for each type of measurement.

RESULTS

A total number of 64 teeth from 8 dental casts were captured and measured by each of the three operators. Average values were calculated for each type of measurement (Table 1 and Table 2).

Intraclass correlation coefficients were obtained, where values higher than 0.75 represent an excellent reliability.

TABLE 1. Average values of measured teeth and intraclass correlation coefficients

Measurement		Upper first incisors	Upper canines	Upper second premolars	Upper first molars	Lower second incisors	Lower canines	Lower first premolars	Lower first molars
MD	OP1	8.32	8.01	6.39	10.11	5.86	6.65	7.47	11.35
	OP2	8.71	8.22	6.38	9.83	6.04	6.60	7.38	11.52
	OP3	8.52	7.90	6.31	10.17	5.96	6.63	7.36	11.44
	ICC	0.9	0.82	0.97	0.8	0.84	0.95	0.91	0.95
OG	OP1	8.33	8.99	5.71	5.63	7.19	9.00	7.74	5.69
	OP2	8.33	8.84	5.85	5.74	7.40	9.14	7.55	5.97
	OP3	8.12	8.72	5.98	5.84	7.25	9.08	7.86	6.08
	ICC	0.96	0.94	0.98	0.94	0.95	0.96	0.94	0.94
VA	OP1	58.57	51.73	26.37	46.55	32.84	46.02	39.02	53.05
	OP2	61.55	50.62	26.44	47.87	35.21	46.42	40.68	54.31
	OP3	58.65	50.58	27.12	48.41	33.08	45.85	41.41	55.92
	ICC	0.91	0.88	0.98	0.88	0.85	0.97	0.83	0.95
VO	OP1	6.84	8.01	9.38	11.52	5.98	7.55	7.99	10.48
	OP2	6.80	8.27	9.40	11.69	6.31	7.61	8.13	10.64
	OP3	6.71	8.15	9.20	11.56	5.92	7.59	7.88	10.55
	ICC	0.82	0.81	0.98	0.91	0.86	0.94	0.93	0.88
OA	OP1	44.01	45.94	48.89	99.76	23.88	37.02	45.53	99.32
	OP2	45.75	46.81	50.41	101.61	22.16	37.69	45.71	99.40
	OP3	43.24	46.62	48.56	100.62	24.00	36.76	44.61	100.86
	ICC	0.88	0.9	0.98	0.82	0.92	0.93	0.98	0.86

MD – mesio-distal, OG – occluso-gingival, VA – vestibular area, VO – vestibulo-oral, OA – occlusal area, OP1 – first operator, OP2 – second operator, OP3 – third operator, ICC – intraclass correlation coefficient

The reliability of all the performed measurements showed high degrees, all values being higher than 0.8. Morphomet-

TABLE 2. Average values of measured parameters on dental casts and intraclass correlation coefficients

Measurement	Operator	Average	ICC
Depth of the palatal arch	**OP1**	14.98	0.91
	OP2	14.42	
	OP3	14.98	
Intermolar width 1	**OP1**	46.89	0.95
	OP2	46.68	
	OP3	46.96	
Intermolar width 2	**OP1**	54.98	0.94
	OP2	55.95	
	OP3	55.72	
Intercanine width	**OP1**	34.97	0.98
	OP2	34.14	
	OP3	33.97	
Arch circumference	**OP1**	95.55	0.98
	OP2	94.62	
	OP3	95.13	
Arch length	**OP1**	25.48	0.98
	OP2	25.02	
	OP3	25.20	

OP1 – first operator, OP2 – second operator, OP3 – third operator, ICC – intraclass correlation coefficient

ric measurements with the highest intraclass correlation coefficient values were found for the upper second premolars, occluso-gingival dimensions, intercanine width, arch circumference, and arch length. The lowest values were found in case of mesio-distal dimension of upper first molars and vestibulo-oral dimension of upper canines (Table 1 and Table 2).

DISCUSSIONS

Measurement-based studies should be performed after assessing the repeatability of the measurements.1 Reliability studies offer information on measurement errors which can occur in the same operator or between multiple operators. In studies using bidimensional image analysis, there are several sources of technical errors of measurement such as poor image quality, errors in the positioning of the calibration scale and the method of calibration, the angle of view, or the detection of reference points for the measurements.[3]

Teeth and dental arches were analyzed with the help of a previously validated bidimensional image analysis method.[4,5]

Increased correlation coefficients were found, in several studies, for the bidimensional image analysis method,

with small errors of method for all parameters.[5–7] A previous study showed excellent coefficients of reliability for dental morphometric measurements. The intra-operator reliability of these measurements was found to be in the Excellent category.[7] If more than one operator needs to be included in a measurement-based study, assessing inter-operator reliability becomes necessary. A descriptive statistical tool, the intraclass correlation coefficient can be used when quantitative measurements are made on units that are organized into groups.[8] The present study showed excellent results for the inter-operator reliability of the same parameters.

CONCLUSIONS

Dental morphometric measurements carried out by multiple operators on individual teeth and on dental casts, using 2D image analysis, can be performed with an excellent reliability.

CONFLICT OF INTEREST

None for all authors.

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