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# Application of Digital Radiography for Measuring in Clinical Dental Practice

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**SUMMARY**
**Introduction** The recent literature data points out a rising application of digital radiography – radiovisiography (RVG) – in dental clinical practice.
**Objective** The aim of this study was to apply and compare RVG with the conventional radiographic technique (CRDG) in terms of accuracy in linear measurement in dentistry.
**Methods** Measurements were done on the mandibular dogs teeth considering incisors crown width and height of the surrounding alveolar bone using RVG and CRDG. The control technique (CONT) involved values obtained by direct gauging in dogs mouth. Each measuring was done by two examiners.
**Results** Considering the incisors' crown width, there were no significant statistical difference in measurement using CRDG, RVG and CONT technique ($p>0.01$). Concerning the alveolar height gauging there were no significant difference in recorded values between the two radiographic techniques ($p>0.01$). The high level of inter-examiner agreement was observed for scoring in all techniques (CRDG, RVG and CONT).
**Conclusion** Although RVG did not expose more accuracy comparing to CRDG, having opulent tool service the first technique contributed more comfortable work during measuring procedures in this study.
**Keywords:** anthropometry; alveolar ridge height; tooth crown width; digital radiography – radiovisiography; mandibular incisor; morphometrics

## INTRODUCTION

According to the literature data, digital radiovisiography (RVG) system incorporated in up-to-date radiography devices has become more than an "auxiliary diagnostic mean" as it was unjustly miscalled for decades. The reason to confirm that statement is in the following review on the history of radiologic devices. The first considerations about a high preciousness and quality of computer analyses of radiographic images were presented far in the past [1]. Soon some investigators worked on specialization in realizing the advantages of operator-interactive, computer controlled system for high fidelity digitalization and analysis of biomedical images [2]. The dawn of the digital era in dental radiography came in 1987, when the first digital radiography apparatus system called RadioVisioGraphy (RVG) was launched in Europe by French company Trophy Radiologie. The inventor of this system, Dr. Francis Mouyen, invented the way to employ fibre optics to narrow down a large x-ray image onto a smaller size that could be sensed by a CCD image sensor chip [3]. Soon Finish engineer-physicist Paul Suni helped in the creation of CCD image sensor technology that was needed to make RVG digital radiography system a reality [4]. Now, two decades later, RVG has exposed many advantages even in veterinary dentistry [5]. There is a possible use of intraoral camera while performing an oral cavity examination. However, LCD display screen enables dental examination even during intervention. The DXA analysis of RVG device enables the measurement of density of radiographied tissues expressed in $g/cm^3$ units, in many literature articles named as bone mass density, also the useful parameter of scoring the periodontal disease whether of hormonal, traumatic or bacterial origin [5, 6]. However, conventional radiographies (CRDG) were used for a long period of time, and even now in tooth and jaw changes in humans and dogs exposing satisfactory results [7, 8].

Nowadays, RVG has become a more suitable device in analyzing dental status in dogs. However intra and extraoral radiograms in dogs proved as a useful diagnostic mean revealing the periodontal disease, one of the most frequent oral pathological conditions of the permanent teeth. Some authors stated that the use of grid template was not so accurate method as computer measuring by RVG [8, 9]. On the contrary, in prospective studies some authors use dental film holder and grid as the accurate system for recording alveolar ridge height (ARH) in old patients following the regression of bone mass [10]. Literature data reported measuring of ARH of human mandibula by manual direct and indirect methods. According to the landmarks the authors applied a sliding calliper for comparing the values obtained by standard software on the two-dimensional reconstructions of mandibular multislice computed tomography scans [11]. With time, the possibility of measuring the ARH and density values followed to diagnose the degree of periodontal disease. This is important especially in hunting dogs, shepherd-dogs as well as police dogs due to their duties and the quality of bite force [5].

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The role of regularly arranged teeth set is important for neutral occlusion and subsequent firm bite (its high value), most wishful feature in humans as well as in some types of dogs. The condition of dentition in thoroughbred dogs has an important role in kinologists' attempts to determine the health status in dogs. The importance of CRDG confirmed the study on incisives performed by intraoral recording to observe retained and fractured teeth [9]. Considering traumatic occlusion, the quality and force of bite as well as in humans may provoke very fast progression of periodontal disease when radiological assessment could be of great value exposing the thickening of lamina dura [12]. The reason for application of x-ray diagnosis considers the following: contrast between alveolar bone and soft tissue radiographically is based on the fact that the bone absorbs around 40 times more x-rays than the soft tissue [12]. Moreover, regarding RVG, image process may expose advantage due to magnification possibility, 3D visualization, low exposure, image inversion or brightness and contrast adjustment, besides being the tool for linear and angular measurements and histogram levels [4, 13, 14, 15]. In dogs as well as in humans the dental narrowness is most frequent and exposed in the frontal mandibular region. One of the parameters that points out the progression of periodontal disease is the height of alveolar ridge i.e. resorption process in the course of time. In addition, the degree of periodontal disease affects the size of lacuna spaces and the thickness of bone trabeculae [5]. Hence the orthodontic therapy of malocclusion is partially based on the scoring of the incisors sum i.e. measuring the width of every single incisor [16]. Beside the function of setting the anomaly of bite (malocclusion) the orthodontic therapy creates the conditions for good oral hygiene considering easy cleaning and (physiological) self-cleaning of teeth and interdental spaces thus stopping or slowing the progression of periodontal disease.

The calliper and ruler direct technique has been proven in orthodontic practice as satisfactory over more than century. The accuracy of orthodontic ruler is of 0.5 mm raster i.e., error of 0.25 mm, which is higher than that of CRDG and common millimetre ruler that present the accuracy of 1.0 mm and 0.5 mm, respectively. Nevertheless, the accuracy of RVG is at the level of 0.1 mm and therefore it can be expected to present superior quality in measuring anatomical structures in dental radiology.

## OBJECTIVE

The aim of this experiment was to estimate the preciseness and convenience in measuring procedures of crown width (CW) in mandible incisors using CRDG and indirect digital mode RVG. Specifically, the study aimed to investigate if the choice of radiographic methods (CRDG and RVG) influences the precision procedures for measuring (CW). Additionally, the study was conducted to evaluate the precision and convenience of CRDG and RVG for ARH measuring in mandible incisors.

## METHODS

CW of all mandible incisors and height of alveolar bone septum (ARH) in central lower incisors were measured in five dogs of Yorkshire terrier aged two by permission of their owner. The study was approved by the Ethics Committee of the Faculty of Stomatology, Belgrade University.

The study was processed through the experimental (CRDG and RVG) and control CONT group. In order to provide uniformity in indirect measuring of CRDG and RVG process the care was undertaken in position of film and tooth i.e. angulation that was standardized for intraoral retroalveolar recording where the dog's head was positioned with the lower jaw parallel with the floor. Each imaging session was performed by two dental x-ray devices: (Heliodent, Siemens, Germany and RVG Trophy 2011, France) by focal-film distance of 30 cm. Both radiography devices were equipped with a long cone for parallel recording technique to avoid discrepancy of original size. The previous pioneer study of several radiographies revealed the most appropriate exposition time for both techniques as 0.1sec with the central x-ray directed perpendicularly to the longitudinal tooth axis. The exposed films were processed by Durr Dental apparatus while RVG images by trimming on the Adobe Photoshop software, version 5 (TIF format). The folders were created for each series and saved in the data bank. Radiograms for RVG measuring were previously adjusted for brightness and contrast.

The direct measuring in CONT group was done by an orthodontic ruler (Acier inox) with the raster of 0.5 mm and accuracy of 0.25 mm and pair of calipers using illuminator and 4× loupe.

The directly measured linear values for CRDG and CONT group were noted using approximation of the nearest mark on the graduated scale of 0.5 mm on the ruler.

### Measuring of crown width

In experimental groups CW of lower incisors was considered as the most mesio-distal distance of the most prominent points on the crown of radiogram (Figure 1).

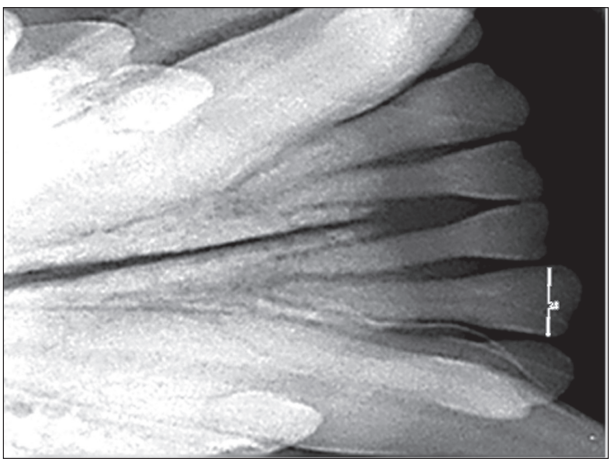

**Figure 1.** Measuring of crown width (CW) in lower incisors

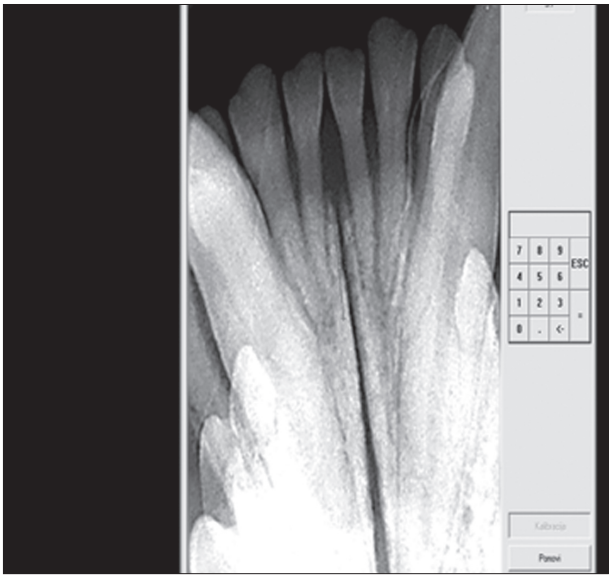

**Figure 2.** The measuring of alveolar ridge height (ARH) in lower incisors

In CONT CW values were obtained by direct recording in dog's mouth considering the same orientation points as in previous groups.

### Measuring of alveolar ridge height

The radiographies of teeth were obtained by a) dental CRDG, and b) RVG device. The next geometric model of triangle was established for ARH indirect measuring on the mandibular mesial cortex between the central incisors. The size of alveolar cortical septum *h* was set as the height of the approximate isosceles triangle whose lateral sides were intermaxillary suture and periodontal lamina of adjacent tooth. The triangle base was considered as the imaginary line perpendicular to the long axis of the incisor and tangenting the root apex (Figure 2). The peak of triangle was most radiologically visible coronal point of alveolar bone in lamina dura tissue. The height value (h1) for tooth 31 was subtracted of (h2) value for tooth 41 in the CRDG group giving difference value for further calculation. The height value (h3) for tooth 31 was subtracted of (h4) value for tooth 41 in the RVG group giving difference value for further calculation.

Comparison of ARH values by two radiographic methods was calculated through the subtraction of differences values such as h1-h2 – h3-h4.

The measuring in a) group was done on the radiographic image by orthodontic ruler, a pair of calipers using illuminator and loupe. The linear measuring for b) group was worked out by automated tool measuring option of Trophy 2001 software program.

### Statistical method

The inter-examiner evaluation for CRDG, RVG and CONT group measuring was conducted by Kendall's coefficient of concordance W. Statistical analyses of obtained measuring values considered standard Student's t-test and paired t-test with significance level of 0.05. The round off for all recorded values was done by arithmetic rule.

## RESULTS

### Crown width in the lower incisors by CRDG technique

The inter-examiner evaluation by Kendall's coefficient (W=0.85) was in the range of high degree concordance. Discordance (three cases) in reading, drawing and measuring of CW was recorded as maximum of 0.5 mm values. These three were calculated as arithmetic mean. The results of CW measuring by CRDG are presented in Table 1, where values exposed CW in central incisors in the range of 2.5-3.0 and 3.0-3.5 mm for laterals. The differences of CW by CRDG in incisor in the same jaw for the entire sample were of 0.0 mm for centrals and laterals. The observed data in Table 1 directs to no statistical significance in CW for the central and lateral incisors at the level of 0.05.

Mean values for CW of central and lateral incisors within the same jaw by CRDG exposed no differences between the left and right central incisors (2.6 vs. 2.6 mm) enabling further statistics. The similarity was recorded for lateral incisors (3.2 vs. 3.2 mm). CV for the central and lateral incisors was 6.1% and 7.5%, respectively. Such low values (CV<30.0%) point at the homogenous sample very confidential for further statistics.

### Tooth crown width in the lower incisors by RVG technique

The inter-examiner evaluation by Kendall's coefficient (W=0.85) was in the range of high degree of concordance. Discordance (two cases) in reading, drawing and measuring CW was recorded as maximum of 0.6 mm values. These two were processed as arithmetic mean. By analyzing Table 2 values it was noted that CW in the lower central incisors was in the range of 2.4-2.8 and 2.9-3.4 mm for laterals. The similarity is very obvious if those RVG range (0.4-0.5 mm) are compared to the Table 1 CRDG values (0.5-0.5 mm). The findings about the differences of CW between the central incisors within the same jaw as well as between the laterals were minimal i.e. in the range of 0.0-0.1 mm. The average value for the difference between the central incisors was 0.00 and 0.04 mm for the laterals. In addition, those values did not show statistically significant difference, exposing the variations of around 3% of average width in the central incisors and around 1.5% for the laterals. Such results present the base for further very confidential statistics. Calculated values for correspondent CW were as far as lower than 30.0% (1.1 to 8.1%), discerned homogenous sample confidential for further accurate statistical processing.

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**Table 1.** Crown width (CW) values (mm) of lower incisors by the conventional radiographic technique (CRDG)

| CW CRDG | Tooth | | | | Σ |
|---|---|---|---|---|---|
| | 31 | 41 | 32 | 42 | |
| Dog 1 | 2.5 | 2.5 | 3.0 | 3.0 | 11.00 |
| Dog 2 | 2.5 | 2.5 | 3.0 | 3.0 | 11.00 |
| Dog 3 | 2.5 | 2.5 | 3.5 | 3.5 | 12.00 |
| Dog 4 | 2.5 | 2.5 | 3.0 | 3.0 | 11.00 |
| Dog 5 | 3.0 | 3.0 | 3.5 | 3.0 | 13.00 |
| Mean | 2.60 | 2.60 | 3.20 | 3.20 | 11.60 |
| CV% | 6.1 | 6.1 | 7.5 | 7.5 | 29.20 |

**Table 2.** Crown width (CW) values (mm) of lower incisors measured by radiovisiography (RVG)

| CW RVG | Tooth | | | | Σ |
|---|---|---|---|---|---|
| | 31 | 41 | 32 | 42 | |
| Dog 1 | 2.40 | 2.40 | 2.90 | 2.90 | 10.60 |
| Dog 2 | 2.40 | 2.50 | 2.90 | 3.00 | 10.80 |
| Dog 3 | 2.60 | 2.50 | 3.40 | 3.40 | 11.90 |
| Dog 4 | 2.40 | 2.50 | 3.00 | 2.90 | 11.90 |
| Dog 5 | 2.80 | 2.80 | 3.20 | 3.20 | 12.00 |
| Mean | 2.52 | 2.54 | 3.13 | 3.08 | 11.27 |
| CV% | 8.10 | 3.70 | 1.10 | 4.70 | 17.60 |

**Table 3.** Crown width (CW) values (mm) of lower incisors obtained in the control group (CONT)

| CW CONT | Tooth | | | | Σ |
|---|---|---|---|---|---|
| | 31 | 41 | 32 | 42 | |
| Dog 1 | 2.50 | 2.50 | 3.00 | 3.00 | 11.00 |
| Dog 2 | 2.50 | 2.50 | 3.00 | 3.00 | 11.00 |
| Dog 3 | 3.00 | 3.00 | 3.50 | 3.50 | 13.00 |
| Dog 4 | 2.50 | 2.50 | 3.00 | 3.00 | 11.00 |
| Dog 5 | 3.00 | 3.00 | 3.50 | 3.50 | 13.00 |
| Mean | 2.70 | 2.70 | 3.00 | 3.20 | 11.60 |
| CV% | 13.30 | 8.90 | 6.70 | 7.40 | 36.30 |

**Table 4.** The sum of incisors (mm) in CRDG. RVG and CONT group

| Sum | Group | | |
|---|---|---|---|
| | CRDG | RVG | CONT |
| Dog 1 | 11.00 | 10.60 | 11.00 |
| Dog 2 | 11.00 | 10.80 | 11.00 |
| Dog 3 | 12.00 | 11.90 | 13.00 |
| Dog 4 | 11.00 | 10.80 | 11.00 |
| Dog 5 | 13.00 | 12.00 | 13.00 |
| Mean | 11.60 | 11.15 | 11.80 |
| Σ | 58.00 | 56.10 | 59.00 |

**Table 5.** Absolute values of mean differences (d) in crown width (CW) obtained by CRDG/RVG, CRDG/CONT and RVG/CONT comparison mode

| d | Group comparison | | |
|---|---|---|---|
| | CRDG/RVG | CRDG/CONT | RVG/CONT |
| Dog 1 | 0.40 | 0.00 | 0.40 |
| Dog 2 | 0.20 | 0.00 | 0.20 |
| Dog 3 | 0.10 | 1.00 | 1.10 |
| Dog 4 | 0.20 | 0.00 | 0.20 |
| Dog 5 | 1.00 | 0.00 | 1.00 |
| Σ | 1.90 | 1.00 | 2.90 |

## Crown width values in the lower incisors by direct technique (CONT)

The inter-examiner evaluation by Kendall's coefficient (W=0.95) was in the range of high degree of concordance. Discordance (one case) in drawing, reading, and measuring CW was recorded as 0.5 mm. The values in the Table 3 obtained by direct in vitro measuring in dogs presented CW of central incisors in the range of 2.5-3.0 mm and 3.0-3.5 mm for the laterals. The average CW deviation did not exist i.e. it was 0.0 mm. The arithmetic mean values for the central and lateral incisor in the control group were 2.7 and 3.1 mm, respectively. CW values in the range of 8.9-13.3% for the central and 6.7-7.4% for the lateral incisor promised reliable further statistics. There were no statistically significant differences in CW comparing bilaterally central and lateral incisors within the same jaw.

Table 4 exposes the mean values of incisive sum of all examined dogs for three study groups. Similarity was noted in the ranges among them: 1) CRDG (11.0-13.0 mm), 2) RVG (10.6-12.0 mm), and 3) CONT (11.0-13.0 mm). These data qualified all three groups as a homogenous sample. The minimal values of CW were in the range of 1.1 to 13.3%, far under 30.0%, very confidential for statistics. Noted absence of significant statistical difference of incisors sums among three groups was at the level of $\alpha$=0.05.

Significant statistical difference did not exist in CW of incisors when comparing the values obtained by CRDG/RVG techniques considering the parameters t=1.845, DF=4, $\alpha$=0.05 as well as CRDG/CONT t=1.000, DF=4 and $\alpha$=0.05 and RVG/CONT t=2.886, DF=4 and $\alpha$=0.05.

Kendall's coefficient W varied from 0.85 to 0.95 indicating a high degree of inter-examiner concordance. Moreover, there were no significant differences in Kendal W values in the reciprocal comparison of CRDG, RVG and CONT groups.

## Measuring of alveolar ridge height by CRDG technique

Kendall's coefficient W=0.80 was in the range of high degree of concordance. Discordance in two cases in reading, drawing and measuring of ARH was recorded as maximum of 0.6 mm values. These two were calculated as arithmetic mean. The difference of ARH values between the central incisors (h1-h2) within the jaw were in the range of 0.0-0.5 mm with no statistical significance by parameters t=1.634, DF=4, and $\alpha$=0.05 (Table 5).

## Measuring of alveolar ridge height by RVG technique

Kendall's coefficient W=0.80 was in the range of high degree of concordance. Discordance (two cases) in reading, drawing and measuring the ARH was recorded as maximum as 0.3 mm values. These two were calculated as arithmetic mean. The difference in ARH (h3-h4) between

**Table 6.** Alveolar ridge height (ARH) values (mm) in central mandible incisors area noted by CRDG and RVG techniques

| CRDG & RVG | ARH values | | | | | |
|---|---|---|---|---|---|---|
| | Tooth 31 mes. (h1) | Tooth 41 mes. (h2) | Subtraction h1-h2 | Tooth 31 mes. (h3) | Tooth 41 mes. (h4) | Subtraction h3-h4 |
| Dog 1 | 6.00 | 6.00 | 0.00 | 5.60 | 5.70 | 0.10 |
| Dog 2 | 8.00 | 8.50 | 0.50 | 7.80 | 8.30 | 0.50 |
| Dog 3 | 7.00 | 7.00 | 0.00 | 6.60 | 6.70 | 0.10 |
| Dog 4 | 8.00 | 7.50 | 0.50 | 8.00 | 7.60 | 0.40 |
| Dog 5 | 8.00 | 8.00 | 0.00 | 7.70 | 7.90 | 0.20 |

**Table 7.** Subtraction differences in measured values of alveolar ridge height (ARH) between the central incisors obtained by CRDG and RVG techniques

| ARH | Subtraction differences | | |
|---|---|---|---|
| | CRDG (h1-h2) | RVG (h1-h2) | CRDG/RVG (h1-h2)–(h3-h4) |
| Dog 1 | 0.00 | 0.10 | 0.10 |
| Dog 2 | 0.50 | 0.50 | 0.00 |
| Dog 3 | 0.00 | 0.10 | 0.10 |
| Dog 4 | 0.50 | 0.40 | 0.10 |
| Dog 5 | 0.00 | 0.20 | 0.20 |

the central incisors within the jaw were in the range of 0.1-0.5 mm with no statistical significance by parameters, t=3.522, DF=4 and α=0.05 (Table 6).

The obtained subtraction differences for ARH were in the range of 0.0-0.2 mm (Table 7) wherein the parameters t=3.145, DF=4 and α=0.05 pointed at no significant statistical difference comparing two radiographic methods. Kendall's coefficient W was 0.80 for both radiographic measuring methods of ARH indicating a high degree of inter-examiner concordance with no significant differences comparing CRDG to RVG findings.

## DISCUSSION

According to the opulent literature data, RVG system incorporated into up-to-date radiographic devices has now become more than an "auxiliary diagnostic mean" as it has been unjustly miscalled for decades. This is the reason to apply RVG system on the experimental model for confirmation in accuracy of its gauge tool in the linear measuring of the crown width and ARH in dogs. The lower incisors were selected because of conformity in radiography process as well as in direct values reading in the control group. Another reason is the fact that mandible exposes the minimum curvature in the frontal region that may not influence considerably to the preciseness of reading. This is of greater importance for RVG where rigid CCD receiver was applied. The horizontal and vertical measuring on RVG images might be of less importance for the first one but of more importance for the second one due to the curvature of alveolar bone in the sagittal plane. However, RVG equipped with a rigid sensor will always expose slightly smaller values in comparison to the classical radiography device and flexible film for the same object. Although our RVG device was not linked to the flexible CCD we used the rigid plate due to the fact that a possible difference would be of minor statistical significance. Considering the aforementioned and in regard to the position of lateral incisor in the alveolar arch the measuring will be always slightly more accurate in central which were selected for ARH gauging.

The reason for the choice of the direct measuring of CW on the dogs' teeth as controls rests on the fact that orientation landmarks (most prominent mesial and distal point of the crown) are more accessible and notable in vivo (dogs mouth) than via radiograms.

It is possible to measure and calculate CW on the formed geometric model using specific anatomic landmarks as referent points thus producing morphometric parameters [11]. This mode is used by authors for measuring the height of human mandibular corpus in the region of the mental foramen [11]. Those authors point out larger errors during indirect measuring due to the relatively lower accuracy detecting the referent landmarks on the CT graphs in comparison to the direct measured values on the human mandible. The same explanations might be for minimal discordance confirmed by the Kendal test in our investigation when comparing direct and indirect measuring where concordance coefficient among investigators were slightly lower in CRDG and RVG findings (graphs) than in the control group.

Obtained values for incisors CW were slightly higher in CRDG than in RVG group. One can say that in most cases these higher values were of systemic origin with no statistical significance. The lower noted values in the RVG group might be attributed to the rigidity of our CCD which could not compensate the curvature of alveolar arch in the frontal mandible region. Previously slightly adapted flexible retroalveolar radiographic film was more successful to follow alveolar arch contour raising the accuracy of incisors CW. Considering our incisors CW values in the control group none of radiographic technique should be favored.

The same statements for the rigidity of CCD and flexibility of conventional retroalveolar dental film could be applied on the ARH findings due to the existence of alveolar septum i.e. root curvature in the incisors region in the crown-apical direction. The measurement of mandibular ARH did not display the differences comparing movable scale and 2D CT technique [11]. The same doctrinal attitude is set on the basis of our experiment comparing ruler and digital measurement. Confirmation for equal preciseness of linear and radiographic density on the same sample (alveolar pocket) gives positive correlation of recorded values [17].

Evaluation of inter-examiner agreement is highly important in studies related to radiographic interpretation hence our study involved two researchers providing a higher level of objectivity. The reliability of radiographic interpretation may be affected by professional formation, experience, quality of radiograms etc. The values of W coefficient for CW in all three study groups (0.85; 0.85; 0.90) are in agreement with the ARH findings (0.80; 0.80). This indicates a high level of inter-examiner agreement and the proper control of the aforementioned factors. The similar results of W coefficient and doctrine attitude were noted by Brazilian authors comparing CRDG and RVG technique for linear odontometric values [15].

The errors in linear measured values might appear because of manual manipulation by ruler and caliper in the CRDG and control group. Considering aforementioned errors in RVG automated process might be less exposed where accuracy was noted as 0.05 mm comparing to the 0.25 mm value noted in the CRDG and control group. The measuring errors might be of round-off protocol to the nearer graduated mark on the scale of the 0.5mm raster in the CRDG and CONT group comparing to the automated process of recording the closest value of 0.1 mm raster.

We can confirm that RVG noted values by automated software are of minor errors in our study including only the misinterpretation of anatomical landmarks avoiding the subjective reading on the millimeter scale like in CRDG and CONT group for ARH and CW values. The presence of systematic errors could be of linear noting values and reading what is in concordance to the observation [11].

The most of CRDG measured values in our study were higher than RVG for CW as well as for ARH but not significantly. The similar findings were found in comparison of CRDG and RVG in the linear measurement of root canal length [15]. The explanation for this might be in higher accurate level of linear detection (0.1 mm for RVG) [15].

Although we were satisfied with the exposed radiographic contrast in our study in the CRDG and RVG group the reason for errors might be in superposition of enamel tissue of adjacent incisor crown in crowding. The measurement of mandibular ARH did not display differences comparing movable scale tool and 2D CT technique [11]. Their values were systematically higher in almost entire sample in the direct measuring. Similar situation was recorded in our direct measuring.

Radiographic misinterpretation of anatomic landmarks such as the most prominent mesial and distal points might be possible factor of error in linear CW measurement or noting the peak of interalveolar septum. The same problem occurred in the identification of superior alveolar limbus and the lowest point of mandibular base in the region of mental foramen [11]. Hence, there is need for standardization of the measuring protocol for the alveolar bone as the very important parameter for osteoporotic process and progressive course of periodontal disease.

All in all, many authors point at the advantages of tools options in digital radiologic device as more comfortable in outpatient practical analysis of radiogram in comparison to CRDG [13-18].

Some investigators expose the contrast option as the most important for accurate location of anatomic structure such as tooth root apex, borders of large bone lesions, etc. [19, 20, 21].

Most studies in humans of the diagnostic efficacy in comparison of digital images with film-based radiographs generally conclude that the second ones are not statistically different from the first ones [20, 21]. The same is to be generally concluded on the basis of our study in dogs. Although there are no similar investigations in literature data review like ours, the findings of human dental measurements by RVG and CRDG revealed no significant differences in accuracy but with more comfort for the second one. On the contrary, some studies confirm more accuracy in linear measurement by RVG [15] while others advocate CRDG [19].

Considering the above mentioned outcomes, a similarity in the conventional and digital methods recorded values can be observed [15, 19]. However the some authors' opinion are equal to ours in agreement that tools for radiographic image processing improves the quality of interpretation, enhancing the achievement of measurements by magnification or zoom, altering the brightness and contrast, inverting the image (negative) or converting in 3D appearance by digital analysis [14, 22, 23].

Altogether, RVG manipulations should be claimed as superior in respect to simple dental CRDG assuming linear measuring.

## CONCLUSION

The presented study showed that image processing by digital RVG aids linear measurement in dental practice such as CW and ARH. Although RVG in comparison to CRDG findings did not expose significant differences in accuracy for above mentioned anatomical structures, opulence in the variety of available tools may contribute to a more comfortable and beneficial clinical practice.

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# Примена дигиталне радиографије у мерењима у стоматолошкој клиничкој пракси

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**КРАТАК САДРЖАЈ**

**Увод** Најновији подаци из литературе указују на све већу примену дигиталне радиографије – радиовизиографије (*RVG*) – у клиничкој стоматолошкој пракси.

**Циљ рада** Циљ рада је био да се *RVG* техника примени и упореди с конвенционалном (*CRDG*) у погледу прецизности за линеарна мерења у стоматологији.

**Методе рада** Мерења су извршена на зубима паса тако што су одређиване ширина секутића доње вилице и висина околне алвеоларне кости уз примену *RVG* и *CRDG* технике. Контролна техника (*CONT*) је подразумевала директни начин очитавања измерених вредности у устима паса. Сва мерења су обавила два испитивача.

**Резултати** Посматрајући измерене ширине секутића, није забележена значајна статистичка разлика међусобним поређењем две радиографске и *CONT* технике мерења ($p>0,01$). Поредећи вредности висине алвеоларног гребена, нису забележене значајне статистичке разлике између примењене *RVG* и *CRDG* технике ($p>0,01$). Забележена је висока усаглашеност међу испитивачима у вези с очитаним вредностима код све три технике мерења.

**Закључак** Иако се на основу наших резултата не може тврдити да је *RVG* техника била прецизнија од *CRDG*, богат избор софтверских алатки инкорпориран код примене *RVG* технике омогућио је комфорније руковање током мерења примењеног у овом истраживању.

**Кључне речи:** антропометрија; висина алвеоларног гребена; ширина крунице зуба; дигитална радиографија – радиовизиографија; мандибуларни секутић; морфометрија

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