Analysis of Tooth Measurement Method Accuracy in Digital Periapical Radiograph for Personal Identification

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Abstract

In the field of forensic dentistry, methods for personal identification through tooth measurement have been developed. This study aimed at proposing a new method for personal identification using digital periapical radiograph.

Seven measurements were performed in 206 digital periapical radiographs (103 patients with age more than 14 years old have double radiographs in the same region of interest) from seven reference distanceswhich were appointed before the measurement in permanent mandibular second premolar and first molar. The measurement process was done in two ways, digital radiography software andmanual measurement.

The reliability of seven reference points was assessed with intra-observer and inter-observer values (TEM < 1 mm). The accuracy of tooth measurement method was assessed withBland-Altman test that demonstrated no statistical difference(p> 0.050) regarding paired radiograph comparison. Limits of agreement (LOA) values from Bland-Altman test showed range of difference (mm) from paired radiograph whichwas still acceptable as same person. The method been examined further through blind test for similarview radiographs resulted 100% match between one pair radiograph with true identity came from thesame person.

The method proposed in this study is able to identify person accurately.

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Introduction

Health legislation of Republic Indonesia (No. 36/2009) gives mandate to government and community to identify unidentified person due to mass disaster incident.[1,2] Determining person identity is termed by personal identification.[3]The most important thing in identification process is preservation of biological sample.[4] Tooth have been proven to be resistant biological sample.[5–10]

Antemortem and postmortem dental comparison commonly use radiograph as an objective tools since every single anatomical structure will be projected on it.[11–14] The accuracy of radiograph utilization in forensic identification process reaches 81.6% in MacLean *et al* study and 93% in Balagopal study.[11,15]Periapical radiography technique with good visual and geometric aspectsis usually been used in identification process rather than any other techniques.[7,11,16] It is also common technique in clinical practice which makes periapical radiograph as a valuable antemortem data.[1,7,11,16–18]

Digital radiography technique becomes well received in Indonesia, even though its use is still centralized in class A hospital.[19] Digital technique offers enhancement in picture quality through dental software package, better visualization, radiograph in screen monitor, and retaking radiograph instantly.[20–24] Digital radiographs can be printed in certain paper for assessment and communication purpose. It has high sensitivity and good overall display compared with screen monitor view.[25]

In line with the development of digital radiography technique, identification method using digital system is believed to be more accurate, faster, efficient, and accepted

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legally.[26–28]Some conditions are not feasible to be examined with conventional radiography technique like fragile decease or stiffness induced by heat.[12,29]

Digital periapical radiography technique is able to identify person as stated in Maurya *et al* study.[26] Similar to Maurya *et al*, Borker and Naik study tooth measurement method to identify person by using reference points in teeth with accurate result.[30] Santoro *et al* on their study has introduced c*emento-enamel junction* (*CEJ*) as a stable anatomical part on teeth so that it can be used as reference point in tooth measurement method to identify person with sensitivity 97%, specificity 85%, and accuracy 95%.[31]

In order to effectively establish individual identity through personal identification, it is necessary to increase new studies and evolve new methods.

Materials and methods

The sample was 206 digital periapical radiographs (103 patients that have double radiographs), with known age more than 14 years old. These radiographs belong to the Specialized Pavilion at Faculty of Dentistry, Universitas Indonesia. Sex was not separated in this study based on assumption that the result from tooth measurement comparison will match individually.

In this study, reference points were appointed and tooth measurements were performed. For method validation, calibration was set with two examiners. The examiners examined 206 digital periapical radiographs in different place and time. Intra- and inter-observer test were applied using Dahllberg formula (Technical Error Measurement or TEM) for method calibration. However, only one examiner examined 206 printed radiographs.

For standardization of measurement, digital radiographs were calibrated in 41 mm size with no image enhancement and printed radiographs (JPEG format) were calibrated in 31 x 41 mm size before printed in glossy paper using HP inkjet with standard optimization.

For tooth measurement obtainment, digital ruler (Digora for windows 1.51) was used for digital radiographs and caliper digital (Mitutoyo) was used for printed radiographs. Measurements were obtained by measuring the distance between reference points previously appointed in c*emento-enamel junction* (*CEJ*) and apical part of permanent mandibular second premolar and first molar. Measurement results were tabulated in Excel spreadsheet.

For tooth measurement, the distance between twoselected reference points was measured with total of seven distances (three from mandibular permanent second premolar and four from mandibular permanent first molar) (Figure 1). As already mentioned above, the sample was digital periapical radiograph from 103 patients with each patient has two radiographs which were first-taken and second-taken radiograph. The 103 samples consisted of 49 samples left mandibular and 54 samples right mandibular.

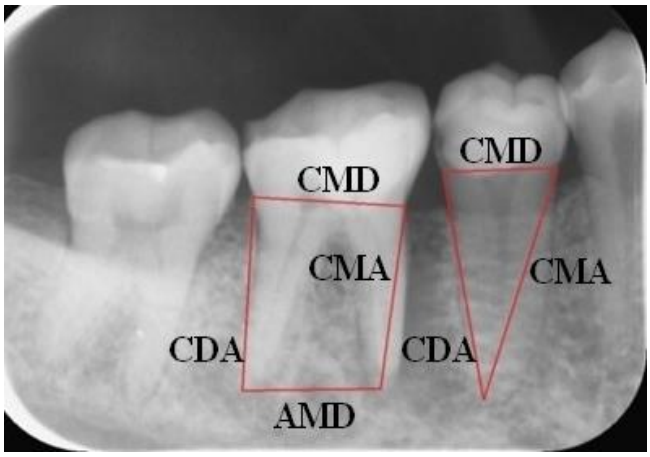

Figure 1. Reference distancesaccording to tooth measurement method.
CMA) Distance between mesial CEJ and mesial apical.
CDA) Distance between distal CEJ and distal apical.
CMD) Distance between mesial CEJ and distal CEJ.
AMD) Distance between mesial apical and distal. apical.

Comparison of seven reference distances measurements from digital periapical radiograph was done between first-taken (analogue as antemortem radiograph) and second-taken (analogue as postmortem radiograph) radiographs for each 103 samples, so was printed radiographs. The measurement difference (mm) between paired radiograph comparisons then analyzed further to determine to whom it belongs.

For the statistical analysis, reliability of reference points was assessed with Dahlberg formula. The accuracy of tooth measurement method on digital periapical radiographs was assessed with Bland-Altman test without doing descriptive analysis or normality test first

because the sample is more than 30 (for Bland-Altman only). Measurement comparison between digital periapical radiographs and its printed was then assessed with student t-test.

The application of this method aimed at developing radiographic measurement from tooth for personal identification.

Results

Dahlberg formula was used to test the reliability of reference points with Technical Error Measurement (TEM) intra- and inter-observer result below than 1 mm for all reference points.

Bland-Altman test result in table 1 shown p-value for tooth measurement comparison between paired digital periapical radiograph samples. All of the reference distances were considerably above significance level ($p > 0.050$) with its limits of agreement (LOA) value.

Bland-Altman test result in table 2 and table 3 shown p-values for tooth measurement comparison in different mandibular side, both were considerably above significance level ($p > 0.050$) for all reference distances with its LOA value.

Bland-Altman test result for tooth measurement comparison in printed radiographs for left mandibular samples shown p-value below significance level which was CMD 2ndP ($p = 0.019$), meanwhile result for right mandibular samples shown p-value was considerably above significance level ($p > 0.050$) for all reference distances.

In addition, student t-test result for measurement comparison between digital periapical radiographs and its printed has shown significance p-value ($p = 0.000$) for all reference distances.

Blind test result in table 4 shown positive matches between one first-taken radiograph with three second-taken radiographs that have similar view with first-taken radiograph in Mr. X2 (57.14% and 71.43%).

Blind test result in table 5 shown positive matches between one first-taken radiograph with four second-taken radiographs that have similar view with first-taken radiograph in Mr. X4 (100%).

Reference Distances	p	CI	Limits of Agreement (mm)
CMA 2ndP	0.705	-0.057 to 0.039	-0.493 to 0.475
CDA 2ndP	0.335	-0.073 to 0.041	-0.557 to 0.505
CMD 2ndP	0.648	-0.029 to 0.046	-0.367 to 0.385
CMA 1stM	0.217	-0.018 to 0.077	-0.444 to 0.504
CDA 1stM	0.306	-0.024 to 0.110	-0.606 to 0.672
CMD 1stM	0.809	-0.046 to 0.036	-0.419 to 0.409
AMD 1stM	0.842	-0.046 to 0.056	-0.507 to 0.517

Table 1. Tooth measurement comparison result for whole samples of digital periapical radiograph.

Reference Distances	p	CI	Limits of Agreement (mm)
CMA 2ndP	0.711	-0.072 to 0.105	-0.586 to 0.618
CDA 2ndP	0.456	-0.063 to 0.137	-0.645 to 0.719
CMD 2ndP	0.345	-0.031 to 0.087	-0.374 to 0.430
CMA 1stM	0.150	-0.046 to 0.293	-1.035 to 1.281
CDA 1stM	0.196	-0.058 to 0.278	-1.039 to 1.259
CMD 1stM	0.371	-0.039 to 0.101	-0.447 to 0.509
AMD 1stM	0.434	-0.151 to 0.066	-0.781 to 0.697

Table 2. Tooth measurement comparison result for left mandibular samples of digital periapical radiograph.

Reference Distances	p	CI	Limits of Agreement (mm)
CMA 2ndP	0.840	-0.089 to 0.072	-0.586 to 0.570
CDA 2ndP	0.227	-0.136 to 0.033	-0.662 to 0.558
CMD 2ndP	0.759	-0.056 to 0.041	-0.354 to 0.340
CMA 1stM	0.682	-0.052 to 0.079	-0.458 to 0.486
CDA 1stM	0.392	-0.047 to 0.118	-0.558 to 0.630
CMD 1stM	0.093	-0.089 to 0.007	-0.386 to 0.304
AMD 1stM	0.676	-0.054 to 0.083	-0.480 to 0.508

Table 3. Tooth measurement comparison result for right mandibular samples of digital periapical radiograph.

Limits of Agreement	Mr. X 1	Mr. X 2	Mr. X 3
Mandibular	28.57%	57.14 %	42.86%
Left Mandibular	42.86%	71.43%	57.14%

Table 4. Percentages of match obtained from mandibular and left mandibular LOA of seven reference distances.

Limits of Agreement	Mr. X 1	Mr. X 2	Mr. X 3	Mr. X 4
Manidbular	28.57%	57.14%	28.57%	100%
Right Mandibular	28.57%	57.14%	28.57%	100%

Table 5. Percentages of match obtained from mandibular and right mandibular LOA of seven reference distances.

Discussion

Positive identification could be made by comparing specific appearances from multiple teeth or even from one single tooth.[5,32,33] Development of prophylactic dental care, consequential, and preventive treatment resulted in the decrease of caries incident and tooth restorations.[5,14,17,34] These factors made the identification process became harder if it just relied on specific appearances. Tooth measurement turned out to be an important aspect in comparison,[35] as being mentioned in previous studies.[26,30,31]

In this study, another tooth was added as sample.Reference points were determined by the author with total of seven reference distances were gained from two teeth. Thus reliability of these reference points needs to know in advance at the beginning. All of the reference points could be use in tooth measurement method based on Technical Error Measurement (TEM) result, since acceptable measurement tolerance (MT) for tooth and bone measurements was 1 mm.

Samples on this study were slightly not equal on each mandibular side. However, this study tried to analyze the whole, left and right mandibular sample. Bland-Altman test result showed nosignificance statistical difference (p-value) for all reference distances in digital periapical radiographs.Meanwhile, result from printed radiographs shown two significance p-values in whole samples and one significance p-values in left mandibular samples. Non-significance p-values were needed in this methods means that there were no great deviations between paired measurements. Measurement result from digital periapical radiograph seems to be better than printed radiograph.

P-value result for measurement comparison between digital periapical radiographs and its printed shown great deviations. Measurement from digital periapical radiograph should not be compared with its printed directly, as we finally knew that there was some digital data loss when digital radiograph was being printed to glossy paper.

The author tested the accuracy of this new developed method by re-measuring and comparing one first-taken radiograph to several second-taken radiographs that have similar view. As mentioned above, the differences (mm) those were still in the range of limits of agreement (LOA) might indicated the same person. Paired radiograph from one person may have measurement match almost in seven reference distances as we could see in blind tests above.

Previous studies used only mandibular permanent first molar and measured it with their own methods. Positive identification was claimed only based on statistical analysis. New methods of personal identification are still anticipated, especially in the needs of definite measurement. The present study aimed at bringing new insights in terms of personal identification methodology.

Conclusions

It is thus concluded that the method presented in this study is accurate for personal identification by using limits of agreement (LOA) from seven reference distances from mandibular second premolar and permanent first molar. Comparison of paired radiograph should be done between the same radiograph techniques. However, further studies are required to achieve better results and to develop limits of agreement from other tooth.

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Declaration of Interest

The authors report no conflict of interest.

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