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Original Article

The accuracy of single emulsion radiographic film in linear measurement of spiral tomography

Arash Dabbaghi[1], Ali Shokraneh[2], Nastaran Farhadi[3]

[1]Departments of Oral and Maxillofacial Radiology, School of Dentistry, Ahvaz Jundishapour University of Medical Sciences, Ahvaz, [2]Torabinejad Dental research Center and Department of Endodontics, [3]Dental Implant Research Center and Department of Oral and Maxillofacial Radiology, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran

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Address for correspondence:
Dr. Nastaran Farhadi,
Department of Oral and Maxillofacial Radiology,
School of Dentistry, Isfahan University of Medical Sciences,
Isfahan 8174673461, Iran.
E-mail: nastaranfarhadi@yahoo.com

ABSTRACT

Background: Conventional tomography used for evaluation of the small areas of the jaws provides acceptable information. It has some advantages of availability, less radiation dose and cost in comparison to computed tomography (CT) and cone beam CT. Double emulsion film usually used for taking tomograms requires less exposure than single emulsion film; on the other hand, the latter provides more sharpness and spatial resolution. The aim of this study was to compare diagnostic accuracy of these two kinds of films in the spiral tomography.

Materials and Methods: In an experimental study, 20 lines (10 lines anterior and 10 lines posterior to the mental foramen) were selected on two dry human mandibles and tomographic images were taken from each line with and without metal marker by single and double emulsion films. For quantitative assessment, the mandibular width and length was identified and measured on 80obtained tomograms. Afterwards, the mandibles were sectioned on each line and their actual width and height were measured. For each line, the data of tomograms were subtracted from gold standard as measurement error. These errors were divided into three groups: Greater than +1 mm, between +1 mm and −1 mm and less than −1 mm. Obtained data were analyzed by Pearson Chi-square test (α=0/05).

Results: There was no significant difference between the single and double emulsion films, with and without markers in the measurement of both height and width of mandible ($P > 0.05$).

Conclusion: The single emulsion film is not recommended to be used for taking the spiral tomogram.

Key Words: Emulsion, tomography, X-ray film

INTRODUCTION

Imaging techniques are very important in the treatment of dental problems. Concurrent with improvement of dentistry science, there is demand for the techniques providing more information about patient's status. For e.g., with the development of implantology as a routine part of dentistry, the cross-sectional images such as conventional tomography, multi detector computed tomography (MDCT), and cone beam computed tomography (CBCT) have been popularized.[1]

With outspread of the advanced imaging techniques such as the MDCT and CBCT, the use of the conventional tomography has been decreased. Furthermore, the tomographic machines that were easily available are being replaced by CBCT machines. However, the tomographic images are very suitable and practical in evaluation of high contrast anatomy such as temporomandibular joint and implant.[2,3]

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Although the MDCT and CBCT eliminate superimpositions and provide the cross-sections with the higher contrast resolution and accuracy,[4-6] they cannot completely replace the conventional tomography because of the higher radiation dose and cost.[7-12] In addition, many studies have been shown the conventional tomography has the acceptable accuracy in comparison with the CBCT and computed tomography (CT).[13-18] Therefore, the CT is the most suitable technique in the evaluation of the both mandible and maxilla simultaneously and the conventional tomography is the best choice in scanning of the small areas of the both jaws on the account of its accessibility and information reliability.[1]

According to the number of emulsion layer in the film, it is divided to single and double emulsion. Routinely, the tomographic images are taken with the double emulsion films.[19] These films require the lower exposure, but have the less sharpness and spatial resolution.[20,21] Recently, with the extension of popularity of the digital images between the dentists, there is tendency to use the single emulsion film in the dental radiographies. This type of film has the similarity to the digital images from the point of seeming sharper and transparent.

After comprehensive search, we did not find any study conveyed on the diagnostic accuracy of usage of the single emulsion film in the conventional tomography taking into consideration of the high exposure and cost. Therefore, the aim of this study was to evaluate and compare the diagnostic accuracy of the tomograms taking by the double and single emulsion films.

MATERIALS AND METHODS

In an experimental study, one complete and one semi-mandible that were edentulous and had not severe alveolar bone resorption, torus mandibularis, exostosis, and any other bone anomalies were selected. Twenty lines with 5 mm spacing (10 lines anterior and 10 lines posterior to the mental foramen) from the crest of the edentulous ridge to the inferior border of the mandible were determined. In order to help reproducibility of the imaging, buccal and lingual plates of these lines were drawn with ink-marker on the bone [Figure 1a]. These lines were drawn by help of laser ray of the tomographic machine. From each line, two tomograms were taken

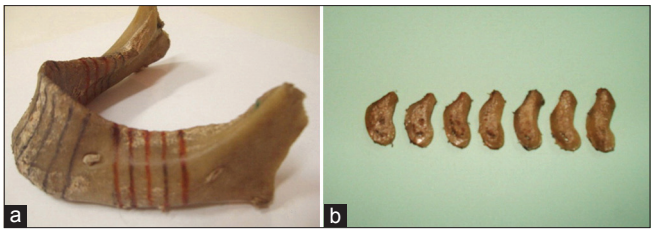

Figure 1: (a) The lines were drawn with ink marker on the bone; (b) bone sections for actual size determination

by the spiral tomographic machine (Cranex Tome, Soredex, Finland) once by the single emulsion film (Agfa, Mortsel, Belgium) and another by the double emulsion one (Agfa, Mortsel, Belgium) using medium speed cassette (Kodak Lanex, Eastman Kodak Company, USA). All of the lines were adjusted in the machine's midline respectively, to be sure that each tomographic section is exactly matched to its line. Then, the tomographic images were taken. For minimizing radiologist's error in the determination of reference point and decreasing interpretation difficulties, the radiographs were taken once with the markers (bands in 1 mm width from the leaded sheets of the periapical films) and again without them. These markers were placed on the lines drawn on the bones, fixed line by line and the tomograms were obtained from each line by its band. All the tomograms were processed in the dark room with the same developer and fixer solution (Champion, X-ray Iran Co., Iran).

Therefore, four groups of the tomograms were taken in this rule: Group A, the single emulsion film with the markers (20 tomograms), Group B, the double emulsion film with the markers (20 tomograms), Group C, the single emulsion film without the markers (20 tomograms) and Group D, the double emulsion films without the markers (20 tomograms).

Mandibular height (the longest line connecting the superior border of the mandibular crest to the inferior border) and width (the perpendicular bisector line to the mandibular height connecting the lingual border to the buccal border) were described as variables for quantitative analysis. All tomograms were analyzed by two radiologists who first interpreted images without the markers and then with them. From at least the three tomographic cross-sections in the each tomographic image taken, one section that had best quality according to radiologists' opinion was selected and traced. The tomographic cross-sections were traced

and the height and width of each line were drawn. Another person who was blind to the radiographic techniques measured the width and height of each line by digital caliper (Mitutoya MTI Corporation, Japan) at nearest 0.001 mm and the measurement from the both radiologists tracing were recorded. All measurements were divided to magnification factor of the machine (1.5 for Cranex Tome), for elimination of magnification effect of the tomographic machines. Mean value was taken as a result.

In order to obtain actual size (gold standard), the samples were sectioned at the level of 20 lines previously drawn [Figure 1b] and measured by the digital caliper. For each line, the data of the tomograms were subtracted from the gold standard as measurement error. These errors were divided into three groups: G_i, error more than +1 mm, G_{ii}, error between +1 and −1 mm, G_{iii}, error less than −1 mm. As data were non-parametric, Pearson Chi-square test was performed with the statistical difference set at 0.05 for all statistical analyses (SPSS 10.0 for Windows, SPSS Inc, Chiago, IL). Furthermore, in order to assess inter observer reliability, the Cohen's kappa statistics was used.

RESULTS

According to the width of mandible, there was no significant difference between the single and double emulsion films in the both marked (P = 1) and unmarked images (P = 0.63). Furthermore, from the viewpoint of the mandibular height, there was no statistical significant difference between the both types of the films in the marked (P = 0.81) and unmarked (P = 1) tomograms. The results were summarized in Table 1 and Figure 2.

In addition, inter-observer agreement was excellent for the assessment of tomographic images, showing a kappa value of 0.83.

DISCUSSION

The radiographic films basically have two parts: Base and emulsion. The base provides solid structure that the emulsions lie on it. The emulsion is the heart of the film and sensitive to X-ray and light. Most of the films, used in the radiography, are the double emulsion films. This type of film has the two emulsion layers cover the both sides of the base. The films used in the mammography, CT and magnetic resonance imaging have one layer emulsion and so called the single emulsion film.[19] For the reason of decreasing the patient exposure in the extra-oral radiographies, combination of the film, and intensifier screen is used.[1] In order to optimize the speed, the film-screens usually have two emulsions. Mainly, the purpose of this film usage is to increase efficiency. It is possible by application of two intensifier screens that expose the films from the both sides. This can amplify the speed twice of that could be attain by

Table 1: Distribution of tomograms measurement error according to height and width

Group	Measurement error (%)					
	G_i		G_{ii}		G_{iii}	
	Height	Width	Height	Width	Height	Width
A	20	0	55	100	25	0
B	15	0	65	100	20	0
C	30	10	60	90	10	0
D	30	15	60	85	10	0

G_i: Error less than −1 mm; G_{ii}: Error between −1 mm and +1 mm; G_{iii}: Error more than +1 mm; Group A: Single emulsion film with marker; Group B: Double emulsion film with marker; Group C: Single emulsion film without marker; Group D: Double emulsion film without marker

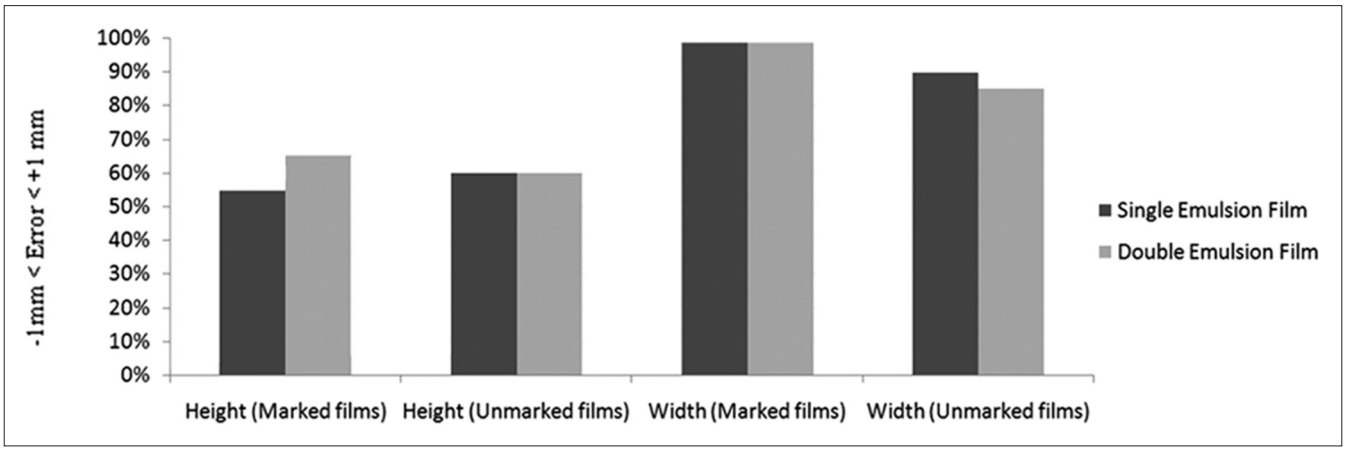

Figure 2: Distribution of measurement error between −1 mm and +1 mm for four groups

the single emulsion film and results in decreasing the exposure and patient dose.[19]

One of the limitations of the double emulsion films with the two intensifier screens is crossing over. When light scintillates from the intensifying screen, not only exposes the adjacent emulsion, but also exposes the opposite one. This effect is named crossing over that results in decreasing the sharpness and resolution and increasing the blurring.[19] In addition, the presence of the images on the both sides of the film results in the image unsharpness. It is due to the image size on the farther emulsion is greater than the closer one, results from the divergency of X-ray. This effect is named parallax and can reduce the resolution and blur the images.[1] In addition, the use of double emulsion films increases radiographic noise due to decrease of exposure and therefore, decrease of photon numbers on the surface unit.[1,19]

Routinely, the double emulsion films were used for the taking tomography. Recently, application of the single emulsion films with visual attraction is increasing. Among the studies that compared these two kinds of films, most of them were focused on the exposure rate and almost all regardless of evaluating the measurement of the accuracy of both films, the main target of the present study. For example, Talaeipour, *et al*.[21] compared the target organ absorbed dose in the panoramic radiography using these films. They demonstrated the single emulsion film requires twice exposure of the double emulsion to provide equal optical density. They also stated the high optical quality and transparency, the two characters of the single emulsion film, are the reasons that radiologists tend to use this kind of film. Arimura, *et al*.[22] evaluated the radiographic noise of the both films and reported the double emulsion film showed the higher noise than the single one in the same condition. In another study,[23] investigators evaluated the ability of the detection of the impacted fish bone by lateral neck radiography taken by the single and double emulsion films. They concluded the ability of imaging of the fish bone increase 50% by the single emulsion film. They also reported there was no significant difference between the cost and radiation dose of the both films. Faridah *et al*.[20] compared the single emulsion-single screen system that routinely used in the mammography with the standard film-screen system. They claimed this combination results in the higher image quality and ability to detect the fracture, but the less speed and contrast with the higher entrance skin dose compared to the double emulsion film.

In the present study, the measurement error is divided into the three groups, because the error between −1 mm and +1 mm in the tomography is suitable and venial in the practical dentistry. The results of this study showed in the height measurement approximately 60% of the tomograms and in the width measurement over 85% of the tomograms had the error in the range of −1 mm to +1 mm [Figure 2].

According to this division, there was the tendency to underestimate in the single and double emulsion films with the markers in the evaluation of the both variables. The under estimation amount for height variable was 30% for the both films. Furthermore, for width variable it was 10% and 15% for single and double emulsion films respectively. The both films had the high accuracy in the evaluation of the mandibular width with the markers and 100% of the measurement error was in the range of −1 mm to +1 mm. The tomograms had the tendency to over-estimate the measurement of the height variable in the images with the markers.

In addition, the both types of the films showed the higher accuracy in the evaluation of the width variable rather than the height. It might to be the result of distinct cortical border in the both sides of the width of mandible. Whereas, in the measuring the mandibular height, there was not the obvious cortical border for the detection of the alveolar crest. Therefore, the least error was reported for the measurement of the mandibular width in the images with the markers and the most for the height evaluation in the single emulsion film without the markers.

Furthermore, in the present study, the tomograms are prepared with and without the metal markers. The presence of these markers might decrease the observers' error and facilitate the variable measurement. In the other hand, it is not practical to place the 20 metal markers on the 20 lines simultaneously. It is due to the possibility of artifact formation. Therefore, only one marker was used line by line. Finally, the results showed there was no significant difference between the accuracy of the linear measurements of the marked and unmarked images.

CONCLUSION

The spiral tomography from the dry human mandibles showed the single and double emulsion films had the

equal accuracy in the linear measurement. Therefore, in terms of the high exposure and cost, the single emulsion film is not recommended to be used in the conventional tomography.

REFERENCES

1. White S, Pharoah M. Oral Radiology Principles and interperetation. 6th ed. St. Louis: Mosby Co; 2009. p. 56,62,597, 607.
2. Schropp L, Wenzel A, Kostopoulos L. Impact of conventional tomography on prediction of the appropriate implant size. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;92:458-63.
3. Rockenbach MI, Sampaio MC, Costa LJ, Costa NP. Evaluation of mandibular implant sites: Correlation between panoramic and linear tomography. Braz Dent J 2003;14:209-13.
4. Dalili Kajan Z, Bavagharian F, Atrkar Roshan Z. Spiral tomography for measuring bone width at different levels from the crest to the inferior border of the mandible *in vitro*. Oral Radiol 2006;22:58-61.
5. Klinge B, Petersson A, Maly P. Location of the mandibular canal: Comparison of macroscopic findings, conventional radiography, and computed tomography. Int J Oral Maxillofac Implants 1989;4:327-32.
6. Lindh C, Petersson A, Klinge B. Measurements of distances related to the mandibular canal in radiographs. Clin Oral Implants Res 1995;6:96-103.
7. BouSerhal C, van Steenberghe D, Bosmans H, Sanderink GC, Quirynen M, Jacobs R. Organ radiation dose assessment for conventional spiral tomography: A human cadaver study. Clin Oral Implants Res 2001;12:85-90.
8. Lecomber AR, Yoneyama Y, Lovelock DJ, Hosoi T, Adams AM. Comparison of patient dose from imaging protocols for dental implant planning using conventional radiography and computed tomography. Dentomaxillofac Radiol 2001;30:255-9.
9. Chau AC, Fung K. Comparison of radiation dose for implant imaging using conventional spiral tomography, computed tomography, and cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107:559-65.
10. Tammisalo E, Hallikainen D, Kanerva H, Tammisalo T. Comprehensive oral X-ray diagnosis: Scanora multimodal radiography. A preliminary description. Dentomaxillofac Radiol 1992;21:9-15.
11. Ekestubbe A, Gröndahl K, Gröndahl HG. Quality of preimplant low-dose tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;88:738-44.
12. Ekestubbe A, Thilander A, Gröndahl K, Gröndahl HG. Absorbed doses from computed tomography for dental implant surgery: Comparison with conventional tomography. Dentomaxillofac Radiol 1993;22:13-7.
13. Clark DE, Danforth RA, Barnes RW, Burtch ML. Radiation absorbed from dental implant radiography: A comparison of linear tomography, CT scan, and panoramic and intra-oral techniques. J Oral Implantol 1990;16:156-64.
14. Kassebaum DK, Nummikoski PV, Triplett RG, Langlais RP. Cross-sectional radiography for implant site assessment. Oral Surg Oral Med Oral Pathol 1990;70:674-8.
15. Hanazawa T, Sano T, Seki K, Okano T. Radiologic measurements of the mandible: A comparison between CT-reformatted and conventional tomographic images. Clin Oral Implants Res 2004;15:226-32.
16. Tyndall DA, Brooks SL. Selection criteria for dental implant site imaging: A position paper of the American Academy of Oral and Maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;89:630-7.
17. Peltola JS, Mattila M. Cross-sectional tomograms obtained with four panoramic radiographic units in the assessment of implant site measurements. Dentomaxillofac Radiol 2004;33:295-300.
18. Butterfield KJ, Dagenais M, Clokie C. Linear tomography's clinical accuracy and validity for presurgical dental implant analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;84:203-9.
19. Bushong SC. Radiological sciences for technologists: Physics, biology and protection. 7th ed. St. Louis: Mosby Co; 2008. p. 181-213.
20. Faridah Y, Abdullah B, Ng Kh. Improved fracture detection using the mammographic film-screen combination. Biomed Imaging Interv J 2005;1:e3.
21. Talaeipour A, Sahba SS. Comparison between absorbed doses in target organs in radigraphy, ysing single emulsion and double emulsion films. Acta Med Iran 2007;45:178.
22. Arimura H, Okawa T, Okamoto M, Ikari T, Nakamori N, Kubota H, *et al*. Relation between radiographic mottle for double and single emulsions. Med Phys 1998;25:1625-35.
23. Abdullah BJ, Kaur H, Ng KH. An *in vitro* study comparing two different film-screen combinations in the detection of impacted fish bones. Br J Radiol 1998;71:930-3.

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