Reproducible X-ray projection geometry in endodontic practice

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Abstract

Introduction: Clinical application of radiography in endodontic practice is affected by reproducibility in the orientation of the x-ray source, image receptor and object. The inability of dentists to locate intra oral films or sensors in appropriate positions in different cases can cause complications in the performance of endodontic therapy. Commercially available film holder (endoray) and conventional imaging methods seem to be insufficient and difficult to perform. The purpose of this investigation was to develop a novel and easily performed device for endodontic radiography and to asses its reproducibility and accuracy in vitro.

Materials and Methods: The present work surveys and evaluates the design steps of a newly constructed film holder with modified bite block and a beam guiding device, in an attempt to perform a diagnostic study. References wires and balls were attached on the film holder and to the alveolar crest of maxillary molar region inserted in the conventional phantom for measuring the projection errors relative to the film holder and repositioning .One hundred and twenty radiographs of a conventional phantom were taken by one of the authors and by two dental students using the novel device and Endoray.

Results: The %95 CI for precision of radiologist and one of the students was less than 8 (7.313 ± 0.1989) .The %95 CI for precision of the other student was less than 12 (10.941 ± 0.4217). There was no significant difference ($p= 0.679$), regarding the interoperator precision, between radiologist and first student. There was significant difference between second student and the others ($p<0.05$). No significant difference was noted between the radiographs achieved by the Endoray and new device.

Conclusion: The novel device appears to be a potential means of obtaining reproducible radiographs in endodontic practice .Further research is needed however, to study in vivo aspects, reproducibility and accuracy.

Keywords: Endodontics, Reproducible, x-ray.

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Introduction

The need for radiographs in all phases of endodontic therapy has been well established (1). Endodontic treatment films (ETFs), radiographs taken during the treatment phase of endodontic therapy, are used to determine working lengths and the adequacy of obturation (2).When ETFs are inaccurate and have to be retaken, endodontic treatment becomes less efficient, and patients are exposed to additional radiation(2). The ability to take radiographs of good diagnostic quality is essential for successful root canal therapy (3). It is important to see clearly the root canal filling to detect its presence, extent and apparent condensation (4), on the other hand, radiographic analysis of the maxillary and mandibular bone has been proposed as a potential diagnostic tool for endodontic research and treatment (5). However, conventional radiography is of limited value in detecting minor bone changes.

In contrast, digital subtraction radiography (DSR) has made it possible to detect minor changes in the bone density. However, a prerequisite for valid DSR is reproducible projection geometry. As a consequence, clinical application of radiography in endodontic practice, including diagnosis, Treatment and Follow up is affected by reproducibility in the orientation of the x-ray source, image receptor and object. Furthermore, inability of GPs to locate intra oral films or sensors in appropriate positions for different cases can cause complications in the performance of endodontic therapy (4). The devices which could address the foregoing problems are called film-holding instruments. Commercially available film holders such as endoray and conventional imaging methods seem to be insufficient and difficult to perform.

The purpose of this investigation was to develop a novel and easily performed device for endodontic radiography and to assess its reproducibility and accuracy in vitro.

Material and Methods

Film- holder system: A novel system has been designed (5-18) to stabilize the relationship between the x-ray tube, teeth and film. This mechanical alignment device comprises a modified film-holder fixed intra orally by a new type of bite block. Fig.1 shows the film-holder connected to the beam guiding device by an adjustable screw (-20, 0, +20). Its two-piece constructed from stainless steel and supplied with a disposable bite block, is a feature consistent with frequent sterilization and good clinical hygiene. It provides inherent rectangular collimation and optimal radiation protection with primary and secondary shields made of heavy steel to reduce secondary background radiation of the film to a minimum and provide ideal support of the dental film for the elimination of unintentional film curving and bending during exposures, for optimal imaging.

Image acquisition: Evaluation of operator precision was performed on a conventional phantom head (Fig. 2). Radiography was carried out on the upper molar region whose radiography is more difficult. References wires and balls were attached to the film holder and

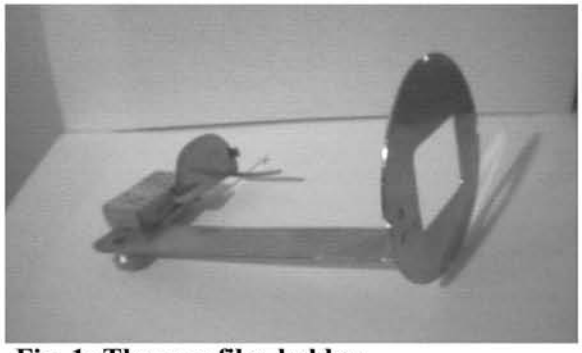

Fig. 1: The new film-holder

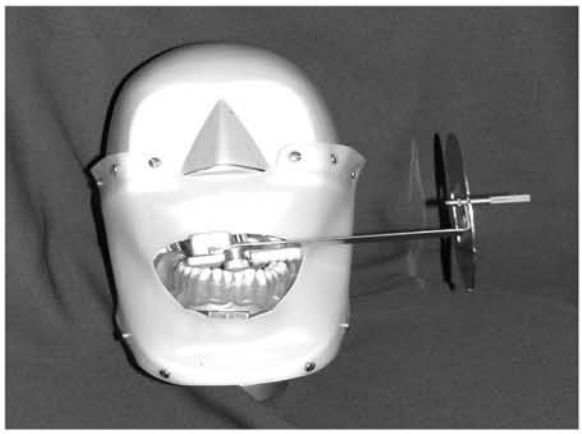

Fig. 2: The new system in place on phantom

to the alveolar crest of maxillary molar region inserted in the phantom head for measuring the projection errors relative to the film holder and repositioning. A clump with cold curing acrylic resin has been made to mimic the situation of a patient under endodontic therapy.

To determine intra-operator precision, one author took 60 radiographs with the novel and endoray systems. Two undergraduate dental students were then asked after detailed instruction to take 30 radiographs with the novel system. A heliodent (Siemens, Germany) was used for taking radiographs. The exposure time was 0.3 second Ektaspeed film (Eastman, Kodak, USA) was used and the processing was done with Teyfsaz solution at 27 C.

Image analysis: The radiographs were digitized by an intraoral camera (RES=350 line, Total pixel=320k).The vertical distance between the outer surfaces of the balls was measured parallel to the midline index. The horizontal distance between the rods was taken as the distance between the centers of the coronal ends; parallel to the midline index (Fig.3).The measured distances were corrected

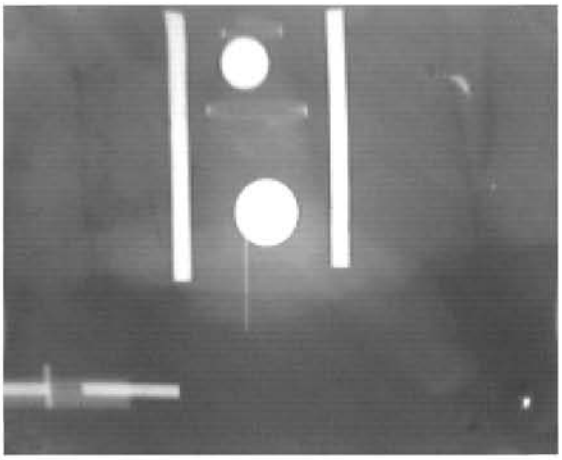

Fig.3: Radiograph showing the position of the two metal balls and rods and the method of measuring the angular deviation

by the magnification factor (1.0425).The angular discrepancy (*a*) between any two radiographs was calculated according to the underlying equation: a=arcos(a/c) –arcos(b/c). Where c is the true distance, a and b are the distances measured on the two radiographs for the desired dimension.

The mean and the standard deviation were calculated for the total angulation's variations. Intra operation validity for the endoray and the new system used by the radiologist, were measured by comparing the results with the true dimensions .The interoperation precision was compared using the Kruskal-Wallis test with $P<0.05$ considered significant.

Results

Table-1 shows the percentage of the dimensional precision for the radiographs taken by radiologist with endoray and the new system. No significant difference was noted between the radiographs achieved by Endoray and the new device.

Table 2 shows the values for total angular deviation between radiographs. The %95 CI for precision of radiologist and one of the students was less than 8 (7.313 ± 0.1989) whereas the %95 CI for precision of the other student was less than 12 (10.941 ± 0.4217).

The Kruskal-Wallis test was performed by the Analyses-It software the results showed that there was no significant difference (p=0.679) in the interoperator precision (between radiologist and first student). There was a significant difference ($p<0.05$) between the second student and the others.

Table-1: dimensional percision

	Horizontal	Vertical
BGI*	92%	80%
Endoray	92%	87%

*BGI: Beam Guiding Instrument

Table-2: Total angular error

Specialist(BGI)	7.313*	4.1441**
Specialist(E)	12.780	6.7864
1st student	7.015	4.0029
2nd student	10.941	7.3038

*Mean **SD

Discussion

It is obvious that reproducible projection geometry is an important prerequisite for many diagnostic and evaluation methods in dentistry.

In 1988, Rudolph et al. evaluated x-ray guiding device with different stents and concluded that the combination of Rigisil and RinnXcp is the most acceptable device and 71% of the angulation errors was operator related faults. Unfortunately the research method was unable to differentiate operators' tube adjustment error, film repositioning faults and errors originated from device design. Meanwhile "magnification" had not been considered in the study.

In 1991, Van Aken, conducted a study to determine the clinical imaging errors of an innovative film holder combined with an X-ray guiding device. The X-ray generating device used in the study, with an accurate adjustable hydraulic mechanism, could expose in the any given angulation with high accuracy. There are sensors together with a digital monitor attached on the tube to assure the correct tube positioning in relation to collimator and indices were placed on patients' teeth to register the difference in projection angulation. Accuracy of the study and its statistical analysis are admirable. However placing the indices on patients' teeth seems to be unethical and

obtaining patients' consent has not been mentioned. Furthermore, its complexity produces its use in many dental centers and is merely applicable in specific sites of the mouth. In addition, it is not useful for working radiography in endodontics. It is to be mentioned that these were not among designers' main goals. In 1999 Handschel et al. designed a novel X-ray guiding device for edentulous patients that were fixed extraorally. They measured the accuracy and reproducebility of the method, placing indices, including 2 bars, on both sides of the crest (in phantom head). Half of the radiographs were taken by students and the rest by a radiologist.
Indices were not placed on the film holder, thus the operator error in adjusting x-ray direction and device error could not be separated.

Conclusion

Different recommendations have been made for the minimal acceptable angulation error. Using a computer-assisted algorithm it is conceivable that small osseous changes can be detected despite an angulation disparity of 10-16 (12). As the angular errors in our study were between 8 and 12, our device enables the dentist to obtain radiographs with reproducible geometry during endodontic treatment with rubber dam.
Future studies would evaluate an enhanced version of the new alignment system applying the method to the other parts of the mouth.
Further research is needed however, to study in vivo aspects, reproducibility and accuracy.

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