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The effect of sharpness and contrast processing filter on the measurement accuracy of endodontic file length

Sanaz Sharifi Shooshtari[1], **Mahshid Razavi**[2], **Razie Moarrefpour**[3], **Zohre Roozbahani**[4]✉

[1]Assistant professor, Department of Oral and Maxillofacial Radiology, School of Dental Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[2]Assistant professor, Department of Oral and Maxillofacial Radiology, School of Dental Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[3]Dental Student, Department of Oral and Maxillofacial Radiology, School of Dental Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[4]Oral and Maxillofacial Radiology post graduate student, Department of Oral and Maxillofacial Radiology, School of Dental Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

✉**Corresponding author**
Oral and Maxillofacial Radiology post graduate student, Department of Oral and Maxillofacial Radiology, School of Dental Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz,
Iran

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ABSTRACT

Background and Objective: Precise determination of working length can be effective alternative for optimizing endodontic treatment. There are several methods for determining working length, including digital radiography. Image processing filters can improve diagnostic accuracy of digital radiographs. The aim of present study was to compare the effect of sharpness and contrast inversion processing filters on the measurement accuracy of endodontic file length using indirect digital radiography (PSP). *Materials and methods:* In the present *in vitro* study a total of 36 permanent single rooted premolar teeth were selected for the study. Endodontic access cavity was prepared and #15 K-file was inserted into the canal for measurement the actual size as gold standard. The samples were mounted on resin acrylic blocks. Indirect digital radiographic images (PSP) were obtained using parallel technique. The radiographs were processed with sharpen filters and contrast inversion filters using scanora software program version 5.1. Original images without filtration, images processed with sharpen filters, and contrast inversion filters were observed by two blinded observers and the results were compared by golden standard. Data were analyzed using Friedman test, Dunnett's test, SPSS version 23. *Results:* The difference among original images without filtration, sharpen filters, and contrast inversion filters were significant ($P<0.05$). There were no significant differences between each group of pictures and actual size. Sharpness filters showed less realistic mean value of working length compared to original images without filtration and contrast inversion filters. *Conclusion:* Sharpening filters did not influence the accuracy of endodontic file length and is not preferred for measurement of endodontic file length. Contrast inversion filters have relative priority compared to original images without filtration, but the difference wasn't statistically significant. There were no statistical significant differences between each group of images and the reality.

Keywords: Root canal, Image processing, indirect digital radiography, Contrast inversion filter, Sharpness filter

1. INTRODUCTION

In endodontic treatment working length is considered as the distance from a coronal reference point to the point where canal preparation and obturation ought to terminate. Precise determination of working length (WL) is a significant phase for success of endodontic treatment (Farhadi et al., 2015). There are various methods for working length determination, the most reliable is digital radiography (Kal et al., 2007). Digital radiography is among the most ordinarily used dental imaging techniques particularly in endodontic treatment (Kawauchi et al., 2004). The advantages of digital radiography over conventional radiography include: potential for reduced patient dose, image processing, data storage, no chemical developers, time and productivity savings, quick image sharing, no more lost images, and easier use than conventional radiography (Gormez & Yilmaz, 2009; Parks & Williamson, 2002). Image processing is one of the main advantages of digital radiography (Choi et al., 2014; Kajan et al., 2015). Image processing techniques have potential to improve image quality and reduce the image retaking rate (Oliveira et al., 2012). Each procedure which changes image properties is called image processing (Deepak et al., 2012; Tewary et al., 2011).

Image processing is a technique to make some operations on an image to get an altered image. The main purpose of image processing is to amplify diagnostic signals and eliminate non-deterministic signals, which facilitates image interpretation for diagnostic and therapeutic purposes. Using proprietary processing tools is very important for any diagnostic purpose (Farhadi et al., 2016). Since the introduction of digital radiography in dentistry, several software with various processing tools have been announced, including contrast enhancement, noise reduction, artifact reduction, contrast inversion, edge enhancement, smoothing, and sharpening (Haiter-Neto et al., 2008; Lehmann et al., 2002). Contrast inversion filter changes the grayscale of the image by converting low pixel (dark) values to high (bright) pixel values and vice versa (Oliveira et al., 2012). Sharpening filters reduce low frequency noise, i.e. either remove low-frequency noise or enhance boundaries between regions with different intensities (edge enhancement) (White & Pharoah, 2016).

Various studies have been concerned about the diagnostic accuracy of sharpness and contrast inversion processing filters, but the challenging results have been obtained. Some studies reported an improvement in the diagnostic accuracy of post-processing images; however some other studies found no difference between radiographic images without filtration and post-processing images (Kamburoğlu et al., 2010; Ahmad et al., 2011; Mirbeygi et al., 2016). Due to the different results, versions of software, and research methods, the aim of present study was to compare the effect of sharpness and contrast inversion processing filters on the measurement accuracy of endodontic file length using indirect digital radiography (PSP).

2. MATERIALS AND METHODS

The present *in vitro* study was conducted in the outpatient clinic of oral and maxillofacial radiology, School of Dental Medicine, Ahvaz Jundishapur University of Medical Sciences. The ethical code of the study in ethics committee is IR.AJUMS.REC.1395.90. A total of 36 extracted single-rooted/canal permanent teeth (due to orthodontic and periodontal treatment) were selected for the study. The samples were selected non-randomly using non-probability sampling technique (Judgmental Sampling). The inclusion criteria included intact teeth without the history of abnormality including internal/external root resorption, calcification, cracks, or defects. The specimens were washed with water and immersed for 12 hours in 0.5% hypochlorite disinfectant solution and stored in the distilled water at 4°C. Endodontic access cavity was prepared using round diamond 016 burs (CI, Teeskavan Inc., Tehran, Iran) in a low speed air turbine hand piece (NSK, Nakanishi Inc., Kanuma, Japan). #15 K-file (Mani, Japan) was inserted into the canal and extended 1mm beyond the apex. The file was removed and the distance from the base of rubber stop to the file tip was measured using endo gauge finger ruler (Zolaltebshimi co., Tehran, Iran). The measured value was subtracted 1mm "Safely factor" from the value extended beyond apex and the results were considered as gold standard of root canal length. In order to simulate the periodontal ligament space, the roots of teeth were coated with a thin layer of wax (Modeling Wax; Cavex, Haarlem, Holland) and mounted on the mixture of plaster (Snow White Plaster No. 2; Kerr Italia SpA, Salerno, Italy) and self-cure acrylic resin (Triplex® SRCold, Ivoclar Vivadent AG, Schaan, Liechtenstein) blocks (Fig.1-A).

Digital (PPS) peri apical radiographs were obtained through parallel technique using xgenus®dc" radiography unit (Xgenus DC, deGotzen, Rome, Italy), PSP image receptor (Digora® Optime PSP System, Soredex, Tuusula, Finland) at exposure condition of 63 kV, 8 mA, 0.12s, 2mm total aluminum filtration, and at 34 cm focus-receptor distance(SID). The obtained radiographs were scanned using Digora Optime scanner (Digora Optime, Soredex, Tuusula, Finland) and saved as DICOM format. The DICOM images were loaded into Scanora software program (Scanora 5.1 for windows 2.7, Digora® optime Soredex, Tuusula, Finland) and processed once with sharpening and once with contrast inversion filter, respectively (Fig 1-B, C, D). The radiographs were archived as original images without filtration, images with sharpen filters, and with contrast inversion filters in distinct radiograph collections. The archived radiographs were observed by two oral and maxillofacial radiologists with more than two years' clinical experience using 14" LED monitor, 1366 x768 resolutions (VAIO® SONY Corp, Minato-ku, Tokyo, Japan). The radiographs were observed at the same condition in the dim light room. The observer was seated at a distance of 50-70 cm from the screen. In order to avoid eye strain and fatigue, the observers were examined no more than 20 radiographs in each session. The brightness and contrast on the monitor were kept constant during the observation. The inter-observer agreement was measured using kappa statistics by point (k) and by 95% confidence interval. The results of observations were recorded on the prerequisite data collection form. Data were analyzed using Friedman test, Dunnett's test, SPSS version 23. P values of less than 0.05 were considered as statistically significant.

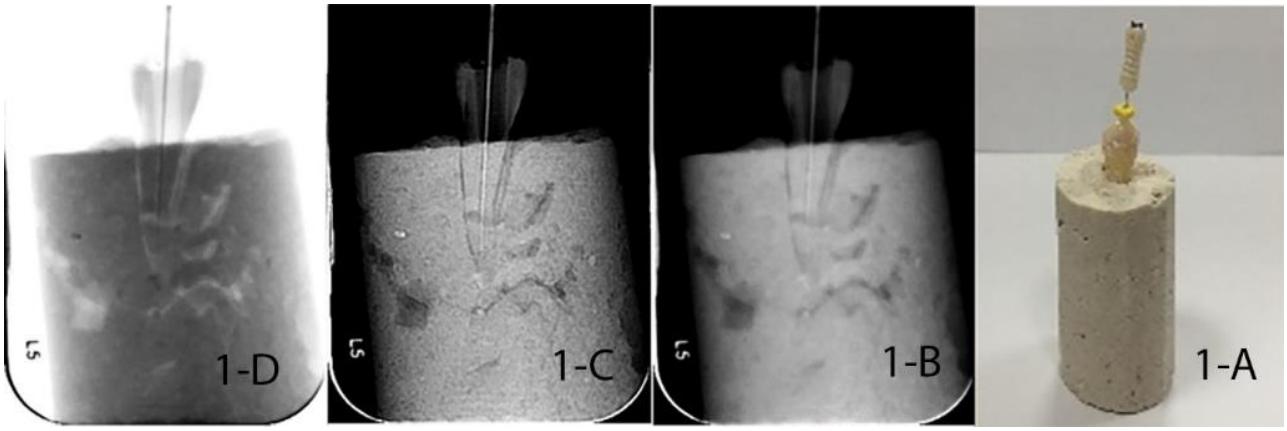

Figure 1 A: The teeth mounted on plaster block, B: The original digital radiograph, C: Radiograph enhanced with sharpening filter, D: Radiograph with contrast inversion filter

3. RESULTS

In the present study the Kappa values to all observers were positive, indicating inter observer agreement. The mean, minimum, maximum and standard deviations were calculated. The results are presented in Table 1. Absolute error was used to express how

close the measurement is to the ideal value. Friedman test compared the quality scores by the three imaging, and Dunnett's test was used to compare the subjective image quality of the original and filtered images.

All three groups of images (Original without filtration, sharpen filter, contrast inversion filter) showed a larger average size of working length than the actual length and tended to overestimate the actual root canal length. But, the radiographs with sharpen filter in comparison with the original and contrast inversion radiographs showed a larger average size of root canal length than the actual length (Figure 2). According to the results of Dunnett's test, no statistical differences were found between the mean values of each three image groups (Original, sharpen, contrast inversion) and actual size ($P>0.05$). According to the Friedman test, there was a significant difference between the mean values of three groups ($P<0.05$). Similarly, a significant deference was found between mean absolute error of three image modalities ($P<0.05$) (Table 2), indicating that the highest mean absolute error was related to original radiographs without filtration (1.17) and the lowest mean absolute error was associated with contrast inversion method (1.07) (Figure 3).

Table 1 Statistical characteristics of four groups

Method	Number	Mean	SD	Min	Max	P-value (Dunnett's test)	P-value (Friedman test)
Original	36	20.90	2.11	16.90	25.00	0.107	
Contrast inversion	36	20.83	2.09	16.80	24.60	1.44	
Sharpness	36	20.98	2.07	16.90	25.00	0.064	0.003
Actual length	36	20.21	1.42	18.00	23.00		

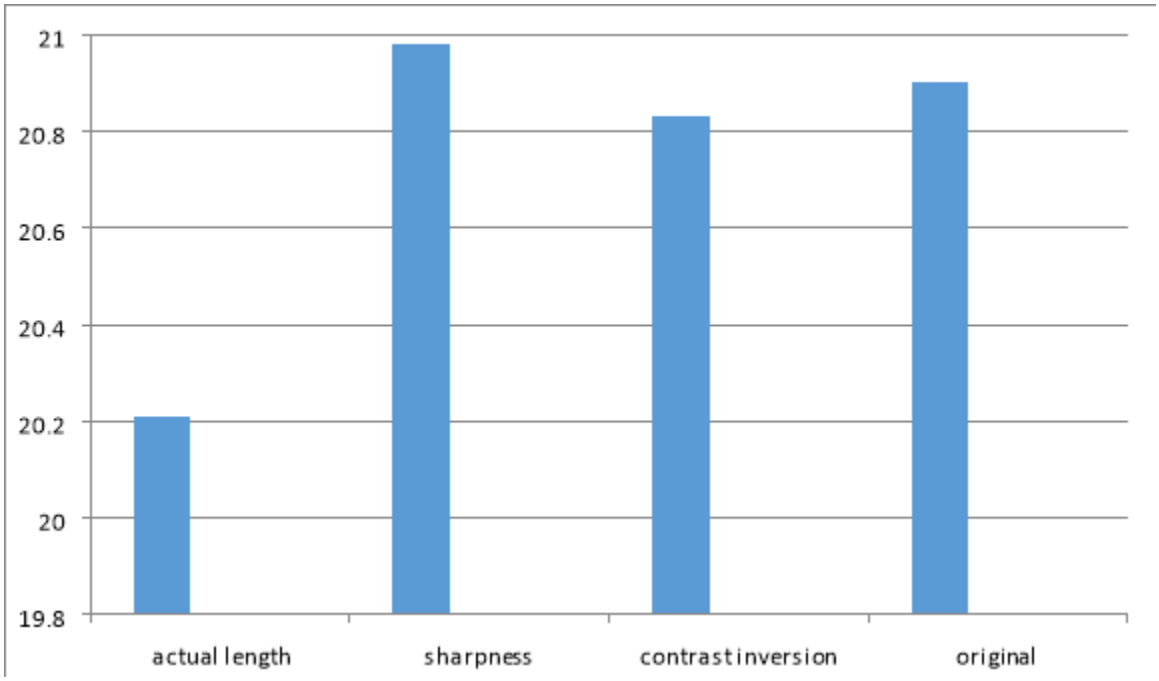

Figure 2 Comparison of all image groups for mean endodontic working length measurement

Table 2 Comparison of the mean error of image modality for endodontic working length measurement

Method	Number	Mean	SD	Min	Max	P-value (Friedman test)
Original	36	1.14	0.76	0.10	3.10	
Contrast inversion	36	1.07	0.77	0.10	3.10	
Sharpness	36	1.17	0.77	0.00	3.10	0.000
Actual length	36	0.00	0.00	0.00	0.00	

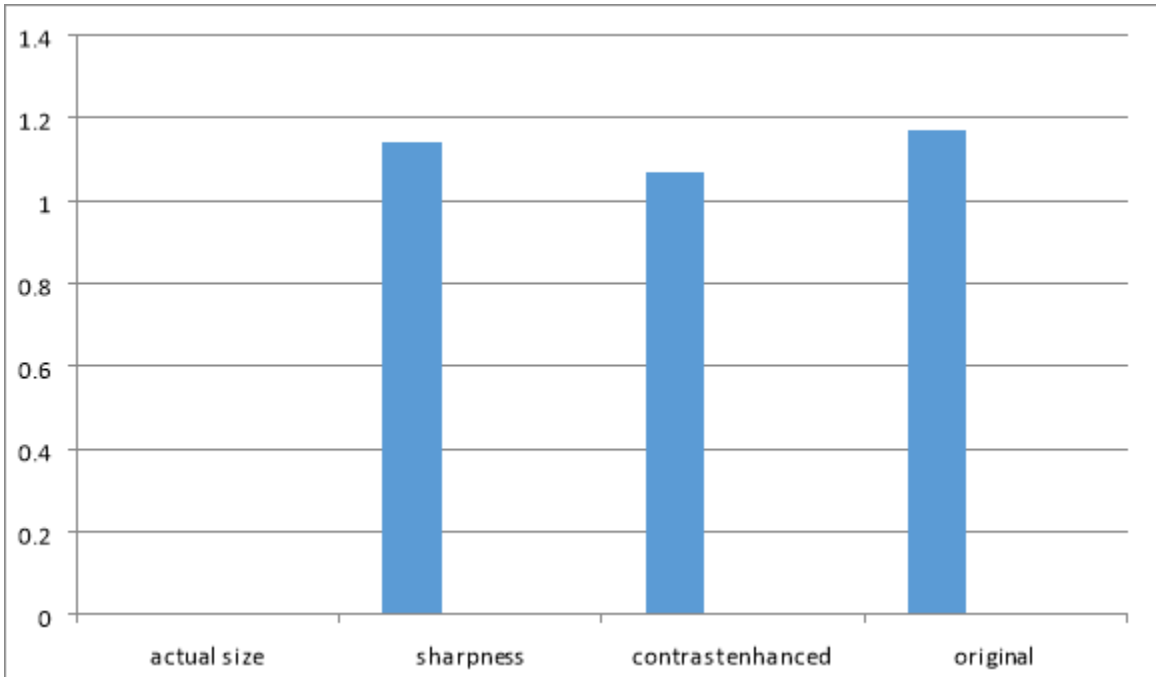

Figure 3 Comparison of the mean error of all image groups for endodontic working length measurement

4. DISCUSSION

The success of root canal treatment depends on accurate access cavity preparation followed by cleaning, shaping, and obturation at the predetermined working length, maintaining the original canal shape during instrumentation (Kamburoğlu et al., 2010; Javidi et al., 2007). The most important step in endodontic therapy is accurate determination of working length. Several methods have been introduced for determination of working length, the most common and popular diagnostic tool is digital radiography (de Oliveira et al., 2012; Woolhiser et al., 2005). One of the advantages of digital imaging systems is improving image quality using image processing software (Haiter-Neto et al., 2009; Nair & Nair, 2007). However, different and challenging results haven obtained concerning the diagnostic utility of digital imaging system (Tofangchiha et al., 2012).

The results of the present study showed that the contrast inversion filter displays the closer mean value compared to actual length, i.e. the mean absolute error of contrast inversion filter in determining working length was lower than original radiographs without filtration and with sharpening filter, the difference was significant ($P<0.05$). So, contrast inversion filter is preferred for determining working length than original radiographs without filtration. Additionally, sharpness filter showed more unrealistic mean value than actual length, indicating that the mean absolute error of sharpness filter in determining working length was higher than original radiographs without filtration; the difference was significant ($P<0.05$). So, sharpness filter is not preferred for determining working length than original radiographs without filtration. Comparison between three methods indicated that contrast inversion filter displays the closer mean value compared to actual length and has less mean absolute error than the other two methods ($P<0.05$). The difference could be explained due to the zero error of determining actual working length. No statistical differences were found between the mean values of absolute error of each three image groups (Original, sharpen, contrast inversion) and actual length ($P>0.05$)

Various studies have been conducted concerning the filter and image processing for improving the evaluation process and patient communication. Kal et al., 2007 compared the accuracy of endodontic file lengths following the application of various image processing methods using indirect digital radiography. The results of the study showed that all studied enhancement softwares (invert, contrast/brightness and edge enhancement) improve the accuracy of endodontic file lengths. As well as, the mean error values of measurement (File # 8,10,15) in original digital images were higher than contrast inversion and sharpness filters. Likewise, the mean error values of contrast inversion filter were lower than sharpness filter. However, no significant difference was found between the mean values of endodontic file lengths before and after application of processing algorithms, which was consistent with the result of the present study. Additionally, according to the result of Kal et al.'s study all of the processing algorithms provided significantly shorter measurements than the true length of each file size, which was inconsistent with the result of the

present study. The difference could be explained due to different processing software, teeth preparation, and different endodontic files (Kal et al., 2007).

Farhadi et al., 2016 evaluated the effect of three levels of sharpness processing filter on the accuracy of endodontic file length determination using digital periapical radiography. The results of the study suggested that the measurement accuracy of original images and that of the sharpen level 1 and sharpen level 2 enhanced images were not significant. However, Level 3 sharpness filter resulted in increased image noise and decreased image quality. In our study one level of sharpening filter was used and similarly the differences between measurements of sharpen images and original images were not significant (Farhadi et al., 2016). Farhadi et al., 2015 in another study examined the accuracy of endodontic file length measurement on digital periapical radiographs following the application of contrast inversion filter. The results of the study showed that the contrast inversion tool exhibited significantly longer measurements compared to the original images, but according to the results of the present study contrast inversion tool showed more realistic measurement compared to original images. The difference could be explained due to the different statistical methods and different file size that was used (08 versus 15) (Farhadi et al., 2015).

Mirbeygi et al., 2016 in a study evaluated the accuracy of working length determination in root canal treatment using different algorithms (emboss, enhancement, sharpen, and negative) in digital radiography. Similar to our study, according to Mirbeygi et al.'s study, none of the indices had a statistically significant difference with the actual file length, but there were no statistically significant differences among all image groups. The difference may be related to different statistical analysis, but according to similar method it suggests further studies with different statistical analysis methods (Mirbeygi et al., 2016). Oliveira et al., 2012 examined the applicability of gray scale inversion in performing digital linear endodontic measurements. They used CDR wireless digital imaging system that is manufactured with a wireless CMOS image receptor. According to the results of Oliveira et al.'s study, no statistically significant differences were found between measurements achieved by original and positive images, but both differed significantly from the actual lengths. The difference between the results of Oliveira et al.'s study and the present study could be explained due to different digital radiography system (direct versus indirect digital methods) (Oliveira et al., 2012). Moreover, various studies have been done regarding the effect of image processing software on diagnostic accuracy of oral and maxillofacial defects and controversies could be seen in their results.

Belem et al., 2013 compared the performance of digital radiography with and without enhancement filters (contrast inversion, sharpen) for the detection of induced proximal caries lesions and concluded that the sharpen filter had the highest performance indices and considered as a valuable tool for identifying subtle proximal caries lesions (Belém et al., 2013). Knob et al., 2004 in a study compared the effect of different image processing filters (median, median plus inversion) on the reproducibility and accuracy of the assessment of central depth of proximal carious lesions using direct digital radiographs. The results of the study showed that digital filtering of radiographic images did not affect the accuracy of central depth measurements of lesion (Koob et al., 2004). Talaeipour et al., 2015 in a study examined the diagnostic accuracy of direct digital radiography with and without sharpening enhancement filter in detection of proximal dental enamel caries of premolar teeth and concluded that sharpening filter does not improve the detection of proximal enamel caries, which was in agreement with the results of the present study (Talaeipour et al., 2015). Sakhdari et al., 2011 compared the diagnostic accuracy of reverse contrast option of digital radiography in detection of horizontal root fracture and concluded that the diagnostic accuracy of reverse contrast filters is equal to original images (Sakhdari et al., 2011). Ahmad et al., 2011 compared the performance of compound enhancement algorithms (original digital intra-oral dental radiograph and images enhanced with sharpening filter as a main filter) for diagnosis of oral and maxillofacial lesions. The results of the study showed that sharpening filter have positive effect on detecting specific oral and maxillofacial lesions, which was inconsistent with the results of the present study. These controversies may be resulted from the different lesion which authors estimated in their articles.

5. CONCLUSION

Sharpening filters did not influence the accuracy of endodontic file length and is not preferred for measurement of endodontic file length. Contrast inversion filters have relative priority compared to original images without filtration and are applicable for measurement of endodontic file length. So, providing contrast inversion filters in processing software improves successful root canal treatments.

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Ethical approval

The ethical code of the study in ethics committee is: IR.AJUMS.REC.1395.90

Conflict of interest

Authors have no conflict of interest to declare.

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