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Clinical Report

Digital Video Image Processing from Dental Operating Microscope in Endodontic Treatment

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Abstract

Recently, optical microscopes have been used in endodontic treatment, as they offer advantages in terms of magnification, illumination, and documentation. Documentation is particularly important in presenting images to patients, and can take the form of both still images and motion video. Although high-quality still images can be obtained using a 35-mm film or CCD camera, the quality of still images produced by a video camera is significantly lower. The purpose of this study was to determine the potential of RegiStax in obtaining high-quality still images from a continuous video stream from an optical microscope. Video was captured continuously and sections with the highest luminosity chosen for frame alignment and stacking using the RegiStax program. The resulting stacked images were subjected to wavelet transformation. The results indicate that high-quality images with a large depth of field could be obtained using this method.

Key words: Microscope — Image processing — Documentation — RegiStax — Wavelet conversion

Introduction

An optical microscope is useful when carrying out precise endodontic or other dental treatments, as it allows magnification, illumination, and documentation of the procedure. Documentation provides image information that can be presented to patients or used for educational purposes. Microscopic image documentation can be obtained using either a still camera (e.g., a 35-mm film or CCD camera) or a video camera. Still images can also be obtained from a video stream by selecting individual frames. This is an effective technique as it can be carried out without the need to interrupt clinical treatment. However, the image quality of a single video frame is generally low due to the presence of pixel and background noise. RegiStax is a software that has been developed by Berrevoets et al. to obtain clearer astrophotography. In this study, RegiStax was used to obtain clear still images from a video of root canal treatment. The purpose of this study was to determine the potential of RegiStax in obtaining high-quality still images from a continuous video stream from an optical microscope.
Materials and Methods

An operation microscope (IMS22Z; MANI Inc., Japan) was used in this study. A magnification range of $\times 3.4$ to $\times 22.0$ and a 15–150 W halogen lamp were used. The objective lens had a focal length of 200 mm and the eyepiece magnification was $\times 10$.

The digital video camera (DXC-107A, SONY Corp., Japan) used in this study is shown in Fig. 1. It had a 400,000-pixel CCD sensor and recorded video at 30 fps. It was attached to the optical microscope using a beam splitter, and video was captured for 7 sec. The section of the video stream with the highest luminosity was used to produce the image stack to be processed. The program RegiStax was used for image processing and Scion Image for image evaluation (RegiStax and Scion Image can be downloaded at http://www.astronomie.be/registax/. The software for Scion Image is attached to RegiStax).
1. Image processing

Image processing was performed as follows using RegiStax and Scion Image:
1) Push the Select Input button and open the avi video file for 7 sec.
2) Select an alignment box size that fits around the observation area.
3) Check the Automatic Processing box.
4) The stacking process starts automatically.
5) Clear color tone is adjusted by Scion Image.

Results

Figure 2 shows stacked images made up of 210 individual video frames recorded during an actual clinical treatment. Figure 3 shows the results of carrying out a wavelet conversion process on the data shown in Fig. 2.

In Fig. 2, the vividness of the photographic subject and a reduction in the noise of the background were observed in comparison with the image before processing. This is shown by change in the coarseness curve of the photographic subject area.

Figure 3 shows a still image (a) and its stacked image (b) at the time of root canal treatment (confirmation of broken instrument). The image here is much clearer.

In Fig. 4, the fine structure of the root canals can be clearly seen. However, even with the use of such image processing techniques, the final image quality may be poor if excessive movement of the patient takes place or the individual frames are not properly aligned.

Discussion

Microscopic endodontic still images can be obtained directly using either a 35-mm film, a digital SLR camera, or extracted as single frames from a video camera. Each method has its merits and demerits in terms of shelf stability, snap-shotting and handiness. There are also merits and demerits in terms of preservation ability and simplicity.

It is difficult to obtain sufficient brightness and depth of field while imaging the apical third of a root canal. A single image obtained using a 35-mm film camera usually has insufficient quality. On the other hand, although the high sensitivity of the sensor of digital SLR provides good images, background noise tends to increase. There is also a conflict between using a slow shutter speed to obtain bright images with a large depth of field and the risk of image blurring due to movement of the object under observation. With a video
camera, each frame contains a large amount of background noise and the image quality is low. Although it is possible to use a computer to carry out image processing and adjust the brightness and contrast, achieving a fundamental improvement in image quality is difficult. This is because it emphasizes parts of the image that could not be seen well, clearing up blurring. However, if the original image is too small or there is too much noise, then it is difficult to process. Standard image optimization approaches include the following: (1) concentration conversion; (2) emphasizing, flattening and smoothing; (3) outline extraction; and (4) geometrical conversion. One effective method of noise reduction is to average successive video frames that are indistinguishable from each other except by the noise structure; this both increases the S/N ratio and leads to smoother images.

In the present study, a composite of 210 video frames was used, and further image processing was carried out on this composite image using wavelet conversion\textsuperscript{14}. RegiStax is a powerful program for stacking and aligning images either from stills or AVI frames. The resulting images had a high quality and a large depth of field, allowing fine structures to be easily observed.

In wavelet transformation, image processing is performed by adjusting intensity based on spatial frequencies present in the image, which allows large and small patterns to be distinguished from each other.

In the present study, video was recorded for 7–8 sec, which may seem to increase the risk
of image degradation due to movement of the patient. However, the results indicate that careful alignment of the individual frames can offset this effect and produce images whose quality is higher than that of still-camera images.

Conclusion

Within the limitations of the present study, the following conclusions may be drawn:

High-quality microscopic endodontic images can be obtained using a digital video camera and subsequent image processing. The method involves the alignment and stacking of a sequence of video frames, followed by the use of a wavelet transform. The results indicate that the quality and depth of field of the resulting images are higher than those of digital still images. This method represents a simple, non-intrusive approach to obtaining image documentation during endodontic procedures.

References


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