Structural effects of sodium hypochlorite solution on RaCe rotary nickel-titanium instruments: an atomic force microscopy study

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Objective. The aim of this study was to investigate the effect of sodium hypochlorite immersion on the surface characteristics of RaCe rotary nickel-titanium instruments using atomic force microscopy (AFM).
Study design. Four new RaCe instruments were used in this study (two 30.06 and two 30.02). One 30.06 and one 30.02 instrument were immersed in sodium hypochlorite solution for 5 min. Surface topography of the instruments was evaluated using the AFM. The instruments were analyzed on 11 points along a 3-mm section. Root mean square (RMS) values were used to compare the topographic deviations. The data were analyzed using Student *t* test.
Results. Mean RMS values for NaOCl measurements were higher than the measurements on new files, and the difference was statistically significant ($P < .01$).
Conclusion. The AFM results show that NaOCl causes deterioration on the surface of RaCe instruments and should be used with care during clinical use because of the risk of unexpected failure. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:661-5)**

In recent years, rotary nickel-titanium (NiTi) instruments have become popular because of their superiority over stainless steel hand files, elasticity, and resistance to torsional fracture.[1] However, irregularities on the surface of these files may result in fracture during clinical use.[2-4]

Surface quality is an important factor, because cracks that arise from superficial defects play a role in instrument fracture.[3] It has been reported that fracture can occur without any visible defects of previous deformation.[5] De Castro Martins et al.[6] reported that the majority of deformations on the instruments could only be observed by scanning electron microscopy (SEM) with high magnification.

The chemical reactions that occur during disinfection, sterilization, or irrigation may cause corrosion and/or deterioration of the instruments, leading to early fracture.[7] Sodium hypochlorite (NaOCl) is a solution which is widely used as a root canal irrigant and lubricant. There is a contact between the rotary NiTi instruments and the NaOCl solution during clinical use and cleaning and sterilization procedures, and corrosion of NiTi instruments could influence their mechanical properties and lead to undesirable and unexpected fracture.[8]

The NiTi instruments are machined rather than twisted, and the former method can increase the surface irregularities.[2] RaCe (FKG, La Chaux-de-Fonds, Switzerland) NiTi instruments undergo an electropolishing procedure and the manufacturer claims that this process improves the strength of the files and provides a smoother surface. Tripi et al.[9] reported that the electropolishing process reduces the risk of machining damage on the file surface and increases fatigue resistance.

Surface morphology of NiTi instruments has usually been investigated with SEM. Scanning probe microscopes and, in particular, the atomic force microscope (AFM) have facilitated the imaging and analysis of surface topography with little or no sample preparation. AFM is a useful tool for investigating structural properties of materials.[10] AFM offers the opportunity to image the 3-dimensional surface topography of specimens with high spatial resolution under a variety of conditions.[11]

Supported by Turkish State Planning Organization (project no. 2001K20590) and Gazi University Research Foundations (BAP 03/2007-13).
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Received for publication Jul 6, 2007; returned for revision Oct 29, 2007; accepted for publication Nov 5, 2007.
1079-2104/$ - see front matter

doi:10.1016/j.tripleo.2007.11.006

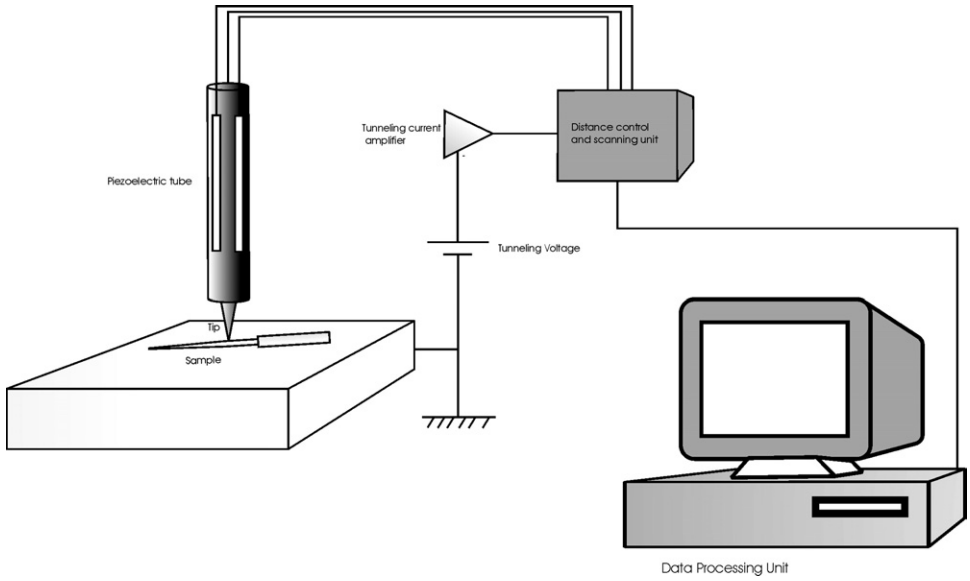

Fig 1. Schematic drawing showing the operating principle of the AFM.

To investigate the effect of NaOCl solution on the surface microstructure of RaCe instruments, we used AFM, which provides quantitative measurements in nanoscale.

MATERIALS AND METHODS

Four new RaCe rotary NiTi files were used in the present study (two 30.06 and two 30.02). One 30.06 and one 30.02 file were immersed in 5.25% NaOCl solution for 5 min. The other two files were used as controls.

All RaCe files were attached to a metal holder using a rapid-setting cyanoacrylate glue. Each sample was placed on the AFM and analyzed on 11 points along a 3-mm section at the tip of the file. The AFM images were recorded using the needle mode operation on an Omicron VT STM AFM (Omicron Nanotechnology, Taunusstein, Germany). The key principle of the AFM is the probing of a sample surface with a needle tip. Similar to the AFM noncontact operation, the needle tip is moved up and down at a frequency of about 1 MHz. Changes in the tip-surface topography then result in a phase shift which can be used for a feedback loop (Fig. 1).

The measurements were carried out at room temperature and atmospheric pressure with 1 μm/s speed scan. Scanned areas were perfect squares (1 μm × 1 μm). Three-dimensional AFM images (400 × 400 lines) were processed with Scala Pro software, and quantitative measurements according to topographic deviations (root mean square [RMS] values) were recorded. Student *t* test was used to test the hypothesis that means were equal when comparing measurements.

RESULTS

Three-dimensional AFM images of the rotary NiTi files are shown in Fig. 2. Topographic irregularities at nanometric scale were observed for all instruments. Mean RMS values for control and NaOCl-treated 30.06 files were 2.06 ± 0.49 nm and 6.99 ± 2.18 nm, respectively, and the difference between them was statistically significant ($P < .01$). Mean RMS values for control and NaOC-treated 30.02 files were 3.68 ± 0.98 nm and 6.72 ± 1.72 nm, respectively, and the difference between them also was statistically significant ($P < .01$).

DISCUSSION

In the present study, the topographic changes occurred on RaCe files immersed in NaOCl solution was evaluated using AFM, and significant deterioration on the surface was detected. It has been reported that topographic irregularities may have a considerable impact on resistance to fracture of endodontic instruments.[4,6,12]

Sodium hyocholorite is used as an endodontic irrigant as it is an effective antimicrobial and has tissue-dissolving capabilities.[13] Corrosion and deterioration of NiTi instruments during disinfection and instrumentation in the presence of NaOCl has been a concern, and there is no consensus regarding this issue in the literature.[14]