PRECISION TREATMENT WITH THE DENTAL OPERATING MICROSCOPE: ANALYSIS OF MICROLEAKAGE AND MARGINAL ADAPTATION USING MTA CEMENT

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Dental operating microscopes are considered to provide easier and more accurate endodontic treatment; however, evidence-based reports of this advantage are lacking. The purpose of this study was to compare mineral trioxide aggregate (MTA) root fillings carried out under three working conditions: with unaided vision, with loupes, and with the microscope. Cavities were prepared on eight extracted human teeth (columnar cavity, depth: 3 mm) using a water laser (Millennium, BioLase). MTA was filled into the root cavity under the three working conditions. All specimens were stored in distilled water for 1 week. The marginal adaptation of each specimen was observed and evaluated using confocal laser scanning microscopy (OLS1100, Olympus). The specimens were also subjected to a dye penetration test for 2 hours using 2% methylene blue to evaluate marginal leakage. The laser scanning microscopy evaluations revealed that fillings performed using the operating microscope showed better marginal adaptation than those performed with unaided vision or loupes. Regarding microleakage, the infiltration of the methylene blue decreased as the magnification increased, and the difference between groups was significant ($P < .05$). It was concluded that procedures performed with the operating microscope provided better results than those obtained with unaided vision or with dental loupes. *Int J Microdent* 2009;1:56–60

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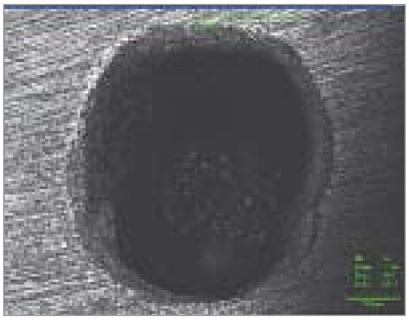
Recently, the dental operating microscope (DOM) was introduced to endodontics, offering significantly improved magnification and illumination. Bellizzi and Loushine advocated the benefits of optical magnification for posterior surgery.[1] Carr stated that surgical and nonsurgical applications for the DOM have revolutionized the practice of endodontics.[2]

The advantage of the combined use of the DOM and visual guidance has been reported clinically in endodontics, but there are few evidence-based studies confirming this advantage. The advantages of using the DOM include identification of cracks and hidden canals (particularly the MB-2 canal); removal of broken instruments; and superior root cleaning, shaping, and perforation repair.

Combined with the current generation of dental materials, the DOM provides excellent and consistent clinical outcomes. Further, the microscopic images or video can be shared with patients and referring dentists or used to help train students and residents.

Mineral trioxide aggregate (MTA) has been demonstrated to have applications in all fields of dentistry and appears to satisfy most characteristics of an ideal cement due to its biocompatibility, excellent sealing ability, marginal adaptation, and hydrophilic properties. MTA can be used for pulp capping, perforation repair, apexification, and retrofilling.

Pitt Ford et al[3] recommended the use of MTA for perforation repair. In a canine in vitro study, they showed



Figs 1a and 1b Root dentin preparation using water laser irradiation.

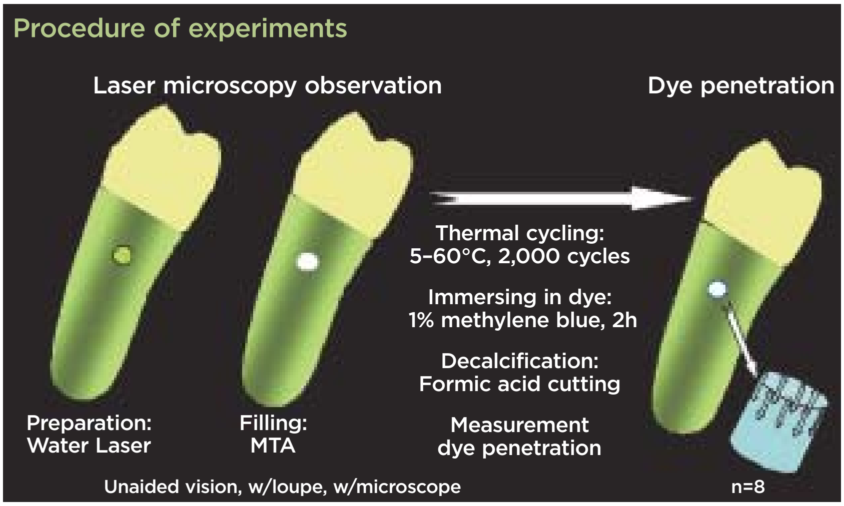


Fig 2 Laser scanning microscopy and dye penetration experimental procedures.

that cementum was produced over the MTA without inflammation. Holland et al[4] reported that no inflammation appeared when repairing lateral root perforations with MTA, and observed evidence of cementum in the majority of specimens over a period of 180 days. MTA also has been shown to successfully seal both furcal and lateral perforations.[5]

This study aimed to provide evidence-based data regarding the advantage of the DOM by investigating the marginal adaptation and microleakage of MTA root fillings carried out under three working conditions: with unaided vision, with dental loupes, and with the DOM.

MATERIALS AND METHODS

Tooth Preparation

Eight extracted human teeth were used for this study. After extraction, the teeth were cleaned and stored in saline until use. Columnar cavities were prepared using a water laser (Millennium, BioLase) with the following conditions: duration, 5 seconds; depth, 3 mm; power, 6 W; air supply, 98%; water supply, 66%. Z6-type tips with a 600-μm diameter and 6-mm length were attached. After the head of the water laser was fixed on the working table, a computer-assisted manufacture milling machine (Pnc-250, Roland) was used to prepare the cavities at a speed of 200 μm/s. Figure 1 shows a confocal laser scanning microscope image of the root dentin preparation.

MTA Fillings

All cavities were filled by one experienced operator using ProRoot MTA (Dentsply) and the DOVCC-0.8 mm Dovgan MTA carrier (Quality Aspirators) under the following three conditions: with unaided vision, with loupes, and with the DOM. For the unaided condition, the distance between the specimens and eyes was 450 mm.

Confocal Laser Scanning Microscopy

After the MTA cement hardened, all specimens were stored in distilled water for 1 week. To evaluate marginal adaptation, each specimen was observed using a confocal laser scanning microscope (OLS1100, Olympus) to obtain three-dimensional (3D) surface measurements.

Dye Penetration Test

All specimens were subjected to 2,000 thermal cycles at 5°C to 60°C. Marginal leakage was evaluated based on the depth of the dye penetration. The specimens were subjected to the dye leakage test for 2 hours using 2% methylene blue. They were then decalcified using formic acid and sectioned for measurement of dye penetration. Figure 2 demonstrates the experimental procedures.

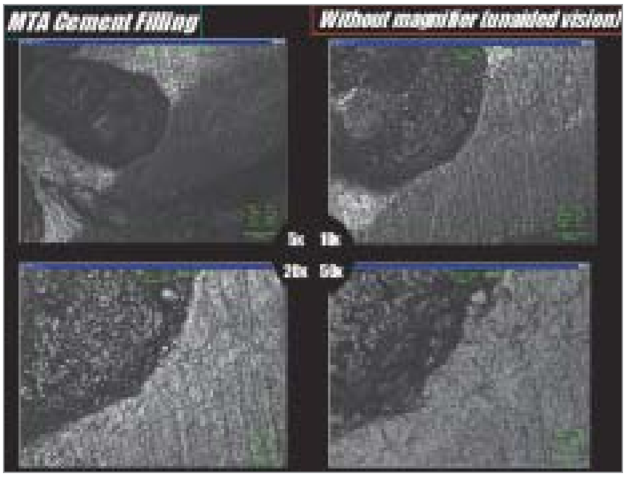


Fig 3 Laser scanning microscope image of the MTA cement filling performed without magnification (unaided vision).

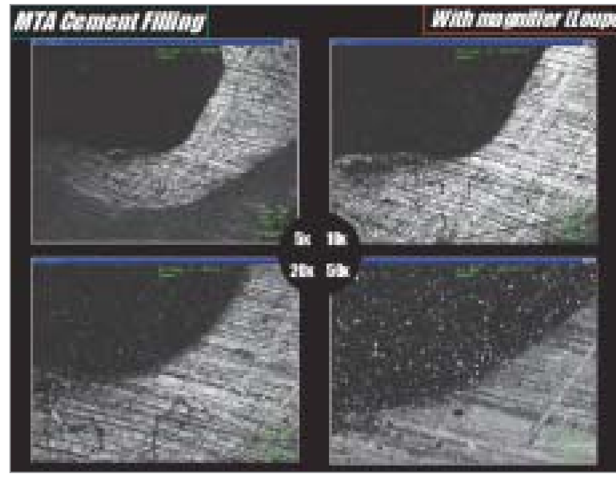


Fig 4 Laser scanning microscope image of the MTA cement filling performed with loupe magnification.

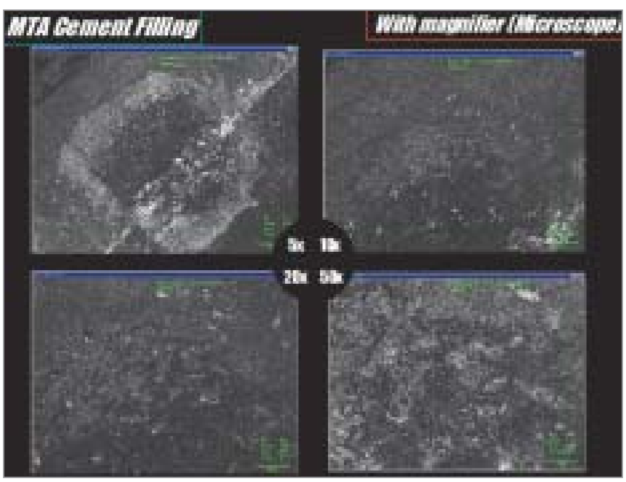


Fig 5 Laser scanning microscope image of the MTA cement filling performed with the operating microscope.

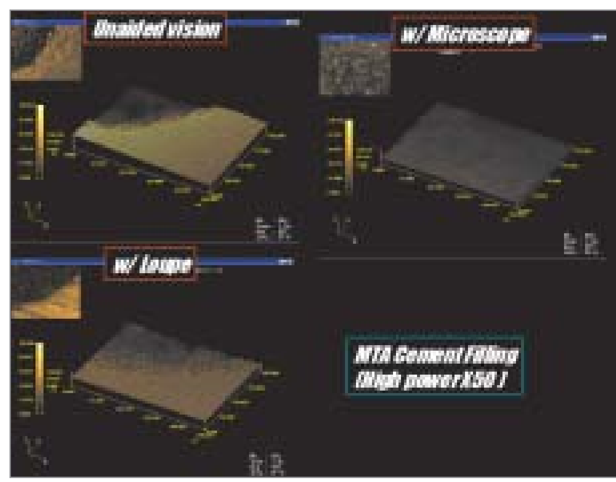


Fig 6 Evaluation of marginal adaptation using high magnification (×50).

Statistical Analysis

Results were statistically analyzed using one-way analysis of variance at a significance level of 5%.

RESULTS

Marginal Adaptation

The laser scanning microscopy evaluation of marginal adaptation revealed a clear gap between the MTA and dentin for the unaided vision group when observed under 5× to 50× magnification (Figs 3 to 6). In the loupe group, a clear gap was not evident under low magnification (< 20×); however, a clear gap was observed under high magnification (50×). In the microscope group, no gap was evident at any level of magnification.

Microleakage

The results of the dye penetration test showed that the dye was able to deeply penetrate the dentin surface of the fillings performed with unaided vision (Fig 7). In contrast, the filling procedure using the DOM strongly blocked dye penetration. The methylene blue infiltration distance decreased as the magnification increased (unaided vision > loupes > DOM), and the difference between groups was significant ($P < .05$).

DISCUSSION

In 1998, a change in ADA accreditation requirements stated that all accredited United States postgraduate programs must teach the use of the microscope in nonsurgical endodontics.[6] Subsequently, use of the DOM by endodontists in the

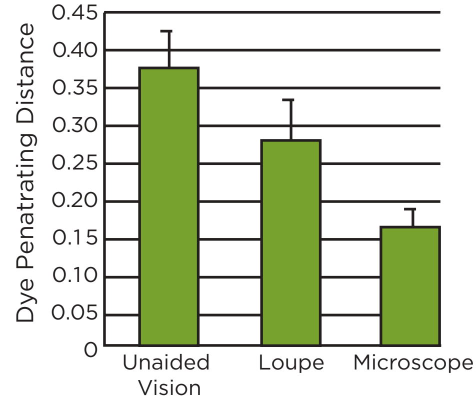


Fig 7 Results of the dye penetration test.

United States increased from 52% in 1999 to 90% in 2007.[7–10] A wide variety of applications has been reported for the DOM in endodontic treatment.[1,11–17]

The DOM is an excellent instrument for detecting fractures, cracks, and canals that cannot be seen using unaided vision or loupes. Slaton et al[18] evaluated the effectiveness of magnification for identifying artificially created dentinal cracks. They tested four working conditions: unaided vision, loupes at 3.3× magnification, surgical operating microscope at 10× magnification, and the Orascope at 35× magnification. The accuracy of identification for these groups was 39%, 45%, 53%, and 58%, respectively. Therefore, the study showed a trend of improved accuracy with increasing magnification.

High magnification provides advantages not only in endodontics, but also in periodontics. Periodontal microsurgery offers results that are predictable and less invasive compared to traditional procedures, with reduced pain, earlier healing, and better patient acceptance.[19,20] Recently, the application of the DOM in implant placement was also investigated.[21]

The OLS1100 laser scanning microscope has confocal optics and a circular pinhole unit that blocks unnecessary light for the capturing of images on the x-, y-, and z-axes. Objects can also be viewed in a nonconfocal mode for greater depth of focus. With a resolution of 1024 × 1024 and 12-bit image memory for increasing gray tones, the system provides high-resolution 3D images that are suitable for measurement and observation. The confocal laser scanning microscope was used to evaluate adaptation because it is able to express height information, which in turn is used to generate 3D images.

The results showed the advantage of the DOM in terms of MTA adaptation to the root surface. MTA is a relatively new material with numerous clinical applications. MTA has been used for pulp capping,[22] root-end filling,[23] and root or furcal perforation repairs.[24] MTA is composed of tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silicate oxide. Its compressive strength is equal to that of intermediate restorative material and super-ethoxybenzoic acid (EBA) cement, but less than that of amalgam. It is available commercially as ProRoot MTA and has been advocated for use in vital pulp therapy.[22] MTA has also demonstrated the ability to induce hard tissue formation in pulpal tissues[25] and promote rapid cell growth in vitro.[26] MTA produces a thicker and faster-forming dentinal bridge and reduces inflammation, hyperemia, and pulpal necrosis compared with calcium hydroxide. Witherspoon et al[27] concluded that MTA may be useful as a substitute for calcium hydroxide in pulpotomy procedures.

In the present study, MTA cement was filled to the standardized cavity with unaided vision, with loupes, and with the DOM to evaluate the adaptability and marginal sealing between the root surface and MTA. It was found that superior marginal adaptation was achieved with the DOM compared to that achieved with unaided vision or loupes. Moreover, microleakage using the DOM was significantly lower than the microleakage using unaided vision or loupes ($P < .05$).

CONCLUSION

An excellent and enhanced result in terms of marginal adaptation and microleakage was demonstrated using the DOM compared to the results using unaided vision or loupes. The use of the DOM reduces clinical errors and provides greater precision and consistency for endodontic outcomes.

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