The main categories of techniques for micro-invasive preparation (MIP) include chemomechanical cleaning with Carisolv gel, air abrasion and dental lasers. The trends for the replacement of the conventional method of preparation led to focus the attention of researchers on the impact of alternative techniques for MIP on hard dental tissues and underlying dental pulp. MIP techniques claim for controlled removal of infected and softened dentin while preserving healthy hard dental tissues and do it with minimal discomfort for the patient. However, currently available data provide contradictory the impact of alternative techniques of MIP on hard dental tissues compared to conventional preparation. Possible reasons for this are the variety of experimental studies and difficulties to standardise the results of clinical researches. It is striking that researchers who give the most positive evaluation of alternative methods of preparation are using mainly clinical criteria for evaluation (perception and tolerance of the patient, noise, atraumatic work, colour and texture of the dentine when probing etc) which are some subjective.

Opposite, the SEM and histologic evaluations are not unanimous for its benefits and advantages. On the dental market new improved versions of alternative systems for preparation are available claiming for clinical efficiency, but scientific data are still scarce (these are generally the multi-frequency high-energy lasers and air abrasion devices). For that reason periodic updates of researches in this rapidly developing and promising field of dentistry are needed. The purpose of this in vitro study was to evaluate by SEM the ultrastructural changes in the hard dental tissues prepared by Er:YAG laser (LiteTouch) and conventional preparation with diamond burs/air turbine and steel burs/micromotor.

**Methods**

Experimental design: the study used 30 human teeth freshly extracted due to advanced periodontal disease. The preparation involved natural carious lesions on tooth surface.

According to the preparation technique the teeth were divided into three groups of 10 teeth (n=10):

**Group 1:** Laser preparation by Er: YAG laser (LiteTouch, Syneron, Israel) (Fig 1 a, b)

**Group 2:** Mechanical rotary preparation by diamond burs/air turbine

**Group 3:** Mechanical rotary preparation by steel burs/micromotor

Preparations are made strictly according to manufacturer’s instructions for service.

The removal of caries is proved by clinical methods – observation and probing. After preparation the teeth are immersed for one hour in four percent buffered fixative solution of glutaraldehyde (0.075 M, pH 7.5). Then rinsed with distilled water and placed for 90 min in cold buffer solution of sodium cacodylate (0.02 M, pH 7.2, 660 mOsm) for fixation of organic matter. Subsequent dehydration is carried out in ethanol in ascending series of 50, 50, 70, 80, 95 and 100 per cent in one hour in each series, such as drying of the teeth is based on CPD (Critical Point Drier) method in SEM evaluation of morphological changes Georgi Tomov discusses tissues prepared by Er:YAG laser and rotary instruments

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a dessicator. Dried specimens are fixed on metal stand and covered with gold layer (200–250nm) by cathode atomisation under vacuum. Scanning microscopy is performed with the electron microscope of Philips (Holland) 515 model SEM with accelerating voltage of 25kV in secondary emission mode. On each specimen were made repectively five pictures with the same magnification (x2000) of randomly chosen areas and different numbers of photos with other magnification.

On SEM photos are rated, described and compared morphological findings and differences in enamel and dentin tissues after treating with alternative methods for caries removal and cavity preparation.

Results
Cavity forms prepared with Er:YAG laser (Group 1) are characterised by a lack of definite and precise geometric configuration and outlined cavity elements. There is rough and irregular surface without presence of smear layer (Fig 2 a). Dentinal tubules orifices are clearly exposed. Intertubular dentin is ablated more than peritubular dentin and that made dentinal tubules appearance more prominent (Fig 3 b). Laser ablation changes enamel and the surfaces appeared strong retentive (Fig 2 c).

In Group 2 (preparation with diamond burs, air turbine and water cooling) a thin, smooth and in some places missing smear layer was observed (Fig 5 a). In the area of water turbulence marked dental tubules orifices can be seen, but without having a clear outline of both tubules lumen and peri- and intertubular dentin (Fig 3 b). The boundary between enamel and dentin is unclear and the cavity surface suitable for adhesive bonding.1 Antibacterial effects of the alternative preparation techniques must not be lower than those of standard necrotomy with rotary instruments and even to exceed them.2

Nowadays the laser devices available for clinical use are capable for effective and controlled ablation of hard dental tissues3–5.

‘Nowadays the laser devices available for clinical use are capable for effective and controlled ablation of hard dental tissues’

forms here smooth contours. When analysing the SEM photomicrographs of the specimens examined, it is found that the conventional method of cavity preparation with steel burs and micromotor at low speed without water cooling (Group 3) leaves contaminated surface covered with smear layer of dentin debris without visible dental tubules orifices. (Fig 4 a, b). Thick smear layer covers all treated surfaces. The walls of the cavities are smooth and rounded and the border between enamel and dentin is not perceptible.

Discussion
The philosophy of minimally invasive cavity preparation approach is based on several main principles – to remove only irreversibly damaged dental tissues and to avoid macroretonement preparation in healthy tissues.6 Additionally these techniques should protect the underlying pulp and to leave the treated surface suitable for adhesive bonding. Antibacterial effects of the alternative preparation techniques must not be lower than those of standard necrotomy with rotary instruments and even to exceed them.2

Newly formed cavities (Group 4) leave no visible dentinal tubules orifices. (Fig 4 a, b). Thick smear layer covers all treated surfaces. The walls of the cavities are smooth and rounded and that border between enamel and dentin is not perceptible.

Results of the present study revealed significant differences in the surface morphology of the studied samples, which would affect the ability to perform effective adhesive bonding. These morphological differences are highly dependent on the mechanism of action of the used preparation systems.

Laser devices use a variety of physical media as sources for generating different wavelength that is absorbed and interact with specific molecules in human tissues. The explanation for the hard tissue ablation is the water content that evaporates when exposed on laser radiation creating high internal pressure and subsequent microexplosions. In this interaction of laser radiation with tissue if inadequate water cooling occurred, that will lead to undesirable thermal effects.7 Depending on parameters such as pulse energy and frequency CO2 lasers, Nd: YAG and Er:YAG lasers cause changes in enamel and dentin as roughing, cracks, cracking, slicing, carbonisation, melting and recrystallisation described in many previous studies.8–11 These changes depend on the laser type, mode of operation, system mode of function for water cooling and proper operation.12 Additionally, the opportunities to ablate porous dentin and enamel strongly vary according to different experimental studies.6–8,11 For argon-fluoride laser (ARF) and the excimer laser there are data on their ability to remove dental caries, which is not of sufficient efficiency.12 Krypton fluoride excimer laser emitting in ultraviolet range has been shown to remove dentin, but enamel resists the attempt for ablation.13

Used in this experimental study, LiteTouch Er:YAG laser incorporates special software, which allows for the broadest range of energy and frequency settings. The unique LiteTouch optical system incorporated in the ergonomic hand piece prevents loss of energy and along with the precision control over pulse duration, pulse energy and repetition rate optimise, allows for a wide range of hard tissue procedures. Another characteristic of this laser is the wavelength (2940nm) which is absorbed mostly by the water and also sapphire tips, showing stability in providing focused energy of laser radiation.1 The mechanism of LiteTouch action is based on interaction between laser radiation and hard tissues incorporated water that results in microexplosions. It is believed that this process is the mechanism of ablating particles from dental tissues without overheating, and without smear layer formation.1 This combination allows precise microinvasive cavity preparation with minimal heating and optimal rate of radiation absorption by the hydroxyapatite incorporated water.1

The program “hard tissue mode” removes enamel, dentin and dental caries effectively and without visible carbonisation or disturbance of the dental microstructure. Evaluated under SEM the dental tissues treated with Er:YAG laser showed rough and irregular surface without presence of smear layer, open dental tubules orifices were found as well. Intertubular dentin is ablated more than peritubular giving a characteristic appearance of the dental surface with mild prominent dentinal tubules. Enamel shows preserved prismatic structure, but also strong retentions due to microexplosions on its surface. Overall the cavity form is irregular, devoid of strict geometry and dotted with microretonements, but with out presence of contaminants or smear layer. The observed changes correspond to changes in hard dental tissues reported by other authors in previous studies.

Figs 1a, b: Laser preparation with Er:YAG laser LiteTouch (Syneron, Israel) “Hard tissue mode” (quanta3/1kHz; 3nm)”
on Er:YAG lasers, but, without the presence of keratin degenerated structures, areas of extensive recrystallisation, melted surfaces or cracks in the dentin, as described in some in vitro studies. It is also reported for better opportunities for adhesive bonding, faster ablation of enamel and dentin compared with rotating burs and an increase in dentinal microhardness after treatment with Er:YAG lasers. Laser treatment statement is not confirmed by other studies. The marked surface irregularities and lack of smear layer observed in the recent study, noted also in other researches provide a solid evidence for the physical mechanism of bonding with composite materials after laser treatment. This fact is not yet fully explored as a possible opportunity to eliminate acid etching of hard dental tissues and its related adverse effects on the underlying dentin and pulp.

The results of some contemporary studies showed that despite the differences between individual authors, the amount of smear layer after treatment with Er:YAG laser in all cases is less than that after conventional rotating instruments, and surface changes are characterised by markedly rugger topography. The morphological features of hard dental tissues observed in our study suggested us to generalise that cavity preparation with Er:YAG laser is consistent with the principles of minimally invasive preparation, leaving clean surfaces and strong microretentions suitable for adhesive restorations. These assumptions about the benefits of alternative techniques for minimally invasive preparation of dental tissues for adhesive restorations should be confirmed in future clinical studies.

Conclusion SEM analysis of hard dental tissues treated with steel and diamond burs showed surfaces covered with a thick layer of debris, which could compromise the adhesion of filling materials. Dental tubules orifices are obturated with debris, with exception the areas under water turbulence where the debris is partially removed. All laser-treated samples showed no evidence of thermal damage or carbonisation. Scanning electron microscope observations of human dentine after mechanical caries excavation. Journal of Dentistry 2000;28:179–86.

References