The main categories of techniques for microinvasive preparation (MIP) include chemo-mechanical 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 treated with Er:YAG laser (LiteTouch) and conventional preparation with diamond burs/air turbine and 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 per cent buffered fixative solution of glutaraldehyde (0.075 M, pH 7.3). 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.

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, Syn-erion, Israel) (Fig 1 a, b)
Group 2: Mechanical rotary preparation by diamond burs/air turbine
Group 3: Mechanical rotary preparation by steel burs/micromotor

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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. Interstitial 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 dentinal 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 Antimicrobial effects of the alternative preparation techniques must not be lower than those of standard necrotomy with rotary instruments and even to excel them.2

Nowadays the laser devices available for clinical use are capable for effective and controlled ablation of hard dental tissues3,4,5. 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.3 This combination allows precise microinvasive cavity preparation with minimal heating and optimal rate of radiation absorption by the hydroxylapatite incorporated water.6

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 dentinal tubules orifices were found as well. Interstitial dentin is ablated more than peritubular giving a characteristic appearance of the dentinal 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 microretentions, but without presence of contaminants or smear layer. The observed changes correspond to changes in hard dental tissues reported by other authors in previous studies.6,7

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 macroretention preparation in healthy tissues.1 Additionally these techniques should protect the underlying pulp and to leave the treated palle for effective and controlled ablation of hard dental tissues; however, not all researchers agree with these conclusions. Therefore, such studies should be periodically updated due to constant introduction of new technologies.

The experimental results of the presented 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.6 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, craters, cracking, slicing, carbonisation, melting and recrystallisation described in many previous studies.7 These changes depend on the laser type, mode of operation, system for water cooling and proper operation.6 Additionally, the opportunities to ablate carious dentin and enamel strongly vary according to different experimental studies.4,5,6 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.8 Krypton fluoride excimer laser emitting in ultraviolet range has been shown to remove dentin, but enamel resists the attempt for ablation.5

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 tissues 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.6 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.3 This combination allows precise microinvasive cavity preparation with minimal heating and optimal rate of radiation absorption by the hydroxylapatite incorporated water.6

Fig 1 a, b: Laser preparation with Er: YAG laser LiteTouch (Syneron, Israel) “Hard tissue mode” (400mJ/20Hz; 8.00W) are fixed on metal stand and (water cooling) a thin, smooth retentive (Fig 2 c).
on Er: YAG lasers, but with- out thermic degeneration of tissue, no evidence of recrystallization, melted surfaces or cracks in the dentin as described in some in vitro studies. It is also reported that better results are obtained with less material ablated and lower levels of ablation energy.8,9 Ablation of enamel and dentin compared with rotating burs is an increase in dentinal microhardness after treatment with Er: YAG pulsed lasers, as described in some previous studies.10 It is also reported that better results are obtained with less material ablated and lower levels of ablation energy.8,9 Ablation of enamel and dentin compared with rotating burs is an increase in dentinal microhardness after treatment with Er: YAG pulsed lasers, as described in some previous studies.10

The author declares not having any financial interest in a company or its competitors that makes a product discussed in the article or any conflicts of interest.

References:
3. Stefanovic, M. Skenirasch electronically - mikroskopski analysis Efektim from vzdeystvieto on Er: YAG lasers 9, 10, but without thermic degeneration of surfaces, are areas under water turbulence with debris, with exception the tubules orifices are obturated with a thick layer of debris, as described in some in vitro studies.8,9 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 pulsed lasers, as described in some previous studies.10 It is also reported that better results are obtained with less material ablated and lower levels of ablation energy.8,9 Ablation of enamel and dentin compared with rotating burs is an increase in dentinal microhardness after treatment with Er: YAG pulsed lasers, as described in some previous studies.10

The results of some contemporary studies showed that despite the differences between individual authors, generally 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 characterized by markedly rugged topography.2,3,5,10

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 damagesignificant surface crystallization and melting. The SEM examination revealed characteristic micro-irregularities of the lased dentin surface without any smear layer, and opened dentinal tubules. Interstitial dentin is ablated more than peritubular dentin and that made the dentinal tubules appearance more prominent. Er:YAG laser ablated enamel effectively and remained exposed enamel prisms without debris. The surfaces are very retentive.

Figs 2 a, b: Laser treated dentin. The surface is clean and free from debris, all dentinal tubules were found open. The surface is irregular, rough, which creates strong retentions. At higher magnification x 500, 2000.

Figs 3 a, b: Enamel treated with Er: YAG laser showed characteristic surface which is very retentive and free from contaminants and smear layer (Magnification x 2000).

Figs 4 a, b: SEM photomicrographs of tooth surfaces prepared with diamond burs and air turbine. In the areas of water turbulence partially removed remnants and single dentinal tubules remains were observed (Magnification x 2000).

Figs 5 a, b: Smooth and thin smear layer covers tooth surfaces prepared with diamond burs and air turbine. In the areas of water turbulence partially removed remnants and single dentinal tubules remains were observed (Magnification x 2000).

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