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Effect of Er:YAG laser beam angle and focal distance on the ultrastructural morphology of enamel

An ESEM Investigation

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Best poster (Research category)

Introduction

In the past decade, extensive research in the field of laser dentistry has led to an increased use of lasers in clinical practice, (3-5) for removal of dental hard tissues prior to application of restorative materials (1,2) Er:YAG lasers emit a wavelength of 2.94 μ m, which coincides with the absorption band of water. The laser energy emitted is well absorbed by hydroxyapatite and more efficiently ablates enamel & dentin in comparison to other laser systems (6).

Hard tissue removal using lasers is a dynamic process & the use of variable laser parameters like pulse energy, pulse repetition rates, wavelength specificity to ablate enamel have been shown to produce morphological changes (7,8). The use of different beam angles and focal distances of the laser beam seem to be extremely important when considering enamel morphological changes. However literature reports regarding the same are deficient. The present in vitro study conducted evaluates the ultrastructural changes seen in enamel while varying the laser parameters of focal distance & beam angle of the Er:YAG laser.

Aim & Objective

To evaluate the effect of 3 different beam angles & 3 different focal distances on the ultrastructural morphology of enamel. To correlate these changes clinically.

Material and Methods

Thirty five non carious human premolars extracted for orthodontic purposes were selected for the study. Each tooth was sectioned upto the cervical third of the root keeping the crown intact (figure 1) & placed in position on the beam angle apparatus to carry out the laser irradiation (figure 2). Each tooth specimen was irradiated with the Er:YAG laser using a non contact handpiece (figure 3) as follows, keeping pulse energy of 250mJ, 15Hz frequency at very short pulse duration (figure 4) constant for all the groups:

Group	Focal Distance	Beam Angle
Group 1	5mm	90°
Group 2	7mm	90°
Group 3	10mm	90°

Tab. 1: Groups evaluated for variable focal distances

Group	Focal Distance	Beam Angle
Group 4	7mm	30°
Group 5	7mm	45°
Group 6	7mm	60°
Group 7	7mm	90°

Tab. 2: Groups evaluated for variable beam angles

Following laser irradiation the enamel surfaces of each specimen were observed under the Environment Scanning Electron Microscope(ESEM). (figure 5)

Beam angle apparatus

An apparatus specially designed to facilitate an accurate setting of focal distance & beam angle was used for all groups. The apparatus consists of the following parts:

Protractor: To permit adjustment of an accurate beam angle value.

Measuring scale: To facilitate setting of an accurate focal distance.

Metal Platform: To enable stable placement of tooth specimen for laser irradiation. (figure 13)



Fig. 1: Premolar specimen

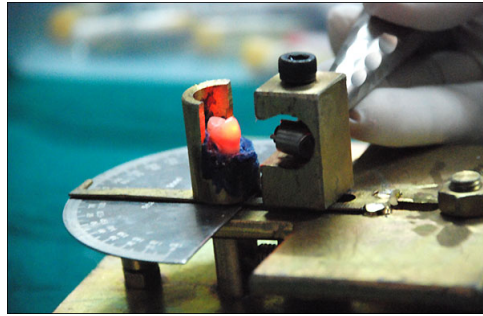


Fig. 2: Laser Beam Irradiation



Fig. 3: Er;YAG Laser Noncontact Handpiece

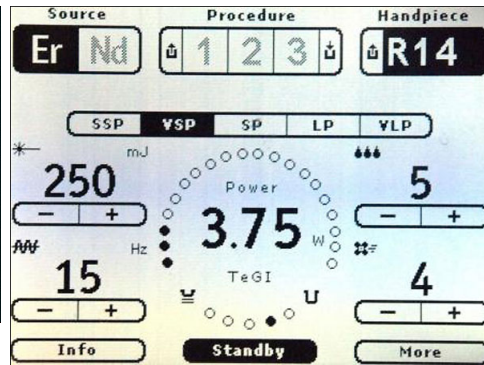


Fig. 4: Er:YAG Laser Parameters

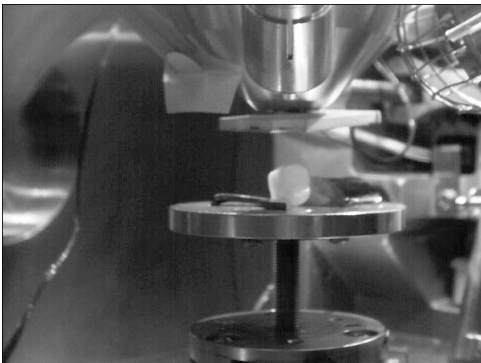


Fig. 5: ESEM

Results

Observation

Groups evaluated for variable focal distances An absence of smear layer may be appreciated in all groups

GROUP 1- 5mm, 90 °: Areas of melting and remineralization (figure 6)

GROUP 2- 7mm, 90°: Crater like defect formation (figure 7)

GROUP 3- 10mm, 90°: Areas of melting and remineralisation with cracks (figure 8)

Groups evaluated for variable beam angles

An absence of smear layer may be appreciated in all groups

GROUP 4- 30° beam angle, 7mm focal distance: Laser beam has brushed past the surface of enamel (figure 9)

GROUP 5 -45° beam angle, 7mm focal distance: Microretentive pattern formation (figure 10)

GROUP 6- 60° beam angle, 7mm focal distance: Microretentive pattern formation with cracks (figure 11)

GROUP 7- 90° beam angle, 7mm focal distance: Crater like defect formation (figure 12)

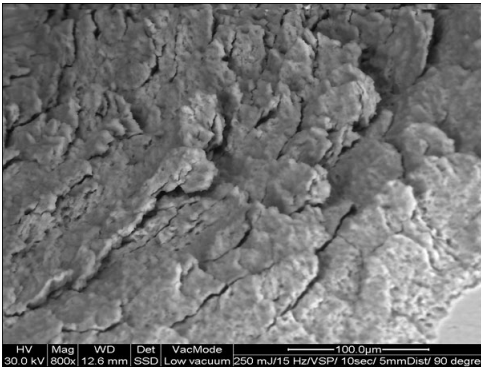


Fig. 6: Group 1 - 5mm focal distance, 90° beam angle



Fig. 7: Group 2 - 7mm focal distance, 90° beam angle

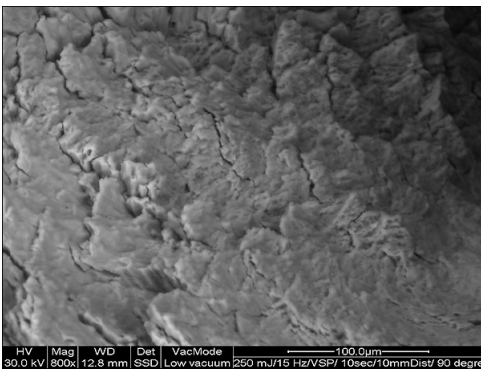


Fig. 8: Group 3 - 10mm focal distance, 90° beam angle

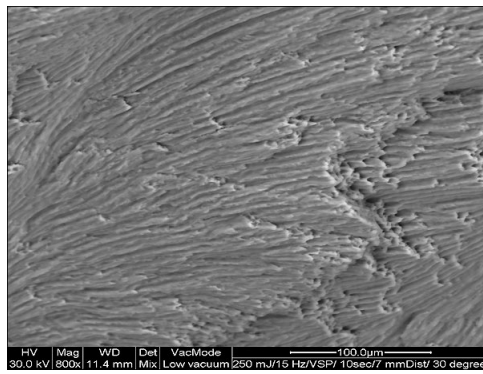


Fig. 9: Group 4 - 30° beam angle, 7mm focal distance

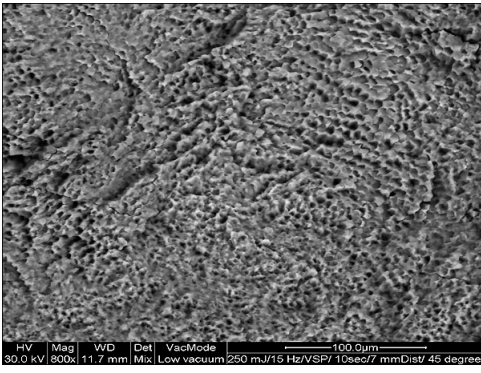


Fig. 10: Group 5 - 45° beam angle, 7mm focal distance

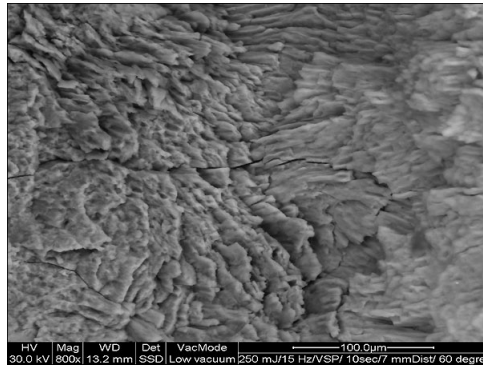


Fig. 11: Group 6 - 60° beam angle, 7mm focal distance

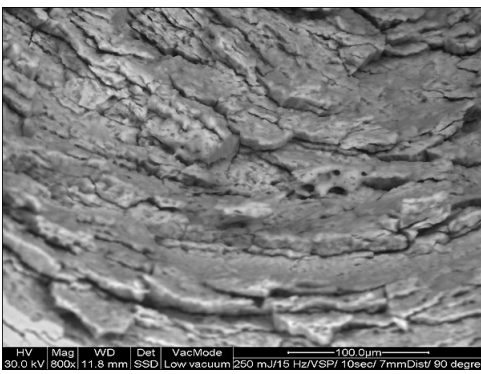


Fig. 12: Group 7 - 90° beam angle, 7mm focal distance

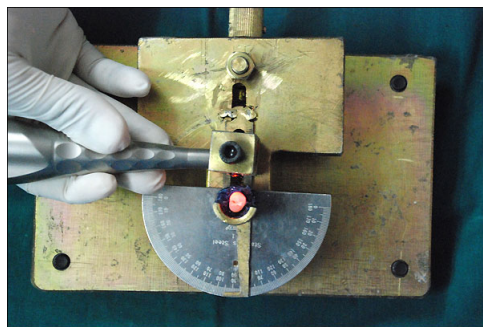


Fig. 13: Beam angle apparatus

Conclusion

The following conclusions may be drawn from the present study:

- 1.Regarding beam angle, 60° provides increased microretentive features & surface roughness at 7mm focal distance, hence it is preferred for procedures requiring etched enamel surfaces.
- 2.The focal distance of 7mm with beam angle of 90° facilitates increased ablation of enamel surfaces with considerable surface roughness as well thus making it suitable to be used for caries removal.

Discussion

Enamel morphology following preparation of the surface with lasers plays an important role in bonding procedures.Previous studies conducted (9,4) have stated that Er:YAG lasers may be used as a viable alternative to conventional mechanical preparation as well as conventional acid etching provided the precise laser parameters may be achieved.The influence of variable parameters of laser irradiation on the enamel morphology seem to be of extreme clinical relevance.

In the current study,the enamel surfaces treated with the Er:YAG laser handpiece in non contact mode ,keeping the beam angle constant at 90° and varying the focal distances revealed scaly irregular surfaces with an absence of smear layer. There seems to be a tendency of greater ablation when using 7mm focal distance and beam angle 90°, clinically, facilitating efficient caries removal. Different surface changes were observed when the focal distance was kept constant at 7mm with variable beam angles of 30, 45, 60 and 90°. Comparatively less microcracks,increased surface roughness with pronounced microretentive features with beam angle 60° and focal distance 7mm reveals that this seems to be more relevant for adhesive procedures.

An understanding of how the variable laser parameters influence enamel topography/morphology is essential for dentists, to facilitate selection of the appropriate technique for different procedures in restorative dentistry.This expertise in the use of recent technologies is a key factor in achieving clinical success.

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2. Mr. Dheeraj Suryavanshi (Automotive research association of India, Pune) for carrying out the ESEM investigation.

Abbreviations

ESEM - Environment Scanning Electron Microscope VSP - Very short Pulse SOLA - Society of Oral Laser Application FODI - Federation of Operative Dentistry ,India IES - Indian Endodontic Society

This Poster was submitted by Dr. Rukshin S. Irani.

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EFFECT OF Er: YAG LASER BEAM ANGLE & FOCAL DISTANCE ON ENAMEL An ESEM Study

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* INTRODUCTION *

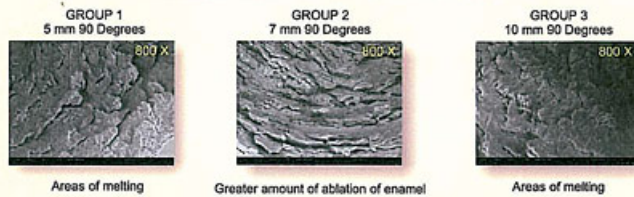
The aim of the present study was to evaluate the effect of 3 focal distances & 3 beam angles on the ultra-structural morphology of enamel and to correlate the changes clinically

* MATERIALS & METHOD *

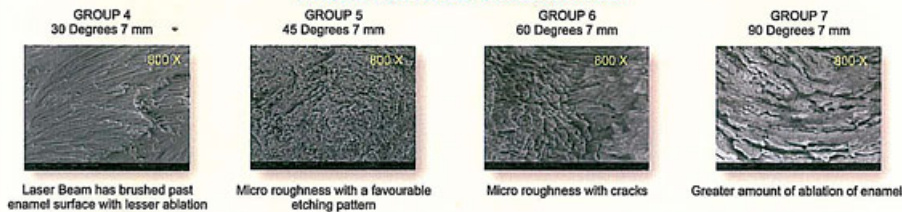
- 35 extracted human premolars sectioned upto the cervical third of the root were randomly divided into seven groups
- The groups 1 to 3 were evaluated for different focal distances and the groups 4 to 7 were evaluated for different beam angles.
- The laser parameters of pulse energy 250 mJ, frequency 15 Hz at very short pulse for 10 sec. were kept constant for all groups.
- Each specimen was subjected to the Laser Beam in non-contact mode and examined under the environment scanning electron microscope.



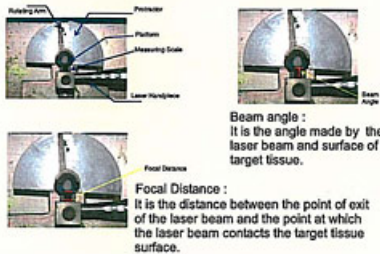
* OBSERVATION * GROUPS EVALUATED FOR FOCAL DISTANCES



GROUPS EVALUATED FOR BEAM ANGLE



* BEAM ANGLE APPARATUS *



* CONCLUSION *

Under the circumstances of this study, the following conclusions can be drawn-

- Regarding beam angle, 60° provides increased microretentive features & surface roughness at 7mm focal distance, hence it is preferred for procedures requiring etched enamel surfaces.
- The focal distance of 7mm with beam angle of 90° facilitates increased ablation of enamel surfaces with considerable surface roughness as well thus making it suitable to be used for caries removal.

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