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Original Article

Laser vs bur for bone cutting in impacted mandibular third molar surgery: A randomized controlled trial

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ABSTRACT

Background: The aim of this study was to assess the feasibility of Er: YAG laser in bone cutting for removal of impacted lower third molar teeth and compare its outcomes with that of surgical bur.

Materials & methods: The study comprised 40 subjects requiring removal of impacted mandibular third molar, randomly categorized into two equal groups of 20 each, who had their impacted third molar removed either using Er: YAG laser or surgical bur as per their group, using standard methodology of extraction of impacted teeth. Clinical parameters like pain, bleeding, time taken for bone cutting, postoperative swelling, trismus, wound healing and complications were compared for both groups.

Observation & result: Clinical parameters like pain, bleeding and swelling were lower in laser group than bur group, although the difference was statistically not significant. However, postoperative swelling showed significant difference in the two groups. Laser group required almost double the time taken for bone cutting with bur. Trismus persisted for a longer period in laser group. Wound healing and complications were assessed clinically and there was no significant difference in both the groups.

Conclusion: Based on the results of our study, the possibility of bone cutting using lasers is pursued, the osteotomy is easily performed and the technique is better suited to minimally invasive surgical procedures. The use of Er: YAG laser may be considered as an alternative tool to surgical bur, specially in anxious patients.

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1. Introduction

During the past two decades, lasers has been widely used in many medical specialties, including general surgery, ophthalmology, and dermatology. In oral and maxillofacial surgery their clinical application has largely been restricted to soft tissue. Initially, ruby and long pulse CO₂ laser were used for cutting mineralized tissues but results revealed serious biological complications, thermal damage,^{1,2} severe carbonization effects and delayed bone healing. Later, comprehensive advancements of short-pulsed infrared laser systems paved the way for successful ablation of dental hard substances and bone.

Er: YAG lasers are solid lasers (Er:Y₃Al₅O₁₂), which typically emit light with a wavelength of 2940 nm, which is infrared light. Due to its wavelength of 2.94 μm, which matches exactly the absorption peak of water³ and is also absorbed by hydroxyapatite, Erbium laser radiation is very efficient in cutting hard structure like bone, to a superficial layer of a few micrometres.⁴

Our study was to assess the feasibility of Er: YAG laser in bone cutting for removal of impacted lower third molar teeth and compare its outcomes with that of surgical bur.

2. Materials & methods

This prospective study was conducted in 40 healthy male and female subjects with impacted mandibular third molar, who visited the outpatient department of Oral and Maxillofacial Surgery, King George's Medical University, Lucknow, irrespective of their cast, creed, sex and socio-economic status, for removal of impacted mandibular third molar. Patients on anti-coagulants, immuno-suppression, systemic or local bone diseases, radiotherapy, pregnant and lactating mothers were excluded. Treatment plan and possible complications were explained to all subjects and informed consent obtained. Detailed history was recorded in a standardized format. All were thoroughly examined clinically and routine haematological investigations were done. Pre-operative radiographic evaluation of the area was done on intraoral peri-apical radiographs and orthopantomogram and type of impaction (mesioangular, distoangular, horizontal) was recorded.

They were randomly categorized into two equal groups of 20 each (Group A: BUR, Group B: LASER), who had their impacted third molar removed either using bur or Er: YAG laser as per their group, using standard methodology of extraction of impacted teeth. The procedure was carried out under local anaesthesia. Ward's incision was made and mucoperiosteal flap reflected protecting the lingual nerve. In group A, bone was removed on buccal and distal portion as required with surgical round bur (#6) using copious irrigation with normal saline (Fig. 1). In group B, Er: YAG laser was used to cut bone and if necessary the tooth (Fig. 2). The surgeon wore protective glasses during the procedure. The wavelength of the Er: YAG laser was 2.94 μm, the pulse energy was 700 mJ (.7 W), at 10 pulses/s or 10 Hz. The duration of each pulse was about 250 s. The laser tip was kept 1–2 mm away from the bone or tooth. The area was copiously irrigated with sterile water. Tooth was delivered with elevator taking care of

Fig. 1 – Bone cutting by bur.

curvature of roots. Any sharp bony margins were smoothed with bone file. The socket was then inspected, irrigated with normal saline and wound was closed with 3–0 silk suture.

Clinical parameters like pain (recorded on visual analogue scale as mild for 1–4, moderate for 5–7, and severe for 8–10), bleeding during tooth removal, time taken for bone cutting, postoperative swelling, trismus, wound healing and complications were recorded for both the groups.

Bleeding was recorded as severe if blood was pumping from the wound and did not stop or slow down with pressure, moderate if it slowed or stopped with pressure but started again upon removal of pressure and mild if stopped on its own or with 15 min of pressure.⁵

Fig. 2 – Bone cutting using Er: YAG laser.

Objective assessment of postoperative swelling was done by measuring the linear distance between corner of mouth & the centre of tragus of ear and angle of mandible (gonion) and lateral canthus of eye was measured pre and postoperatively to quantify facial swelling^{5,6} which excluded lingual swelling (Figs. 3 and 4).

Trismus was recorded as painless mouth opening measured between inter incisal distance. Healing was recorded as interrupted/smooth (presence or absence of persistent postoperative pain & swelling, change in colour of mucosa, pus discharge, palpable lymph nodes). Complications noted were infection (including dry socket), altered sensation – paraesthesia/anaesthesia/hyperesthesia of inferior dental and lingual nerve.

3. Results

Mean age was 27.2 in bur group and 27.7 in laser group. Bur group had 11 females (55%), 9 males (45%) and laser group 8 females (40%), 12 males (60%). Among all patients, 85% had mesioangular, 5% horizontal and 10% distoangular type of impaction (Table 1).

Statistical analysis of variable outcomes revealed no statistically significant difference in pain (Table 2), bleeding (Table 3); but, there was statistically significant difference in swelling (Table 4) in both groups. Time (Table 5) taken in bone cutting was significantly more in laser group, with almost double time taken for bone cutting compared to bur. Trismus (Table 6) persisted for longer period in laser group.

In our study, wound healing (Table 7) was assessed clinically and result showed no significant difference in wound

Fig. 3 – The linear distance between corner of mouth & the centre of tragus of ear.

Fig. 4 – Angle of mandible (gonion) & lateral canthus was measured.

healing between the two groups, although 10% cases in bur group & 5% cases in laser group showed dry socket. 5% cases in bur group showed temporary paresthesia. Though the follow-up period was too short to allow any long-term assessment on quality of healing, short-term follow-up showed no differences in healing between the groups.

4. Discussion

Osteotomies are necessary in oral and maxillofacial region for dento-alveolar surgery, impacted tooth removal, traumatology,

Table 1 – Type of impaction of mandibular third molar.

Table 2 – Postoperative pain in bur and laser group.

surgery for dentofacial deformities and reconstruction. Mechanical drills and saws have been used efficiently to cut bone for hundreds of years. Despite improvements in technology, metallic cutting instruments result in deposition of debris on bone, heating,⁷ vibrations,⁸ noise and discomfort. Recently, lasers have been in demand for obvious advantages like sterilization of the surgical site while cutting tissue, simultaneous haemostasis of small vessels resulting in decreased bleeding and a dry surgical field, no-touch technique, reduced postoperative pain, less oedema and limited scarring.⁹

Pain is one of the most important feature after surgical extraction of impacted tooth. Our study showed reduced intraoperative as well as postoperative pain in laser treated patients. We observed mild pain in 100% patients in laser group but in bur group 85% had mild, 15% moderate and 5% severe pain. However, statistical analysis showed no significant differences. Similar findings have also been reported by Taguchi¹⁰ and Abu-Serriah.¹¹ Possible mechanisms of pain reduction in Er: YAG ablation, is the disruption of nerve terminals in bone, combined with a degeneration of nerve ending. Secondly vibration speed caused by bur is 100 times higher than laser. This higher frequency has its spectrum near the peak sensitivity of hearing, as a potential factor of discomfort and pain provocation.

The Er: YAG laser produced no smoke during the ablation process. There was also no friction sound or vibration the

Table 4 – Postoperative swelling in the two groups.

Swelling	BUR group			Laser group		
	Mean	Std. error mean	Sig. (2-tailed)	Mean	Std. error mean	Sig. (2-tailed)
X preop x	12.30	.272	.000	12.75	.280	.000
72 h x	14.05	.235		13.70	.263	
Y preop y	10.325	.1787	.000	10.100	.2039	.017
72 y	11.15	.167		10.50	.212	
X preop x	12.30	.272	.000	12.75	.280	.330
1 week x	12.95	.256		12.80	.277	
Y preop y	10.325	.1787	.019	10.100	.2039	.577
1 week y	10.65	.131		10.15	.182	
X preop x	10.325	.272	.163	12.75	.280	.330
15 days x	12.30	.247		12.70	.263	
Y preop y	12.20	.1787	.330	10.100	.2039	.186
15 days y	10.275	.1758		9.950	.1698	

Shows overall mean swelling at various intervals.

X = the linear distance between corner of mouth & the centre of tragus of ear.

Y = angle of mandible (gonion) & lateral canthus.

apparatus does produce a repetitive snapping sound, which represents the explosive interaction with chromophores. This has been measured in one study at between 99 and 121 dB although patients did not find this unpleasant and studies have shown that this sound does not damage hearing.¹²

Er: YAG laser has a high bactericidal potential even at low energy densities.^{13,14} Gonzalez² compared the in vitro bone- and cartilage-ablation characteristics of the solid-state erbium:yttrium aluminum garnet laser to those of the carbon dioxide laser and observed that Er: YAG ablated bone averaged 5 microns of adjacent tissue thermal injury, compared with 67 microns with carbon dioxide-ablated bone. Ablated cartilage averaged 2 microns of adjacent tissue thermal injury with Er: YAG laser, compared with 21 microns with the carbon dioxide-ablated cartilage.

Haemostasis is one of the inherent property of low intensity lasers. Infrared low intensity LASER change the

Table 3 – Bleeding in bur & laser group. **Table 5 – Postoperative trismus.**

Trismus	Group	Mean	Std. error mean	Sig. (2-tailed) t-test
Preop	BUR Group	32.70	.594	.865
	Laser Group	32.85	.642	
24 h	BUR Group	23.45	.884	.000
	Laser Group	19.20	.484	
48 h	BUR Group	27.30	.482	.000
	Laser Group	22.95	.555	
72 h	BUR Group	29.50	.407	.000
	Laser Group	25.40	.596	
1 week	BUR Group	32.45	.510	.000
	Laser Group	29.85	.449	
15 days	BUR Group	33.90	.397	.036
	Laser Group	32.50	.505	

Mean mouth opening in both groups.

Table 6 – Time required for ostectomy.

functional activity of proteins of haemostatic system, its effect depends upon the dose and frequency of radiation impulses. Bleeding in our study showed 90% patients in laser group had mild bleeding and 10% moderate whereas in bur group 80% had mild, 20% moderate bleeding. There was less bleeding in laser group than bur group which provides better visibility of operating field and hence better outcome. Although statistical analysis showed no significant difference in bleeding between both the groups. Our study correlates with the studies of Stübinger.¹⁵

There was statistically significant difference in bone cutting time of both groups as p value was .004 ($< .005$). Average time observed in bur group was 11.9 min and in laser group was 23 min. LASER group had almost double time taken for bone cutting compared to bur. This was particularly true when the laser was used to cut thick or dense bone or tooth. Bone contains mineral salts, which retard vaporisation, resulting in prolonged duration of operation. Considering the time taken during cutting, patient should be explained about the procedure before surgery.^{16,17} Papadaki¹⁸ studied vertical ramus osteotomy feasibility with all energy settings and observed that the time required for ostectomy decreased considerably from 28 to 5.33 min as the energy per pulse increased. He suggested that 2000 mJ/pulse was the most efficient setting in terms of time.

Table 7 – Wound healing in bur and laser group.

Postoperative swelling was more in bur group patients. Results were statistically significant during 48 and 72 h follow-up as p value was $< .05$. Similar findings have also been reported by Abu-Serriah¹¹ and Radwan.¹⁹ LASER irradiation causes vasodilation with simultaneous decrease of blood vessel permeability. Also laser increases protein absorption by activating macrophages, modifying hydrostatic and capillary pressure, and inducing the absorption of interstitial fluids with consequent reduction in oedema.

Trismus was greater in the laser group, and persisted for longer duration of time. The difference was significant during first the postoperative week. A greater reduction in the range of mouth opening was found after laser than after bur treatment.¹¹ Generally the severity of the intervention, massiveness of tissue and bone destruction leads to trismus.¹⁸ Longer period manipulation of the mucoperiosteal flap with a retractor during the impacted third molar surgery contributed to the more severe trismus.

Wound healing in our study was assessed clinically and results showed no significant difference in wound healing between two groups; although 10% cases in bur group & 5% cases in laser group showed dry socket. Also 5% cases in bur group showed temporary paraesthesia. Although the follow-up period was too short to allow any long-term assessment of the quality of healing, short-term follow-up showed no differences in healing between the groups.

5. Conclusion

In this study we compared the removal of impacted mandibular third molar using bur and Er: YAG laser for bone cutting. Our study showed that laser allows precise bone ablation without any visible, negative, thermal side-effects; offering advantages like sterilization and bactericidal effect, spontaneous haemostasis, reduced postoperative pain, oedema and limited scarring.

Since the laser tip was used in a non-contact mode and could be positioned freely, unrestricted cut geometries were feasible. Adjacent soft tissue structures could be preserved and were not harmed by the laser beam.

The main disadvantages of laser included increased operating time, long-term postoperative trismus, lack of tactile sensitivity, difficult safety measures and cost factor in laser equipment & maintenance. Also The ablation process using laser and water spray resulted in a considerable spatter of blood. An additional risk may be the creation of an air embolism in the tissue, due to the air-induced water spray.

Based on the results of our study, we conclude that possibility of bone cutting using lasers is pursued. The osteotomy is easily performed and the technique is better suited to minimally invasive surgical procedures. The use of Er: YAG laser may be considered as an alternative tool to surgical bur specially in anxious patients.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Fisher SE, Frame JW. The effects of the carbon dioxide surgical laser on oral surgery. *Br J Oral Maxillofac Surg.* 1984;22:414–425.
2. Gonzalez C, van de Merwe WP, Smith M, Reinisch L. Comparison of the erbium-yttrium aluminum garnet and carbon dioxide lasers for in vitro bone and cartilage ablation. *Laryngoscope.* 1990;100(1):14–17.
3. Spencer P, Payne JM, Cobb CM, et al. Effective laser ablation of bone based on the absorption characteristics of water and proteins. *J Periodontol.* 1999;70(1):68–74.
4. Paghdiwala AF, Vaidyanathan TK, Paghdiwala MF. Evaluation of erbium: YAG laser radiation of hard dental tissues: analysis of temperature changes, depth of cuts and structural effects. *Scanning Microsc.* 1993;7:989–997.
5. Gallardo F, Carstens M, Ayarza M. Analgesic and anti-inflammatory effects of glucamethacin (a nonsteroidal anti-inflammatory analgesic) after the removal of impacted third molars. *Oral Surg Oral Med Oral Pathol.* 1990;69:157–160.
6. Amin MM, Laskin DM. Prophylactic use of indomethacin for prevention of postsurgical complications after removal of impacted third molars. *Oral Surg Oral Med Oral Pathol.* 1983;55:448–451.
7. Kondo S, Okada Y, Iseki H, et al. Thermological study of drilling bone tissue with a high-speed drill. *Neurosurgery.* 2000;46:1162.
8. Takamori K, Furukawa H, Morikawa Y, Katayama T, Watanabe S. Basic study on vibrations during tooth preparations caused by high-speed drilling and Er: YAG laser irradiation. *Lasers Surg Med.* 2003;32:25–31.
9. Bader C, Krejci I. Indications and limitations of Er: YAG laser applications in dentistry. *Am J Dent.* 2006;19(3):178–186.
10. Taguchi T. Thermographic changes following laser irradiation for pain relief. *J Clin Laser Med Surg.* 1991;5:143–147.
11. Abu-Serriah M, Critchlow H, Whitters CJ, Ayoub A. Removal of partially erupted third molars using an Erbium (Er: YAG) laser: a randomised controlled clinical trial. *Br J Oral Maxillofac Surg.* 2004;42(3):203–208.
12. Li ZZ, Reinisch L, Van de Merwe WP. Bone ablation with Er: YAG and CO₂ laser: study of thermal and acoustic effects. *Lasers Surg Med.* 1992;12(1):79–85.
13. Kreisler M, Kohnen W, Marinello C, Gotz H, Duschner H, Jansen B, et al. Bactericidal effect of the Er: YAG laser on dental implant surfaces: an in vitro study. *J Periodontol.* 2002;73:1292–1298.
14. Ando Y, Aoki A, Watanabe H, Ishikawa I. Bactericidal effect of Er: YAG laser on periodontopathic bacteria. *Lasers Surg Med.* 1996;19:190–200.
15. Stübinger S, von Rechenberg B, Zeilhofer HF, Sader R, Landes C. Er:YAG laser osteotomy for removal of impacted teeth: clinical comparison of two techniques. *Lasers Surg Med.* 2007;39(7):583–588.
16. Lewandrowski KU, Lorente C, Schomacker KT, Flotte TJ, Wilkes JW, Deutsch TF. Use of the Er: YAG laser for improved plating in maxillofacial surgery: comparison of bone healing in laser and drill osteotomies. *Lasers Surg Med.* 1996;19(1):40–45.
17. Martins GL, Puricelli E, Baraldi CE, Ponzoni D. Bone healing after bur and Er: YAG laser osteotomies. *J Oral Maxillofac Surg.* 2011;69:1214–1220.
18. Papadaki M, Doukas A, Farinelli WA, Kaban L, Troulis M. Osteotomy with Er: YAG laser: a feasibility study. *Int J Oral Maxillofac Surg.* 2007;36:1193.
19. Radwan DA, Mohammed NH, Zaky AA. Effectiveness of low power laser therapy and betamethasone in minimizing postoperative edema and trismus after third molar surgery: a clinical trial. *J Am Sci.* 2010;6(12):986–989.