# Use of Electrosurgery and Lasers in the Presence of Dental Implants

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*Use of electrosurgery or laser surgery in the presence of metallic implants has been implicated in generating heat-induced injury to peri-implant bone, with the subsequent loss of osseointegration. Studies involving lasers offer conflicting results, while in the case of the electrosurg, little research has been published supporting or refuting these claims. This study measured local heat effects created by use of a unipolar electrosurgical unit, a bipolar electrosurgical unit, and a neodymium:yttrium-aluminum-garnet (Nd:YAG) laser. Absolute temperature increase was measured during an in vitro uncovering surgical procedure performed with each unit. Analysis of variance for repeated measures was performed. Second, absolute temperature increase for each unit was compared with a theoretical clinical limit of a 10°C increase. The findings suggest that use of the unipolar electrosurgical unit should be avoided, while judicious use of both the bipolar unit or the laser unit should produce temperature profiles well within clinical limits.* (INT J ORAL MAXILLOFAC IMPLANTS 2001;16:578–582)

**Key words:** *dental implants, electrosurgery, heat, laser surgery*

Minor revision of soft tissue surrounding a dental implant is indicated for *(1)* removal of small amounts of hyperplastic tissue (such as tissue ingrowth between a loose abutment and the implant head), *(2)* revision of attached gingiva to provide an improved anatomic emergence profile, or *(3)* performance of an uncomplicated stage II (uncovering) surgery.[1] Both electrosurgery[2] and laser surgery[3–6] have been proposed as ideally suited for these delicate procedures. Concern has been raised, however, that incidental contact of either the electrosurgical probe or laser beam with the metallic implant would induce an increase in implant surface temperature, thereby producing a deleterious reaction at the implant-bone interface.[6] Guided by this, cautious clinicians have avoided exposing implants to the possibility of these contacts. However, little research has been published supporting or refuting these concerns where electrosurg use is concerned, while studies involving lasers offer conflicting results.

There is no question that increasing the temperature of a tissue beyond its physiologic limits causes damage or necrosis. Identification of a significant clinical threshold has been the subject of some investigation. Goldstein[7] found that 60% of dental pulps that experience an increase in temperature that is 10°C above normal suffer irreversible pulpal changes. Eriksson and Albrektsson[8] established that "bone tissue is sensitive to heating at the level of 47°C." They further stated that greater injury occurred after heating tissue to 53°C for 1 minute, and that "heating to temperatures of 60°C or more resulted in . . . obvious bone tissue necrosis."[8] The theoretical upper limit can also be assumed to be 56°C, since alkaline phosphatase in bone is known to denature at this temperature.[5] With these findings as a benchmark, researchers have investigated the potential harm caused by heat generated during common clinical procedures.[9–12]

Laforgia and associates[13] studied the change in pulpal temperature induced by a typical crown preparation procedure. They found that pulpal temperature varied from 24.8°C (preparation with

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water coolant) to 45°C (preparation without coolant). Both Gross and Laufer[11] and Brägger and coworkers[12] investigated heat transfer to implant surfaces during high-speed preparation of titanium abutments. While both found that adequate water coolant was capable of limiting the temperature rise to less than 10°C, Brägger and coworkers concluded that "without cooling, extreme overheating could be provoked, reaching the critical temperature that would lead to irreversible bone damage within only a few seconds."[12] Visser, Mausberg, and others[14–16] studied the effects of incidental electrosurgical contact with metallic restorations by measuring the load/impedance differential between normal tissues and teeth restored with silver amalgam restorations. They found that the low impedance of the restoration (compared to the high impedance of the soft tissues) causes a marked responsive increase in power output by the electrosurgical unit, contributing to overheating of the restoration. Krejci and colleagues[17] studied the pulpal response in dogs to electrosurgical contact with Class V amalgam restorations. The study concluded that contacts of less than 0.4 seconds in a simulated clinical procedure produced no change in pulpal histology. Conversely, when contacts exceeded 0.4 seconds, histologic changes occurred in the majority of pulps.

Malis[18] reported that both he and Greenwood independently conceived and introduced the bipolar electrosurgical unit in the mid-1930s (Fig 1). An adaptation of Bovie's early unipolar electrosurgical unit, the new arrangement (originally called a "2-point" arrangement) substituted a second surgical wire on the unit handpiece for the customary neutral plate (placed elsewhere on the patient's body).[18] Units of this design have been in routine use for neurosurgical coagulation for many years. The assumed sensitivity of neural tissues to heat, as well as routine use of these units in the presence of metallic implants during neurosurgery, leads to the conclusion that this design might also hold great promise for dental procedures in the presence of implants.

Use of the laser in the presence of dental implants has been investigated. Ganz[3] observed that laser energy would be expected to be absorbed readily by the water in soft tissues, but would not be absorbed well by dark metallic objects such as implants. In this case, the energy should tend to be reflected, negating potential for heat induction during surgical procedures. His study concluded that a carbon dioxide ($CO_2$) laser was safe to use at 2 to 4 watts in continuous mode for less than 4 seconds. Swift and associates[4] recommended a pulsed laser mode for less than 15 seconds at 8 watts, but did observe that damaging heat levels were attained with 15 watts for 15 seconds. Chu[19] also reported damaging heat levels using a neodymium:yttrium-aluminum-garnet (Nd:YAG) laser. Oyster and coworkers[5] also observed the potential for damaging heat levels, but concluded that conscientious use of the $CO_2$ laser could produce satisfactory results, with limited risk of exceeding the 47°C benchmark. These findings agree with the work of Spencer and colleagues,[1] who studied the effect of the Nd:YAG laser in simulations of typical clinical procedures without the presence of an implant. Once again, it was asserted that conscientiously applied energy could provide satisfactory results, recognizing that damage could occur with prolonged exposure.

The present study measured and compared the temperature effects of incidental contact of a dental implant by *(1)* conventional (unipolar) electrosurg, *(2)* bipolar electrosurg, and *(3)* laser beam. The authors used an in vitro design that simulated clinical surgical conditions.

**Terminology[20]**

**Monoterminal:** A situation of incomplete circuitry which utilizes only a single active electrode. The patient is not grounded to the surgical unit and, therefore, sheds electrons and the current radiates about the patient to the air, walls, etc.

**Biterminal:** An electrical circuit which is made complete by the addition of a return electrode in the form of either a second electrode or a large neutral plate.

**Unipolar:** The familiar electrosurgical arrangement in which the high-frequency current passes over the patient's body between a large, passive electrode which is placed at a distance from a smaller, single active electrode at which the energy becomes concentrated. (term coined for ease of discussion)

**Bipolar:** Utilized two wire electrodes of equal size positioned in close approximation (eg, 2.0 mm, both on the surgical handpiece) thereby eliminating the large passive electrode.

**Fig 1** Terminology used to describe instruments used in the present study.

## METHODS AND MATERIALS

Root-form implants (Lifecore, Chaska, MN) were placed into individual fresh bovine rib sections. A lateral access channel was prepared in the bone to allow the placement of a thermistor. This channel was made perpendicular to the implant from the simulated facial surface.[3] The soft tissue flap was then repositioned and sutured over the implant.

Two dental electrosurgical units (model 400E, Whaledent, New York, NY; and model 90FFP, Ellman, Hewlett, NY) were set up in the usual manner and fitted with a single wire surgical tip. The current was set to the "cut" mode and the power output was adjusted until clean soft tissue incisions were achieved. This resulted in a mid-range setting for these particular units, which is typical of normal clinical operations. These units served as representatives of "conventional" electrosurgical units (configured with a neutral plate), and for ease of discussion will be termed "unipolar." A bipolar oral surgical unit (Bident, Philadelphia, PA) was set up in the usual manner. The unit was fitted with a straight electrode handpiece, and the current level was adjusted to allow normal surgical removal of soft tissue. This resulted in a power setting of 9 on a scale of 10. An Nd:YAG laser unit (model E-008, HGM, Salt Lake City, UT) was set up in the usual manner and fitted with a 0.6-mm spot size tip. The current was set to the continuous mode at 1.5 watts.

The rib specimens were stabilized at room temperature. A thermistor (Tandy, Fort Worth, TX) was placed to the depth of the access channel and positioned adjacent to the implant. The thermistor leads were attached to a digital multimeter, which was connected in turn to a personal computer that had been supplied with commercial spreadsheet software (Excel, Microsoft, Redmond, WA).

Two modes were devised for data gathering. In the first, a series of tests were conducted simulating a typical second-stage implant uncovering, in the manner of Oyster and associates.[5] Soft tissue was removed using energization and rest cycling typical of the clinical procedure, including incidental contact of the energized tip (or light) with the implant. Temperature at the implant surface was recorded once each second.

In a second series of measurements, the energized tip was placed in contact with the implant surface for 1 second, then released for 10 seconds, in the manner of Ganz.[3] This was repeated for 10 cycles (1:10). Temperature at the implant surface was recorded once per second. It was assumed that the latter technique would produce data sets that would be both more rigorous and easily compared. This mode proved to be most productive for use with the laser but could not be used with the bipolar electrosurgical unit (because of the incorporation of an internal safety device, which disabled the unit when both probes are "shorted" against the implant).

A series of 19 recordings were made in the 1:10 mode (unipolar = 13, laser = 6). A series of 18 recordings were made in the simulated implant uncovering procedure (unipolar = 7, bipolar = 11). For each recording, instrument-to-implant strike events were identified, and pre-strike (low) and post-strike (high) temperatures were noted. From these values, a net temperature change for each strike event was obtained.

Statistical analysis was used to summarize results and test the hypothesis that no significant difference in temperature change would be produced with any of the tested units in typical clinical use. Analysis of variance for repeated measures was used for hypothesis testing. Only the first 4 or 6 contacts, whichever was the minimum number of observations in any eligible sample, were included in these analyses. Factors included in the model were sequence number of contact (within cases), type (between cases), and interaction effect. All analyses were performed twice: once using absolute difference (pre-contact temperature versus post-contact temperature) and once using proportional difference (difference/pre-contact temperature). Unless otherwise noted, this transformation of the data made no difference in the statistical test results, and so the results given are based on the analysis of absolute difference. Since there were 3 types of devices, and the analysis of variance only provided an overall test for differences among the 3 groups, Dunnett's test was used to compare the conventional electrosurg to each of the other types of devices. The alpha probability was set at .05 for all hypothesis tests. Analyses were performed using SAS system software (GLM Procedure; SAS Institute, Cary, NC).

## RESULTS

In preliminary analyses, the difference between the 1:10 and the "uncovering procedure" was evaluated using the unipolar electrosurg unit only. No significant difference was observed. Thus, in further analyses, the make of unit (Whaledent versus Ellman), as well as the type of procedure (1:10 versus uncovering), was ignored and focus was turned to the instrument design category, namely, laser, bipolar electrosurg, or unipolar electrosurg.

In the overall analysis of the data, the size of the temperature change was consistent across the 4 contacts within each unit type. In other words, there was no significant effect of sequence number and no significant sequence number/device type interaction. However, there was a highly significant difference ($P < .0001$) in the size of the temperature change between unit types (Table 1, Fig 2). Pairwise comparison of the laser and bipolar groups to the unipolar group showed a significant effect for device type ($P < .05$) for each device at each time point.

**Table 1 Intergroup Temperature Comparisons**

| | Temperature rise | | |
|---|---|---|---|
| **Time point** | **Laser (n = 6)** | **Bipolar (n = 11)** | **Unipolar (n = 20)** |
| Mean and SD (°C) | | | |
| First contact | 0.023 (0.005) | 0.60 (0.60) | 8.87 (4.01) |
| First 4 contacts | 0.093 (0.005) | 1.52 (1.03) | 11.48 (5.56) |
| Percent with temp rise ≥ 10°C | | | |
| First contact | 0 | 0 | 45 |
| First 4 contacts | 0 | 0 | 60 |

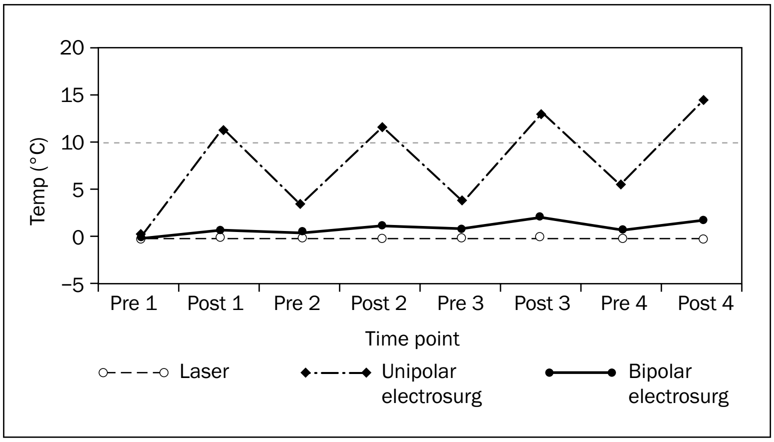


**Fig 2** Mean temperatures before (Pre) and after (Post) 4 contacts with the instruments tested.

The authors counted the number of cases in which a temperature change of 10°C or greater occurred, either in the first contact or cumulatively over the first 4 contacts. A change this large or larger was never observed with the laser or bipolar devices; however, it was observed in a large proportion of the unipolar cases (first contact = 45%; cumulative = 60%) (Table 1).

## DISCUSSION

Heat-induced injury to peri-implant bone is a recognized hazard. If the temperature exceeds physiologic levels, the bone could either necrose or survive as differentiated tissues; in either case this would result in loss of osseointegration.

The conventional (unipolar) electrosurgical unit produced an average temperature rise with each incidental contact of 8.87°C. Furthermore, the 10-second recovery time between contacts was not sufficient to allow the temperature increase to be completely dissipated, resulting in a higher ultimate temperature following each succeeding electrosurg contact. The net result was a rapid temperature increase greater than 10°C, and the implied potential for bone damage.

The bipolar electrosurgical unit design offers a unique possibility for clinicians. Recently, advancement in microcircuitry design has expanded its use to neurosurgical tissue incision, as well as incision of relatively less vascular tissues. The designers assert that reduced unit output requirements (10% of that used for unipolar current and voltage outputs), as well as confinement of tissue effects to the tissue immediately in contact with the 2-point handpiece, substantially reduce the potential for heat generation. Manufacturer assertions that this unit evidences a "lack of heat or current spread" must be qualified. In preliminary tests, it was found that the built-in safety feature that disables the unit when both surgical tips contact the metal implant performs well; however, when only 1 tip contacts the implant, while the other is in contact with adjacent bone (leaving a completed circuit), a considerable amount of heat can be generated. Under simulated clinical conditions, careful clinical technique appears to have reduced this problem to a manageable level, and in those circumstances, heat production was well below the theoretical temperature limit of 10°C (1.52°C). Secondly, Malis stated that the bipolar system works best with vascular tissues.[18] The avascular conditions encountered in harvested bovine rib may require increased output levels and unduly influence heat generation.

The laser temperature profile indicated a limited temperature increase. The average temperature increase for each application was 0.23°C, and although there appears to be little beneficial heat dissipation between energy applications, the total heat increase over 10 applications did not exceed 0.93°C. This would indicate an easily manageable clinical technique. While the use of a laser may be clearly indicated from a heat management standpoint, availability of a small, affordable laser unit for the average office is yet to be realized. For this reason, development of a reasonably priced dental laser unit may be fruitful. Further testing of lower-power, longer-exposure time profiles in lasers is indicated, since the useful potential of lasers extends to surface disinfection in the treatment of ailing and failing implants.[5]

## CONCLUSION

There is a significantly higher potential for heat damage to the implant/bone interface when a conventional unipolar electrosurgical unit is used, as opposed to either a laser unit or a bipolar unit. Marginally significantly more heat is generated by the bipolar electrosurgical unit compared to the laser unit. The laser produced no cumulative temperature gains greater than 1.0°C. The bipolar unit produced no cumulative temperature gains greater than 5.0°C, while the unipolar electrosurgical units regularly produced cumulative temperature gains exceeding 10°C. Further investigation is indicated into electrosurg units incorporating the bipolar design.

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