# Laser Osteotomies Are Here Now

## *A Case Study that Demonstrates Successful Osteotomy and Subsequent Implant Placement Without the Need for a Drill or Scalpel*

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### Abstract

Lasers are quickly becoming an exciting new technology in dentistry, although they have been around for decades. Though their applications were limited in the beginning, there are many all-tissue lasers that promise to do anesthesia-free cavity preps, as well as simple soft-tissue surgery with no bleeding or stitches required. My practice has transitioned to using a laser for most routine dental procedures including hard-tissue and osseous surgeries. This case study demonstrates a 9.3 micron $CO^2$ laser's ability to cut a 10-mm deep osteotomy with subsequent implant placement.


### Introduction

Dental technology is advancing at a breakneck pace. I'm completing my seventh year of clinical practice, and my workflows are radically different than when I started. When I graduated in 2013, I was woefully undertrained with regard to dental technology and how it improves clinical outcomes and, more importantly, patient experience.

CEREC® doctors perhaps better understand how rapidly the technological landscape is changing. In my short seven years of practice, I've cycled through the CEREC Bluecam, Omnicam, and now Primescan (Dentsply Sirona) — all of which were revolutionary technologies in their own right. Each year I think, "It can't get any better, can it?"

I've been treatment planning and placing implants following the CG2 workflow since the update came out in 2015 utilizing my Omnicam and ORTHOPHOS SL. Not much has changed in this regard over the last four to five years…until recently.

In a quest to push the limits of what is possible in my own hands and the profession at large, I challenged myself to take my implants to a different level. What if I said you can place an implant in an edentulous site (not extraction site) without prepping the osteotomy with a bur or drill? What if the osteotomy could be done with a laser instead? What would be the advantages and/or disadvantages?

I've been using the Solea All-Tissue Laser (Convergent Dental) for nearly three years and it has revolutionized how I approach simple procedures such as cavity preps, as well as larger surgeries like implant placement and tori removal. Lasers interact with the target tissue fundamentally differently than burs and scalpels. They are far less traumatic, and the inflammatory response is lessened.[1]

The Solea laser wavelength has been optimized for cutting the hardest tissue in the body — enamel — but is also efficient at ablating bone and gingiva. Aside from its unique wavelength (lasers are all about wavelength), the software controls how the laser beam pulses on the tissue through a process known as computer-optimized beam delivery. The current software allows for spot size to range from 0.25 mm to 1.25 mm in diameter because these sizes mimic our bur diameters used on teeth to remove caries.

There is an increasing body of research that supports using lasers to decontaminate implants,[2] treat periodontitis and snoring, perform crown removals, etc. Additionally, it has been shown that removing failed implants via lasers is preferable to trephining.[3] In my own practice, I've seen many advantages that my laser has over a bur. We have all seen what burs do to teeth when we are performing cuspal reduction for a crown procedure. The enamel splinters or fractures due to how aggressive the bur is. This does not occur with my $CO^2$ laser. The laser disinfects the tooth as it makes contact with the bacteria it is removing. I also find I am able to have extreme precision as it relates to caries removal because the settings can be governed by the computer and accidental pulp exposures no longer occur. Lasers are here to stay and their applications are seemingly limitless.

### Case Study

I would like to present this case in which an implant was placed at site tooth #19 without the need for a scalpel or drill to perform the osteotomy. The procedure was performed

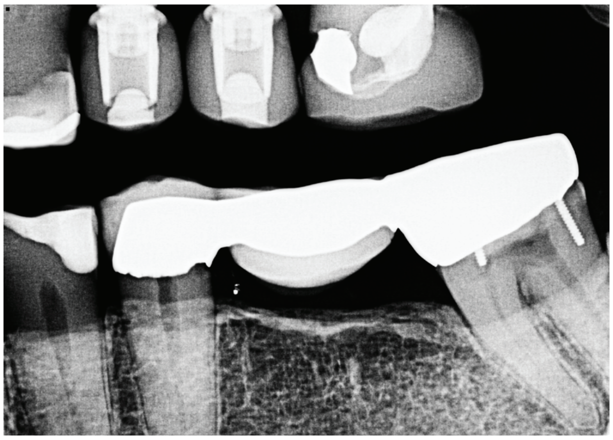

**Fig. 1:** Preoperative bitewing with caries on abutment teeth #18 and #20

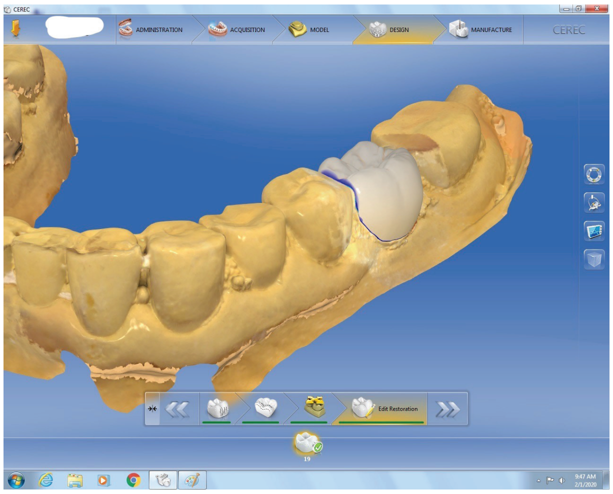


**Fig. 2:** Initial CEREC® scan following model surgery

using the Solea All-Tissue Laser, which demonstrates the ability to make both incisions and ablate bone.

This patient has been with me since I started clinical practice. There are two primary causes for the rampant root caries she has developed in her late 50s: 1) dry mouth; 2) gastric reflux. The patient has had an extensive history of restorative work and her posterior bridges have slowly developed decay on the posterior abutment teeth. The decision was made to extract those teeth and replace pontics with implant-supported crowns. The overall goal is to maintain a first molar occlusion and manage the caries process the best we can.

In early 2019, the patient was diagnosed with caries on teeth #18 and #20 (Fig. 1). The decision was made to extract #18, place an implant in site #19, and replace

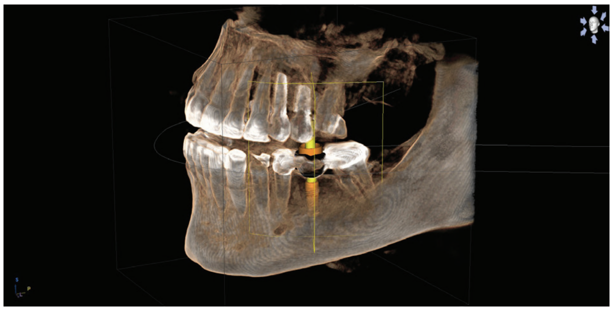

**Fig. 3:** Planning implant placement utilizing GALILEOS

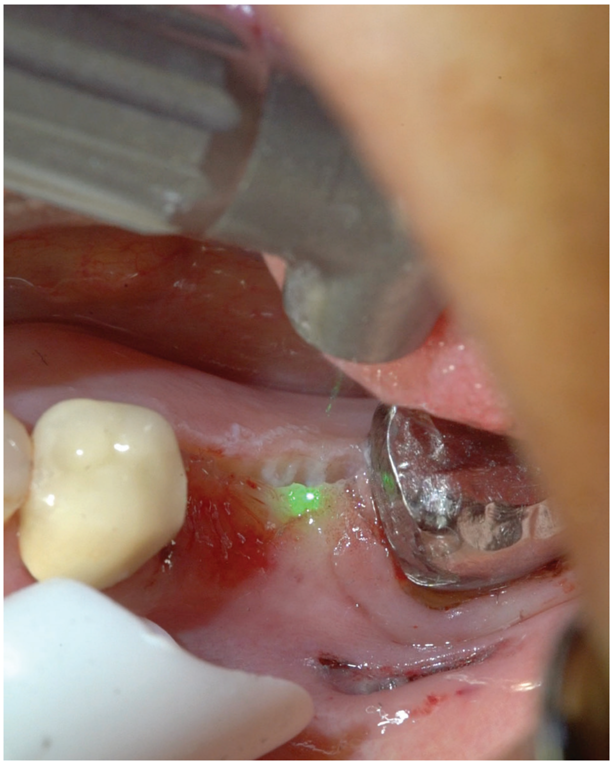

**Fig. 4:** Initial incision made by Solea All-Tissue Laser

crown #20. The patient had an existing stone model that we used to remove the pontic #19. A subsequent CEREC scan was done (Fig. 2) and a computed tomography image was taken to begin planning the implant. We decided to use tooth #18 as a posterior stop for the guide as this would dramatically improve the stability of the CG2.

The initial implant treatment plan utilized a Zimmer Trabecular Metal implant, size 4.1 mm x 11.5 mm (Fig. 3). I have been using these implants on patients with diabetes and patients with soft bone due to how rapidly the implants integrate.

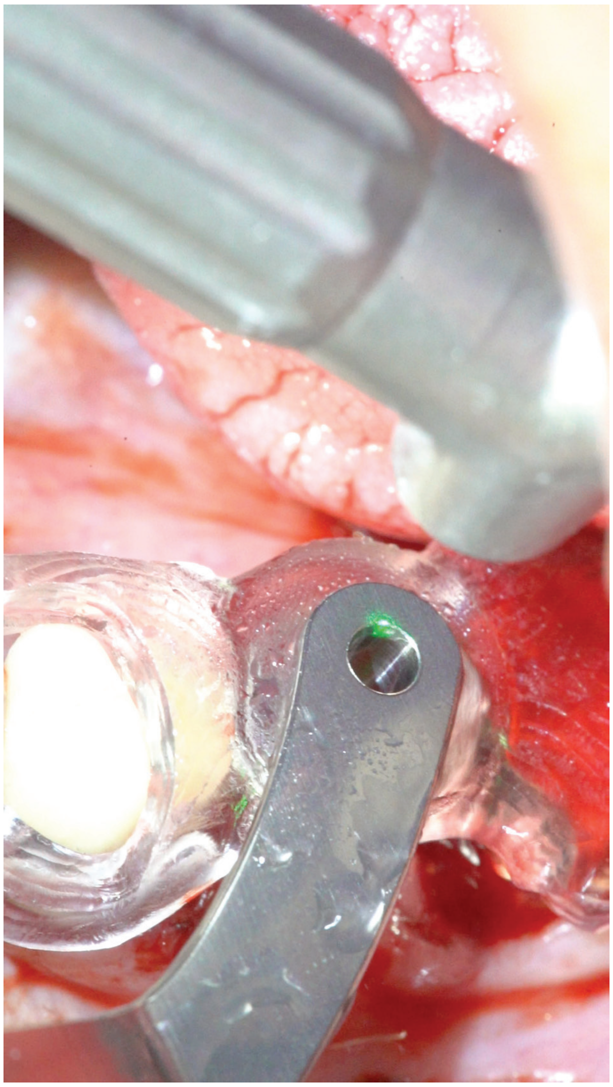

**Fig. 5:** Laser osteotomy initiated by directing laser through the CEREC® Guide 2

**Fig. 6:** Freehand ablation of bone to widen osteotomy apically

The goal of the surgery was to utilize the Solea All-Tissue Laser to perform the initial osteotomy (5–6 mm in depth), which is deeper than I routinely prep for implant surgeries. In the past 18 months, I've used Solea on all my implant surgeries to perform the soft-tissue punch and then decorticate the bone (1–2 mm in depth). This initial decortication is usually done through a 2-mm wide key placed in the guide and is limited to about 2 mm in depth before switching to my standard drilling protocol. I began by anesthetizing the patient via inferior alveolar nerve (IAN) and long buccal blocks. The failing bridge was then sectioned, being careful to maintain the integrity of the abutment crowns. A lingualized, crestal incision was made by the Solea laser between teeth #18 and #20, prior to elevating a full thickness flap (Fig. 4). The CEREC Guide 2 was then placed and a 2.3-mm key was inserted. The key is critical as it has a collimating effect on the beam and ensures that the angulation of the beam stays true. Additionally, the metal does not ablate directly, whereas a plastic guide would be destroyed if it came in contact with the laser. The laser was directed through the key (Fig. 5).

Every 30–60 seconds, the guide was removed and the osteotomy was assessed. The primary concern was not knowing the exact depth at which the laser had penetrated the bone. The keys were sequentially swapped until a size 3.8-mm key was placed. At a 6-mm depth, the guide was removed. The current software that controls the laser is designed so that the

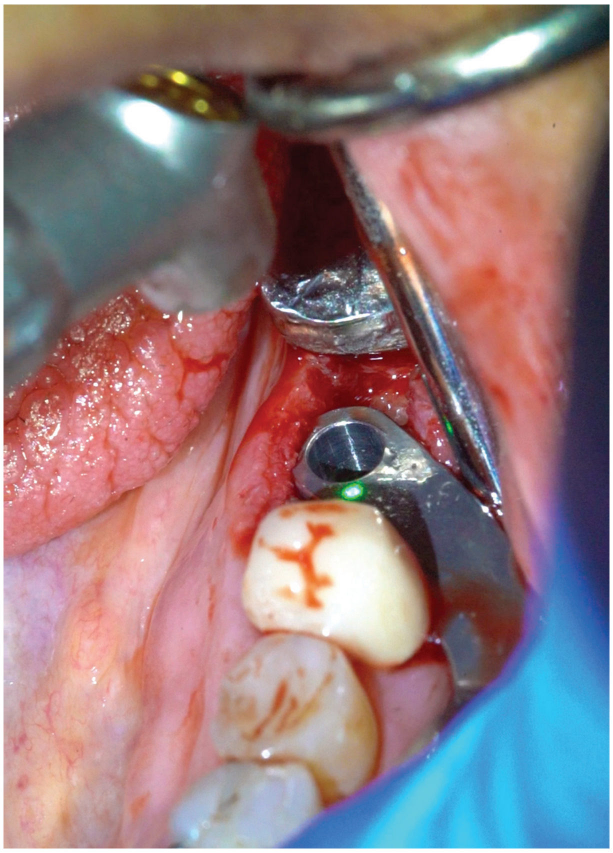

Fig. 7: Placement of key directly in osteotomy

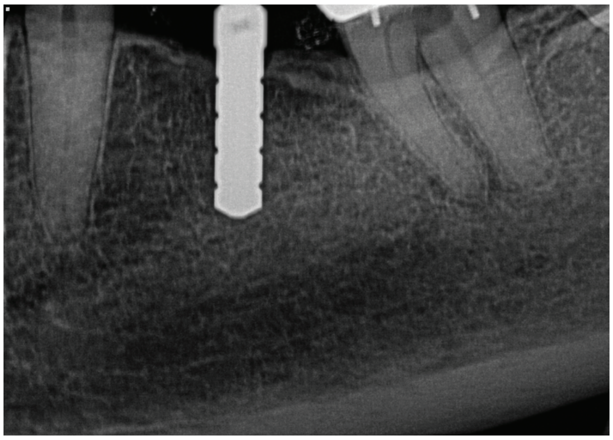

Fig. 8: Guide pin placed to demonstrate uniform width and 10-mm depth of osteotomy

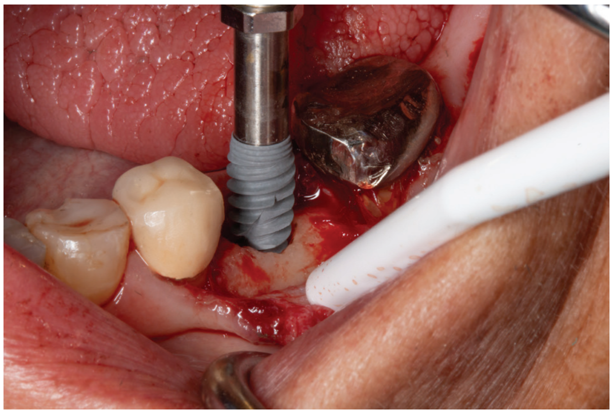

Fig. 9: Driving the Nobel Active implant into the osteotomy

handpiece should be changing angulations continually. In an osteotomy through a key, the angulation is straight down, perpendicular to the bone, and the angle does not change appreciably. This limitation leads to an osteotomy that tapers, resembling a V-shape due to the overlap of the individual laser beam within the selected spot size. The resulting osteotomy is wide at the top and narrow at the bottom. This challenge necessitated free-handing parts of the osteotomy by angling outwardly (Fig. 6). Once the osteotomy was roughly the same diameter at the crestal aspect as at the base of the 6-mm osteotomy, the key (Fig. 7) was inserted directly into the osteotomy in an attempt to demonstrate the uniform width of the osteotomy and depth that had been achieved. The osteotomy was then continued with the 3.8 key (total outer width is 5.2 mm) placed in the bone until a depth of 10 mm was achieved.

The osteotomy was completed in approximately 10 minutes, at which point the dimensions of the osteotomy measured roughly 3.8-mm wide and 10-mm deep (Fig. 8). At this point in the surgery, a decision was made to attempt to place an implant into this drill-less osteotomy prep.  The original plan was to place a Zimmer trabecular metal implant, but it is not self-tapping and is more of a press fit. We did not trust that our osteotomy was sufficiently prepped to accommodate this implant, so we decided to substitute a Nobel Active 5.0 x 10 mm (Nobel Biocare). We were confident that the 10-mm depth had been achieved. The Nobel Active implant is tapered, self-tapping, and could be driven into this osteotomy. The implant was torqued in at greater than 35 NcM (Fig. 9). A radiograph was taken to confirm the final implant position. A cover screw was placed and primary closure achieved with chromic gut sutures. Follow up was done at the 1-month mark.

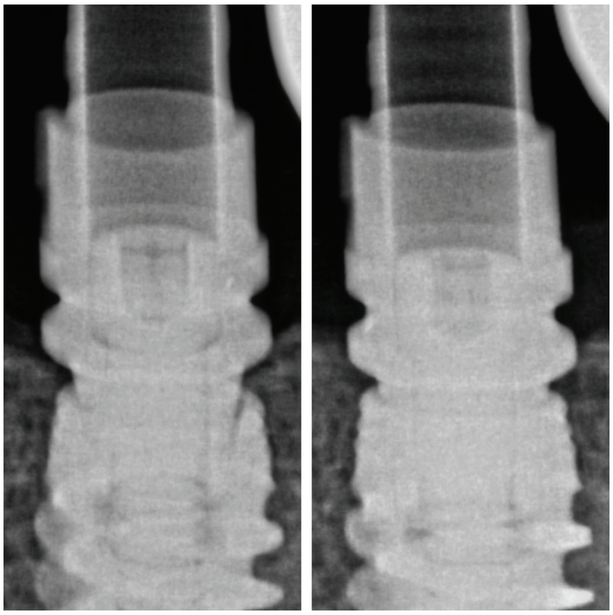

**Fig. 10:** Incomplete seating of ScanPost prior to bone profiling with the laser

**Fig. 11:** Two-month postoperative photo

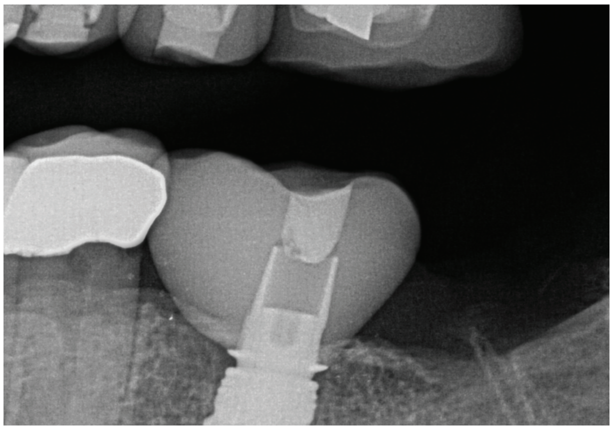

**Fig. 12:** Two-month postoperative bitewing

At 4 months healing, the implant was uncovered and the implant was checked for stability. We placed a Dentsply Sirona ScanPost and determined radiographically that it was not seated. We then profiled the bone with the Solea laser to allow for complete seating (Fig. 10). A custom healing abutment was placed and the patient was instructed to return in a few days for final crown placement. The abutment crown was fabricated utilizing the CEREC implant workflow and the screw-retained crown was placed. The patient was then instructed to return for a postoperative visit in two months (Figs. 11 and 12).

## Discussion and Practicality

Some might object to preparing an osteotomy using a laser ("just because you can doesn't mean you should") or that our current accepted implant protocol using a sequence of drills works well and does not merit change. Currently, at our practice, we use the Solea laser to complete most of our fillings, which has represented a huge paradigm shift in our practice of dentistry. If a hard-tissue laser can successfully replace the traditional handpiece and bur, is it not reasonable to consider that it also can replace the implant motor, handpiece, and drill? That was our thought process, at least. And since we already owned the Solea laser, the answer to "Is a laser osteotomy practical?" was an easy YES.

As hard-tissue lasers gain more market share in dentistry, we think they'll increasingly replace some of our older, more traditional instruments and techniques. That said, we are undoubtedly in the early days of hard-tissue lasers. Accordingly, the research and development as well as protocols and techniques for these lasers are advancing. With this development and user adoption, techniques like a laser osteotomy will become easier, more predictable, and ultimately much more practical — especially for the practitioner who already owns a hard-tissue laser that they use for many other procedures.

The burning questions surrounding laser osteotomies are: 1) Does the laser potentially create a better osteotomy? and 2) What are the concerns with using a laser to create an osteotomy?

## A Better Osteotomy?

With our case study, we don't have data to support a claim that a laser osteotomy is a better one. However, there are guidelines for what defines a good osteotomy. Does the laser pass the following osteotomy tests? A good osteotomy protocol should:

1. be precise and accurate in its intended location
2. be predictable and repeatable across cases
3. be relatively easy to perform by the practitioner
4. be relatively comfortable for the patient
5. have few limiting factors (such as anatomical or patient maximum opening)
6. promote proper implant integration and overall healing.

In the case presented here, requirement numbers 3–6 were adequately satisfied. Requirements 1 (precision and accuracy) and 2 (predictable and repeatable) cannot be fully concluded due to the novelty of the procedure. The precision and accuracy of the final implant placement was less than that which we experience when performing a fully guided implant surgery but about equal to that of a free-handed implant placement.

Considering this was, to our knowledge, the first time a full implant laser osteotomy with subsequent implant placement was attempted on a live patient, we were quite satisfied that the procedure passed the majority of tests for a good osteotomy. Furthermore, if the laser manufacturer and others help build out the laser osteotomy protocol, precision, accuracy, predictability, and repeatability would likely dramatically improve.

## Potential Advantages of Laser Osteotomies

In addition to the general benefits of lasers in dentistry already discussed, laser osteotomies aspire to solve other issues and provide other benefits to implant surgeons. They may include:

1. reducing the physical challenge of inserting long drills in posterior regions, especially for patients with limited opening
2. cost savings due to reduced "drilling" armamentarium
3. multipurpose use of laser to reduce the need for other equipment or instruments
4. laser light does not deviate or deflect when it comes in contact with a socket wall or sloped ridge.

## Potential Concerns of Laser Osteotomies

In our own experience and in limited discussions with other practitioners, most concerns regarding a laser osteotomy fall into one of the following categories:

1. overheating bone
2. general bone healing and implant integration
3. angulation control
4. depth control
5. loss of tactile sense.

Fortunately, a literature review revealed considerable prior investigation into the topic of laser osteotomies[4] and specifically some of the above concerns.

Overheating of bone: Eyrich et al.[5] demonstrated that a 9.6 um $CO^2$ laser (quite similar to the Solea laser) actually causes less temperature increase in porcine osteotomies than both conventional drill sequence osteotomies and Er:YAG laser osteotomies. In a rare human model laser osteotomy paper, Stubingner et al.[6] concluded there was no laser-related thermal damage to bone and that laser osteotomies are practical in oral surgeries. Numerous other studies[1] supported the claim that thermal damage during laser osteotomies was not a concern.

Bone healing and implant integration: In 1999, Montasser et al.[7] showed that osseointegration of titanium screws in rats could be achieved following Er:YAG laser osteotomy. That study was confirmed in a future study with rabbits. Other animal model studies[1] have demonstrated similar healing processes and osseointegration success when comparing laser osteotomies to traditional drill osteotomies. Some studies even demonstrated that compared to traditional osteotomies, laser osteotomies yielded better bone formation, as well as improved bone healing.[4]

Angulation and depth control: Admittedly, with our patient's laser osteotomy, angulation and depth control were perhaps the two most challenging variables of the procedure. Depth control was addressed by a start-stop technique of alternating using the laser and then measuring depth. Stubinger et al.[6] concluded that there is no depth control with laser osteotomies. Angulation control was managed by a combination of surgical guide initial use followed by a start-stop technique alternating using the laser and then checking angulation. Seymen et al.[8] did conclude, however, that angulation control could be accomplished using an SLA stent. We believe that future innovation could dramatically improve both angulation and depth control during laser osteotomies.

Loss of tactile sense: $CO^2$ lasers, like the Solea All-Tissue laser, are noncontact surgical instruments, and thus the very "natural" and often comforting tactile sense is lost. Talk to enough experienced implant surgeons and you'll hear them discuss their ability to feel their way through bone, claiming to be able to distinguish, for example, cortical plates from softer, cancellous bone. There's no easy answer to this concern for lasers. Tactile sense will likely be replaced by both a dependence on reliably accurate technology and for the skeptical, a start-stop technique to ensure the osteotomy is not perforating a cortical plate. With current fully guided implant surgeries a lot of tactile sense gets lost in the extra hardware, thus making the jump to a tactile-less laser osteotomy a little more manageable for some.

## Future Steps and Recommendations

Currently, the Solea laser's software maximizes speed of tooth ablation and comfort and has a maximum spot size of 1.25 mm. To address the reproducibility, angulation and V-shaped tapered osteotomy concerns, a software patch that allows for spot sizes of 2.0–5.0 mm (to mimic implant drills) would allow for the beam to be spread out more uniformly with less overlap and resulting in a more uniform width of the osteotomy. This would dramatically reduce the need to freehand. Additionally, a specialized handpiece or metal tip with varying diameters could be manufactured to coincide with the larger spot sizes to regain part of the tactile sense that is lost when using lasers. There is a periodontal tip that has this same effect. It has markings for measurements and allows the practitioner to sound the bone prior to firing the laser. The metal tip or attachment would correspond with the diameter of the keys or surgical guide, further improving the accuracy and reproducibility of laser osteotomies.

## Conclusion

While a seemingly novel approach, laser osteotomies date as far back as 1999 in the literature.[6] The case study we present here is, to our knowledge, the first known fully laser osteotomy on a live patient with subsequent implant placement. Successful implant integration and restoration of the implant provides a proof of concept that lasers are formidable surgical instruments when compared to traditional instruments and protocols. Additionally, substantial research over the past couple decades has provided good evidence that laser osteotomies do not cause thermal damage to bone or inhibit implant osseointegration. Angulation, depth control, and a loss of tactile sense are recognized hurdles for laser osteotomies. In our opinions, they represent solvable challenges, especially as laser technologies continue to evolve as they gain both market share and popularity as multipurpose, precise, and biologically friendly dental instruments.

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