Explantation of a fully or partially osseointegrated titanium implant is a complex procedure for myriad reasons and often results in major bone loss and pronounced defects of the hard and soft tissues. This may require more elaborate surgical interventions in cases of re-implantation. In this patient case, an osseointegrated titanium implant with some visible bone loss, missing attached mucosa at the buccal aspect, and a nonideal three-dimensional (3D) position had to be explanted. For this, the implant’s inner connection was heated using a CO\textsubscript{2} laser, which resulted in localized laser-induced thermo-necrosis at the bone-to-implant contact. One week following laser application, explantation could be performed easily with a torque slightly more than 35 Ncm. No complications occurred during the healing period. The result was a very easily performed explantation while preserving a maximum of the surrounding bony structure. Healing was uneventful, and no further visible bone loss could be observed during the healing time. 

**Keywords:** CO\textsubscript{2} laser, explantation, implant, induced osteonecrosis, removal
would instead be more practical to use a common CO\textsubscript{2} laser device, which is prevalent in both dental universities and private practices and is therefore available for widespread application. Several publications have analyzed the thermodynamic effect of lasers when exposing previously covered implants, or in implant surface decontamination.\textsuperscript{16–19} However, at present, there are no data available on laser-induced, controlled thermonecrosis of bone. Therefore, the aim of the present case report is to demonstrate a minimally invasive explantation method to remove a malpositioned titanium implant.

**CLINICAL REPORT**

A woman aged 66 years presented at the University of Geneva, Department of Prosthodontics and Biomaterials, for a prosthetic rehabilitation in the maxilla and the mandible. The patient’s chief complaint was to restore her masticatory function, as well as the improvement of the esthetic appearance. The patient had no preexisting medical conditions and is a nonsmoker.

A previous dentist had already placed two implants (Straumann Bone level RC implants 4.1 × 10 mm; Institut Straumann) in the maxilla at the positions of the right canine and the right second premolar. The implant at the right second premolar position had been placed at a prosthetically incorrect position, being too shallow as well as too far buccally for a prosthetic reconstruction. Additionally, the vestibular aspect of the implant showed no attached mucosa, and there was already greater than 1.5 mm of bone loss at the mesial and distal aspect on the radiograph. Due to the aforementioned risk factors, the decision was made to replace the implant at the right second premolar position before the prosthetic reconstruction (Figs 1a and 1b).

Having planned for a re-implantation at the right second premolar position at a later stage, it was imperative to preserve as much of the surrounding bone and soft tissue structures as possible. The current explantation technique (drilling) was therefore considered too invasive. After trying to unscrew the implant with the implant ratchet (Institut Straumann) and the corresponding explantation tool (explantation device for RC implants, Institut Straumann), it was decided to perform a novel technique, developed at the Division of Fixed Prosthodontics of the University of Geneva (Worni A et al. CO\textsubscript{2} laser induced temperature changes on the outer surface of titanium implants – an in vitro evaluation; ongoing study, 2018), assumed to have the potential for greatest bone preservation.

The internal part of the bone-level implant was therefore intraorally heated for a very short time with a CO\textsubscript{2} laser device (Lutronic Denta 2, Lutronic) (Fig 2a). As the heat can induce slight pain, a local anesthesia was applied. Using previously established results stemming from different in vitro investigations (Worni et al. CO\textsubscript{2} laser induced temperature changes on the outer surface of titanium implants – an in vitro evaluation; ongoing study, 2017), the appropriate laser settings were chosen. The laser application was done in four intervals of 40 seconds with a pause of 40 seconds between each interval. The power was set to 4 watts, increasing to 6 watts for the final interval. After the laser heating, some parts of the surrounding mucosa of the implant were scorched, indicating positive heat conduction through the implant (Fig 2b). A healing abutment was applied on the implant.

Two days after laser application, a control examination was performed, where the patient reported a slight pain directly after the intervention, but no other symptoms or complaints were noticed. Seven days after the laser application, the patient reported no pain,
but the tissues around the heated implant showed localized swelling, redness, and fibrine, but no signs of infection (Fig 3a). On the radiograph after 7 days, no signs of additional bone resorption could be observed (Fig 3b).

A Loxim transfer piece (Institut Straumann) was connected to the implant at the position of the second premolar. The transfer piece incorporates a predetermined breaking point of 80 Ncm. This breaking point was originally designed to limit the forces during the implant placement in order to prevent mechanical destruction of the bone at the implant site. It serves as a safety measure, as it has a predefined maximum force threshold at which the implant will either be loosened or the Loxim transfer piece will break. Employing the implant ratchet for force control, the implant could easily be unscrewed with a force of slightly more than 35 Ncm. A curettage of the wound was then performed to completely remove the remaining necrotized bone.

The fact that the presence of the silhouette of the implant threads could be felt during the curettage demonstrates the finesse of the procedure and that only limited bone resorption occurred. After thorough irrigation with saline solution, a coagulum was formed. As can be observed in Fig 4a, the wound after the explantation is minimal, both facilitating and accelerating the healing process. In addition, there was almost no bone adhering to the implant surface, which indicates that the localized laser-induced thermo-necrosis was effective in the dissolution of the osseointegrated bone (Fig 4b). As the surrounding bone structure remained intact, the significant advantages of this method were observed, especially in comparison to the standard explantation protocol.

After a healing period of 7 days, the explantation wound was completely covered with granulation tissue (Fig 5a). The patient reported no further pain, and no complications could be observed. The patient was
then followed for a period of 2 months, during which no complications occurred (Fig 5b).

**DISCUSSION**

The present case report shows a patient with a malpositioned osseointegrated titanium implant that was explanted using a new procedure that produces a laser-induced thermo-necrosis at the bone-to-implant-contact (BIC). The result was an easily performed explantation with a force of slightly more than 35 Ncm and an uneventful healing period.

In a preliminary in vitro study (Worni et al. CO₂ laser induced temperature changes on the outer surface of titanium implants – an in vitro evaluation; ongoing study, 2017), the heat distribution and conduction properties of titanium implants were measured. According to results from this preliminary work, if the internal part of an implant is hit with a CO₂ laser beam of a minimum 4 watts for 50 seconds, the outer surface of the implant (bone-implant connection) will heat up to approximately 70°C, not exceeding 85°C. According to the literature, human bone starts necrotizing at approximately 70°C. Therefore, the goal was to create a localized laser-induced thermo-necrosis of
the bone at the BIC to loosen the implant for easier explantation.

Explantation of fully osseointegrated titanium implants remains a difficult procedure and often results in significant bone loss, thus requiring further surgical measures to improve the sites in case of re-implantation. In the patient case presented, an unfavorably placed bone-level implant had to be removed. At a later stage, a re-implantation is planned, and therefore, a minimally invasive method was indicated. The implant’s inner connection was heated using a CO2 laser device and three intervals of 4 watts and one final interval of 6 watts. It is expected that this resulted in controlled localized thermo-necrosis of the bone at the BIC. After 1 week, the implant could be removed with relative ease using a transfer piece and a force of approximately 37 Ncm. This result is promising, as nearly the entire surrounding bone structure remained intact.

The goal of this new explantation method is to facilitate the removal of osseointegrated implants and to reduce the invasiveness of such an intervention, thereby simultaneously decreasing the complexity of future surgical procedures. Before any clinical recommendations can be made, the completion of ongoing research and preclinical studies are needed to define the operation protocol and the different laser settings for different types of implants (length, diameter, manufacturer, material, etc).

ACKNOWLEDGMENTS

The development of the new explantation method as well as the associated in vitro study is being supported by the SSO research fund (Grant number 291-16); Switzerland. The authors reported no conflicts of interest related to this study.

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