Cone Beam Tomography-Assisted Minimally Invasive Surgical Approach to Remove Fractured Dental Implants

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Abstract

Following the extraction of teeth, restoration is needed via treatment modalities that ensure functional and aesthetic continuity. With the introduction of dental implants, a wide range of treatment options were introduced to dental professionals for resolving the lost function and aesthetics of dentition. Scientific publications in the past decade have clearly shown long-term durability and survival of dental implants. In many early studies, titanium was the primary implant material; notably, titanium is a biocompatible material that comprises the optimal restoration material for tooth structure in dental implants. Many publications have reported a high success rate when using dental implants. Additionally, implant failure assessments have been performed; causes of late failures in dental implants include overloading or the material properties of implant fixtures, complications resulting from implant fracture, or loosening/fracture. With the increasing number of implants used in dental treatment, there is a need to explore treatments for implant-related complications, such as implant fracture. In this study, a new approach is proposed comprising guided surgery driven by cone beam computed tomography, which can be used to remove fractured implant parts with minimal damage to alveolar bone structure.

Keywords: dental implants, cone beam computed tomography, implant fracture, alveolar bone, implant failure

Introduction

As a result of periodontal diseases, caries, dental trauma, or developmental anomalies, patients can lose their teeth. To maintain functional and aesthetic continuity dental implants became an available treatment options. (1,2)

The long-term durability and survival of dental implants (3-6) the formation of titanium dioxide, following exposure of the titanium surface to air, enables direct integration between the implant and bone tissue (Oshida Y (2007) In: Oshida Y, Editor. Bioscience and bioengineering of titanium materials. Oxford, Elsevier; 159-214.). Based on extensive clinical research, endosteal implants have become the most well-characterized and broadly used type of implants, as they provide adequate occlusal force distribution, ease of surgical intervention, and improved functional and esthetic clinical results, relative to other types of implants. (7) Importantly, the notions of survival and success are often used in a confusing manner, although precise definitions are available (8; Albrektsson T, Isidor F (1994) Consensus report of session IV. In: Lang NP, Karring T, Editors. Proceedings of the 1st European Workshop on Periodontology. London: Quintessence Publishing Co., Ltd.; 365-369.). Survival is defined as the presence of implant and fixed prosthesis in the mouth, independent of biological and/or technical complications. Success is defined as freedom from complications throughout the observation period. (6, 9-12).

Importantly, analyses of implant failures for late failures of dental implants, due to overloading or the material properties of implant fixtures, comprise complications that result in implant fracture or loosening/fracture of the abutment screw. This can be explained by adverse occlusal forces resulting in mechanical complications of oral implant components (15).

Fracture of implant fixtures can occur such that a portion of the fixture remains in the jawbone. Therefore, there is a need to design minimally invasive approaches to remove these fractured portions of dental implants without causing extreme damage to the jawbone, thereby preserving as much bone as possible.

Material and Methods

The search for a method to remove fractured implant fixture pieces from alveolar bone was started with a case of a 45-year-old woman who was referred to our center inorder to an implant-supported porcelain fused to metal bridge. Seven months later, the patient noticed mobility of the bridge and informed the complication of fixed bridge because of overloading on dental implants, and the bridge was removed. Several years later, the patient visited our center with a request to receive maxillary dental implants, although the oral mucosa was intact and there was no sign of pathology. During panoramic oral radiographic analysis, we discovered that there were two implant fixture pieces remaining in the alveolar bone (Fig. 1).

Newton cone beam computed tomography images showed the exact location of the fractured pieces (Figs. 2-5). The anterior implant exhibited interference with the nasal cavity. Both fractured implant pieces showed no radiolucency between bone and implant. Moreover, 3D-reconstructed images (Fig. 6) suggested that by classical flap surgery, it would be difficult to precisely locate the fractured pieces in the bone because they were covered by bone (one was superficially located, while the other was deep within the bone) and no visual index was available for the surgeon.

We searched for a minimally invasive technique to remove these fractured pieces from the maxilla while preserving the maximal amount of bone tissue. Few studies have been published regarding the removal of fractured implant pieces, and these primarily analyzed the etiopathogenesis of failure, rather than the method to remove fractured osseointegrated pieces. Thus, we determined that an individual approach was required for this patient, following investigation via computerized digital scanning to localize the fractured pieces with 3D radiological analysis, in order to develop a surgical guide for removal of pieces.

A custom-made surgical guide for reaching the fractured pieces was fabricated for minimally invasive surgery (Fig. 7). The custom-made surgical guide was placed on the alveolar bone after careful elevation of the periosteal tissues. Direct osteotomies were performed through the hole of the surgical guide. The pieces were easily extracted with minimal bone tissue elevation. No bone regeneration material was applied. Soft tissues were sutured with 3.0 suture (Ethicon-Johnson & Johnson). Postoperative medications, including antibiotics, were prescribed. The healing period was uneventful and patient comfort was satisfactory.

Discussion

Parafunctional loads for dental implants significantly differ in posterior partially edentulous or single-tooth restorations, relative to full-arch prostheses. Support for full-arch restorations is based upon the use of multiple implants positioned on a curved line, which is dictated by the residual alveolar process. Theoretical studies indicate that bending moments increase stress levels in the implant components and supporting bone, relative to compressive or tensile forces. Excessive bending moments may lead to various types of failures, including implant fracture(20). Failures were associated with marginal bone loss, which may have been induced by overload before fracture occurred. Maxillary fracture of the implant fixtures of the patient in the present report is is higher than the mandibula (6). Conversely, results from Canada, based on 49 edentulous jaws treated (21). A study in Belgium revealed five fractures among 509 implants for partial prostheses because of exposed to abnormal non-axial loading. (22). Five-year data from a prospective multicenter study of partially edentulous patients (24) based on 521 loaded implants, revealed five fractured implants (1.0%). Many factors affect the clinical outcomes of dental implant long-term success. As an unexpected result of many clinical parameters and relevant implant material factors, implant fractures can occur.

Conclusions

Regarding the increasing number of implant treatments, there is a need to develop surgical strategies for removal of fractured implant pieces with minimally invasive surgical procedures. With technological advances in cone beam computed tomography and integrated surgical guide manufacturing modalities, the use of highly precise removal surgical guides can be more often performed in the near future. The minimally invasive approach will avoid deformation in residual alveolar bone, thus enabling new implant placement in the same alveolar bone region.

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FIGURES

Figure 1: Panoramic radiographic image showing two fractured implant pieces in left maxillary anterior region

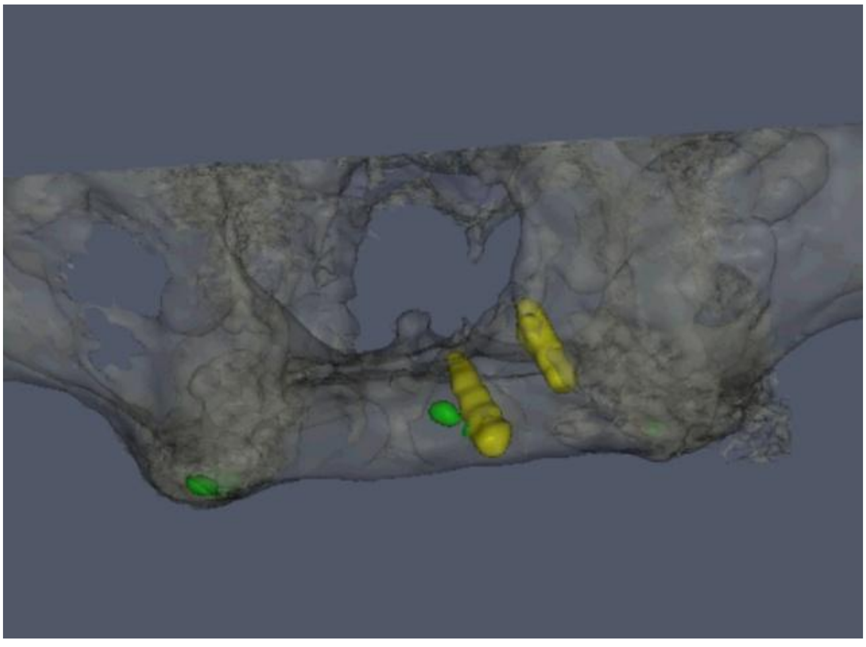

Figure 2: Radiographic analysis of three-dimensional images

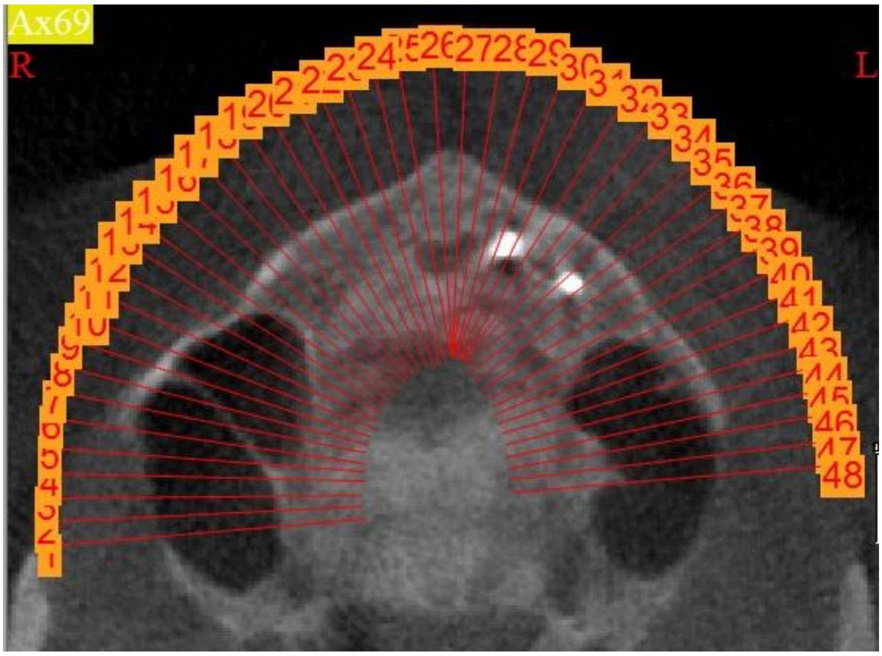

Figure 3: Maxillary cross-section, 1-mm slices

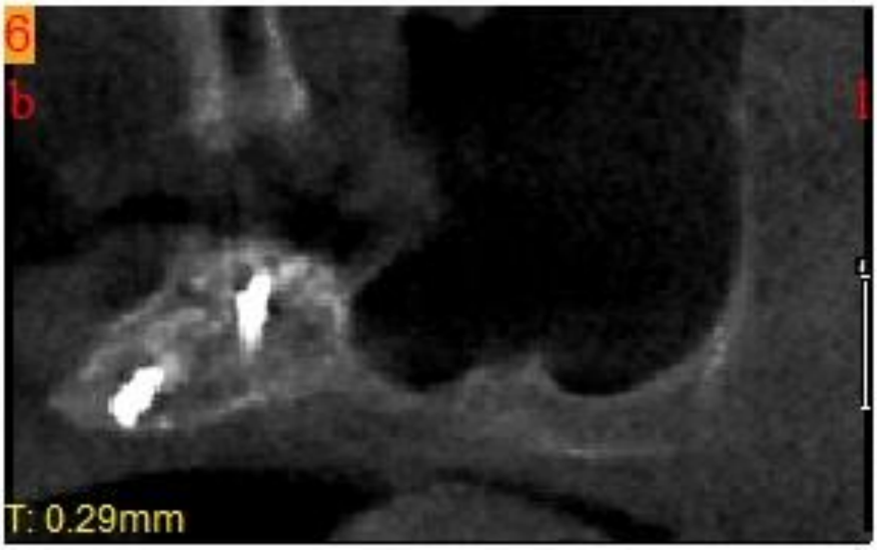

Figure 4: Cross-sectional slice showing fractured pieces

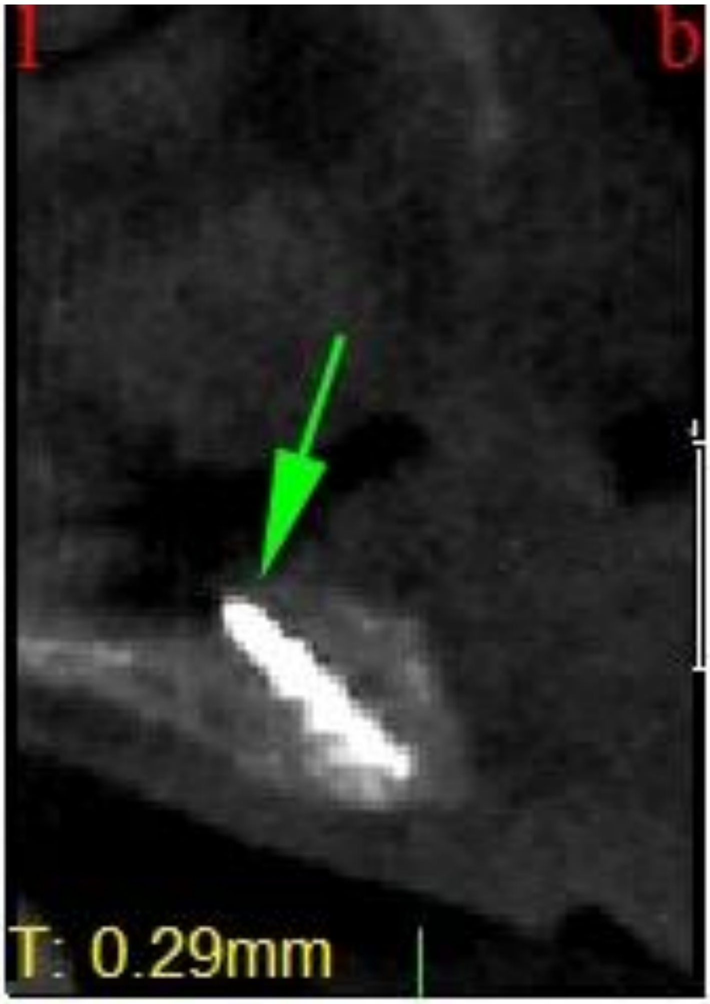

Figure 5: Cross-sectional slice showing fractured pieces

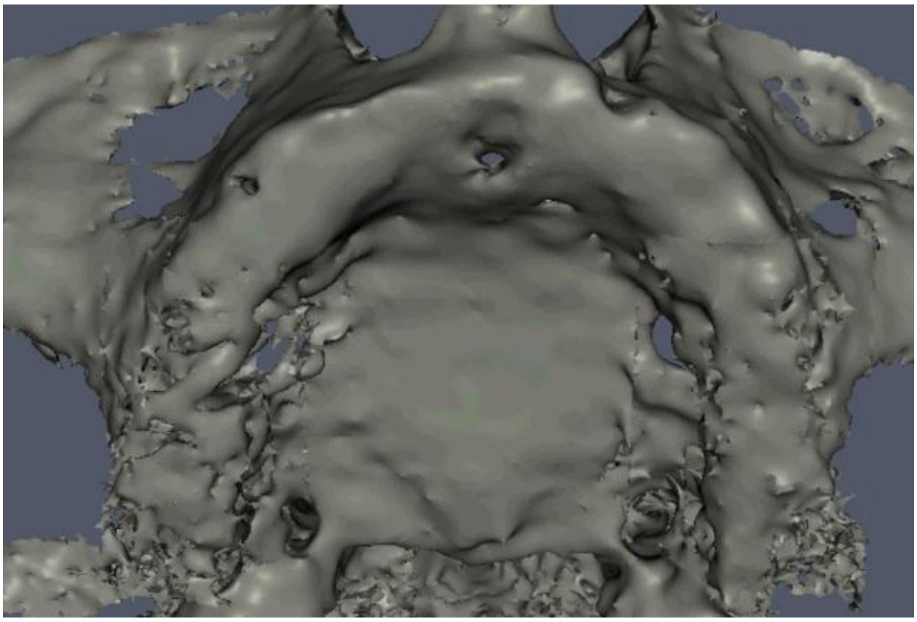

Figure 6: Three-dimensional view of reconstructed image of the maxilla

Figure 7: Custom-made surgical guide for the patient

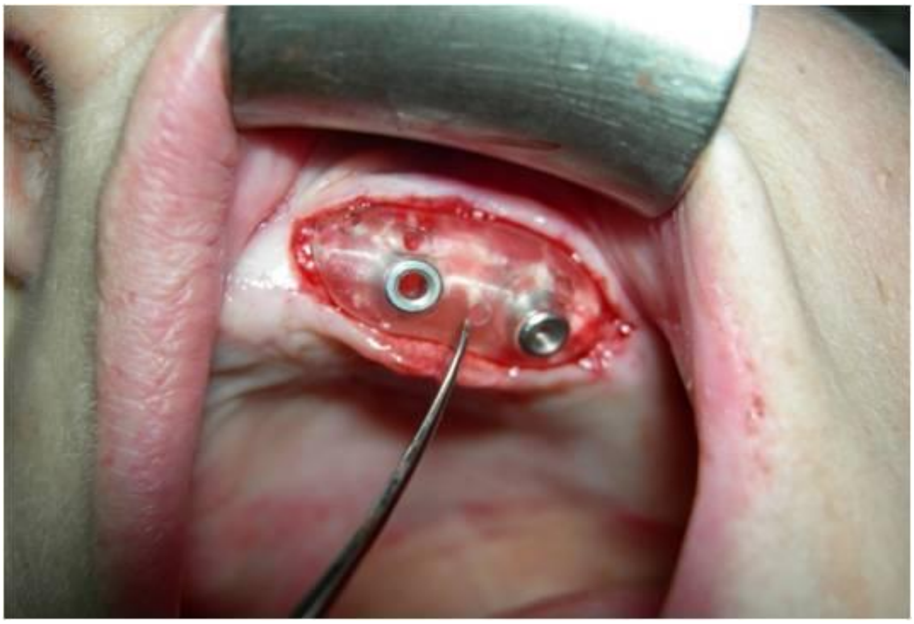

Figure 8: Positioning of the surgical guide in the maxilla after elevation of soft tissues with a small flap

Figure 9: Fractured implant pieces were removed

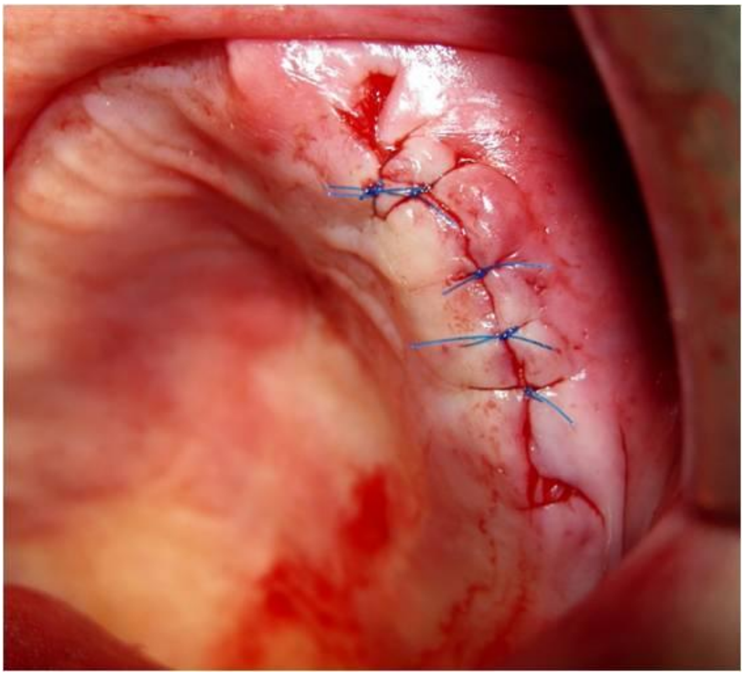

Figure 10: Soft tissues were sutured