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Research Article

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A Review of Flapless Implant Surgery

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Abstract

Dental implants, which are usually foreign matter to patients, are surgically inserted into or onto the jawbone. These alloplasts are used to support a single prosthetic tooth and serve as either abutments or cosmetic products for missing teeth. Several methods have been conducted to satisfy patients and surgeons. Flapless implant surgery, a more accepted procedure by patients and doctors nowadays, which uses the soft tissue punch device requiring a circumferential excision of keratinized tissue at the implant site may guarantee predictable and esthetic results. This review aims to analyze literature published in the field of implantology with flapless surgery, to compare traditional flap implant surgery and the latest flapless implant surgery, to illustrate the current scientific evidence and the new developments of this technique.is not strong enough and deformed. The second one is the most useful for needle knife instruments. More clinical study is recommended.

Introduction

Since the 1970s, modern implantology is based on the concept of surgery with flap elevation. The flap may be performed before or after atraumatic extraction of the hopeless tooth [1]. Direct bone anchorage of metallic implants was discovered by Brånemark in 1962. After some animal experiments, the first incision performed in the oral vestibule and mucosa was applied clinically for oral implants in 1965 [2, 3]. When the approach was updated, the incision line and suture remained separate from the location of the implant. This structural and functional union of the implant with living bone is greatly influenced by the surface properties of the implant [4]. Because of the chemical, physical, mechanical, and topographic characteristics of the surface of a dental implant, trying to prevent the infection of the surgical area and shorter healing times should be taken into consideration.

The traditional approach for implant placement is according to the flap. Original protocols called for burying implants from 4 to 6 months with mucosal flaps [3, 5]. The design of the flap was modified by De Sanctis & Zucchelli (2007) and required 2 stages [6]. Originally, the purpose of modifying is to eliminate infection and minimize micromotion. During the past 20 years, flap designs for implant placement have been undergoing continuous modification for better vascular network, functional and health-related aspects, increased stability, and visual appearance [7, 8]. Among these modifications, flapless implant surgery is fast gaining popularity. Based on the results of several experiments on animals and humans, flapless implant surgery is considered to be a stable technique expected to give good prognoses [9]. Contrary to the flap technique, this technique utilizes a tissue punch or a crystal incision with minimal elevation and perforates the alveolar mucosa and bone, requiring no reflection of a mucoperiosteal flap. Therefore, flapless surgery guarantees less invasive, maintain tissue vasculature, no vertical incisions and more comfort for patients, and decurtate perioperative period. Patients heal with minor, or no swelling [10-12]. If there is an abundance of bone, adequate keratinized tissue, and acceptable osseous contour, a flapless technique can be used [13].

The flapless technique is usually performed by minimum incision, perforation with the drill through the soft tissues, or soft tissue removal using a tissue punch or rotary burs without flap elevation, so the vascular supply and surrounding soft tissue can be well preserved [12, 14]. With the advance of flapless surgery, the traditional flap method is being challenged because it is being perceived as unnecessary. The results of a 1-year prospective clinical study of immediate loading of complete-arch fixed prostheses for edentulous maxillae after flapless guided implant placement shows that after one year of immediate loading, the implant survival rate was 98.6% [15]. And the result of a 3-year retrospective study using flapless surgery reported a cumulative survival rate of 91% [10].

Most recently, the concept of flapless implant surgery has been introduced for patients with sufficient keratinized gingival tissue and bone volume in the implant recipient site. In a flapless procedure, the implant is installed through the mucosal tissues without reflect-

ing a flap. Therefore, a thick and wide keratinized peri-implant mucosa is essential to prevent mucosal recession and maintain peri-implant condition. The accepted reasons to choose the flapless implant technique are to stabilize soft tissue, preserve hard tissue architecture and save efforts on handling tissue problems, thus live up to patients' expectation of esthetics and reduce morbidity and treatment time [16].

Flapless implant surgery can be accomplished by conventional implant placement without the use of a surgical guide (free-handed), guided surgery using conventional backward planning without three-dimension (3D) navigation, and guided surgery using 3D navigation techniques (3D implant planning software) [17]. This technique is said to have satisfactory clinical outcomes in the long term for its preservation of tissue and is suggested to patients for comfort and aesthetics [16, 18-22].

Our present work aims to produce a thorough review of the literature published in the field of implantology covering flapless surgery and illustrate the current scientific evidence for applying this technique, along with the new developments in this area.

Advantages of Flapless Implant Surgery

Studies have shown that flap elevation results in amounts of bone resorption around natural teeth and postsurgical tissue loss from flap reflection [23]. A 2-year followed-up study conducted in 2013 shows that comparing to flap implant surgery, flapless implant surgery results in less crestal bone loss both during the healing period and after loading [24]. Thus, indicates that elevating flap for implant placement may lead to less ideal outcomes, especially on the anterior maxilla. Flapless implant surgery has been shown to have several advantages, such as preservation for circulation, soft tissue architecture, and hard tissue volume at the site. Besides, it helps to shorten the perioperative period and increase comfort for the patients, allowing the patients to resume normal oral hygiene procedures as long as the surgery complete.

Many advantages make flapless implant surgery more attractive for the clinician and the patients.

1. Faster healing of perioperative period: flapless procedures can ensure better clinical results for a prevented reflection of soft tissue with shorter surgical time and rapid recovery for the patients. Contrary to conventional surgery in which the flap is likely to dehiscent, following flapless procedures, the surrounding mucosa has a smaller, cleaner, less open wounds. Cleaner wounds may improve peri-implant mucosal healing [25]. The absence of suture in the majority of cases contributes equally to the best postoperative appearance of the surgical area [26].
2. Well preserved circulation: after preparing the implant osteotomy, the implant is placed. The flapless technique uses rotary burs or a tissue punch to gain access to the bone without flap elevation, so the vascular supply and surrounding soft tissue are well preserved compared to which will be largely affected if conducted large flaps that require broad-based to avoid flap necrosis [10]. Moreover, the intact vasculature means the reduction of bleeding, providing a clean surgical field, and reducing the complications [27, 28]. As a minimally invasive surgical technique, the integrity of the interdental papilla and the alveolar blood supply of the surrounding osseous are well preserved [17]. In animal experiments and some studies, due to the intactness of mucoperiosteal flap, the implant site of flapless surgery has better oxygen and blood supply and postinsertion condition. These advantages result in a lower inflammation ratio [22, 29].
3. Shortened surgical time: since it does not need flap elevation and minimizes operations on surrounding tissues, the reflection of mucoperiosteum and suturing are not necessary after the surgical procedure. Hence shorten its duration in most cases.
4. Lower morbidity rates and increased comfort: Traditional techniques often require longer surgical-time and dedicated instruments, presenting more difficulties in the process and resulting in higher morbidity. Some studies even suggest that with flapless implant surgery, patients' postoperative discomfort such as swelling and pain is almost negligible. Thus, flapless implant technique is well accepted by patients with expectations [17, 30].
5. High survival rates: Del Fabbro M analyzed 50 articles involved in flap and flapless implant in 2013 [31]. They evaluate success rate, safety and bone changes, find a 97.86% of success after one year with flapless technique, not having statistically meaningful differences compared to flap technique.

Disadvantages of Flapless Implant Surgery

1. One of the drawbacks is limited visibility, which means surgeons are unable to visualize anatomic landmarks and vital structures. Therefore, the implant could not be positioned as well as in the flap approach and increase the risk of malposed angle or depth of placement, which resulted in more bone loss. While as the development of modern society, this seems not to be a problem before long. Computer-aided methods realize the 3D visualization of the implant recipient site including the neighboring anatomical structures [32].
2. Bone cell survival is susceptible to heat, so the potential for thermal damage secondary to reduced access for external irrigation during osteotomy preparation. The overheating of surrounding bone can cause local bone necrosis, followed by the interposition of fibrous tissue at the implant-bone interface [33]. Flapless implant surgery cannot completely avoid bone resorption even if it guarantees minor discomfort for most patients. If the vestibular bony wall is not thick enough, then bone resorption may occur [34].
3. Flapless implant surgery has a decreased ability to contour osseous topography when tissues are needed to facilitate restorative procedures and to optimize soft tissue contours.
4. More importantly, this surgery inescapable entails the removal of the tissue punch at the implant site and has a great chance of a significant reduction in the width of keratinized tissue around the implant [35]. It is unable to manipulate soft tissues to ensure circumferential adaption of adequate dimensions of keratinized gingival tissue around emerging implant structures [14]. The potential disadvantage to this technique is that it involves a masked approach that the mucogingival tissues are not raised, in which certain surgical risks and complications may occur, including unrecognized bony dehiscence/fenestration and the improper vertical

implant position [36]. This may lead to esthetical problems or implant losses.

As noted from the revision of scientific evidence, the flapless technique presents certain limitations as well which are analyzed below:

1. A blind surgical procedure;
2. Unexpected bone loss;
3. Difficulty of keratinized gum;
4. Unless guided, placement can be compromised
5. Limited access to bone grafting/resection

Different Loading Implants in Flapless Surgery

Immediate implant placement by flapless approach is a well-accepted surgical protocol and a routine for primary implantation in the esthetic zone due to less operative time, better prognosis, and especially lower costs compared to delay loading [19, 37-39]. However, some retrospective studies demonstrated an unsolved paradox in the outcomes of immediate loading implants. In terms of clinic parameters including implant survival, bone resorption, and keratinized gingiva, the outcomes appeared no remarkable differences between immediate and delayed procedures [40]. It's also found that one-stage flapless surgery with delayed implant placement received preferably aesthetic feedback in patients with initially partial missing facial bone walls [41]. On the contrary, immediate placement might elevate facial esthetic through the preservation of peri-implant soft tissue with initial recession range from 1 to 3 mm [42]. Furthermore, immediate loading didn't express osseointegration defects, providing evidence for the response of peri-implant bone to these conditions [43].

It's currently accepted that immediate loading restoration in extraction sockets is at least as reliable as delayed loading in the majority of patients [40]. Preoperative planning is critical to improve implant survival and achieve favorable outcomes in respect of precise implant positions. The conventional procedure is still recommended in certain situations as the gold standard [31]. Advanced computer software and tomography applied to immediate flapless surgery realize the high reliability clinically [44]. Concerning prognosis and costs, immediate flapless surgery inclines to be a more promising choice under the premise of strict case selection and surgical expertise [45, 46].

The Safety of Flapless Implant Placement

Compared with flapped surgery, it has been proved that flapless procedures to be more reliable and less common complications like flap dehiscence, bleeding, and persistent pain [47, 48]. However, various complications were reported in different cases, including surgical, postoperative, and prosthetic complications. Surgical complications mainly contained primary implant instability, misfit, and fracture of the surgical guide [49, 50]. Whereafter during the postoperative stage, early implant loss was frequently reported. Other common postoperative complications like mucositis, peri-implantitis accompanied by prolonged pain, were related to the immunity of patients [50]. The most frequent prosthetic complication was prosthesis fracture, when extensive occlusal adjustments, loss or loosening screw, misfit of abutments, midline deviation were also common [49, 50]. What's more, in some situations, serious or even life-threatening complications still occur. Luisa Limongelli et al. reported the first case of massive lingual and sublingual hematoma following post-extractive implant placement in the anterior mandible with flapless technique [51]. Similarly, at least 18 cases have been reported in which cases access to the bone by mucoperiosteal flap is described and mainly by post-extractive procedures [51].

When flapless surgery was applied, preventing such complications should be considered. To visualize mandible contour, define drilling parameters such as length and angulation and thus protect the sublingual soft tissues and vasculature, three-dimensional (3D) imaging by CT analyses is mandatory [52]. Overall, flapless surgery remains several complications and additional preventable measures should be taken.

Factors Influenced Implant Cumulative Survival Rates (CSRs)

Implant failure associated with low stability exists in both flapped and flapless methods hindering long-term implant survival [50]. The flapless approach presents a higher risk of implant failure than the open-flap technique, so it attaches importance for cumulative survival rates (CSRs) evaluation [53]. Several studies have been published to explore factors involved in CSRs including implant time period, gender, age, jaw, position, loading protocols, and smoking [54-58].

Lower CSR could be observed with a longer time period of implants and might be related to other factors [54-58]. Gender was considered no remarkable impact on implant survival rate. Controversially, both lower CSR in women and higher failure risk in men were also reported [59-61]. A parallel paradox arose in age and jaw. Most studies found no significant difference among ages but Jemt T deemed lower CSR in young patients than the elderly [54, 55, 57, 58]. Moreover, the survival rate comparison between mandible and maxilla showed no distinct difference against higher success rate in the maxilla [54-57]. The majority of the studies observed a greater failure rate in posterior regions than anterior regions of the mandible and maxilla [54]. In the upper jaw, less failure was observed for implants placed in canine and third molar position comparing with the first premolar which was the major implant site in the maxilla. Furthermore, implants in lower canine position appeared observable success rate, whereas the outcome in lower central incisor or second premolar was easier to suffer failure [57]. Similarly, to the jaw, it was not certain whether immediate loading of implants was better or not but immediate loading might prevent the interaction among adjacent tissues or bones from inflammations [54, 57, 58, 62]. Smoking is different from the above factors. Studies came to the consensus that smokers had remarkably lower CSRs [54, 57]. In addition to the above, experienced surgeons significantly reduced failure rates, suggesting specialists were needed in flapless surgery [54-57].

Though various factors were proved to affect the success rate, the individual situation should be taken into account. Considering the

above factors and circumstance into surgery procedure is beneficial for both surgeons and patients to improve implant survival and minimize patients' discomfort.

Flapless Implant Surgery in Maxilla

To reduce complications and elevate implant survival effectively, screening eligible clinical cases is a necessity. It's previously reported that flapless surgery has multiple limitations [14]. The lack of visibility of underlying anatomical structures is an obvious difficulty for surgeons. In addition, the inability to preserve keratinized gingiva with tissue perforation and potential thermal damage in the underlying bone also generates inconvenience. Hence, these defects cause difficulty to correct intraoperative errors and assess the drilling into the planned implant point. To avoid these drawbacks, flapless surgery is mainly used in the osseous contour in which cases adequate quantity and quality of bone and keratinized gingiva are acceptable [13, 63]. Concerning mandible and maxilla, the latter can satisfy these requirements.

N. Doan et al. reviews the relevant literature published between 1971 and 2011 on the outcome of flapless implants in the posterior maxilla, which demonstrates that the posterior maxilla can be regarded as a feasible and well predictable treatment area for implantation. Recent studies yielded positive outcomes of a flapless surgery in the anterior maxilla followed by immediate implants in the account of osseointegration level, quality of bone and soft tissue, along with aesthetic demanding [64-66]. Maxilla inclines to be the practical region used in flapless surgery. Yet further controlled clinical trials are needed, especially long-term studies.

Flapless Surgery Assisted By Piezosurgery

Recently, piezosurgery has been widely applied in implantology and orthodontics owing to its minimally invasive feature. Compared with classical methods, piezosurgery-associated flapless surgery has advantages of high success rates, reduced healing time, alleviated inflammation with piezoelectric bone cuts [67].

During implantation, to preserve the implantation site and to maximize patients' comfort are the main purposes using flapless surgery assisted by piezosurgery [68]. Flapless crestal sinus floor elevation with piezosurgery appears more effective with fewer complications such as trauma and early implant failures since sinus elevation by the crestal approach becomes a routine in the posterior edentulous maxilla [69]. In addition, corticotomy has been applied in a variety of forms over the past two decades [70]. The flapless corticotomy method with piezosurgery was proved to be effective for accelerating orthodontic tooth movement and retraction in dental crowding cases [71, 72]. Also noteworthy are cautions needed in the surgery process that the consecutive cold water and restrictive operation mistakes should be monitored to avoid potential thermal damage of tissues. Under preventive measures, flapless surgery with piezosurgery is clinically popular dealing with enhancing esthetics and comfort due to its superiority.

Digital Technologies Combined with Flapless Surgery

It is known that both accurate implant placement and full preoperative planning of the restoration are essential for satisfying the oral rehabilitation of patients with dental implants. In consequence, computer-guided surgery is now playing a more and more important role in implant dentistry. There are four common digital techniques assisted in flapless surgery: cone beam computed tomography (CBCT), intraoral scanners, CAD/CAM software, and s-CAIS.

The first step of digital implant surgery is preoperative CBCT. It provides cross-sectional imaging then makes a 3D reconstruction of the maxillofacial skeleton. A comparative low radiation dose CBCT possesses great accuracy and reliability in linear bone measurements as the gold standard with a 2mm safety margin needed [73]. Of special interest is that during preoperative preparation, CBCT is required for the buccal wall assessment to decide whether cases are ideal for immediate implant flapless surgery [74]. To make flapless treatment less challenging, CBCT should consider tooth angulation and the alveolar ridge as well [75]. Following 3D reconstruction by CBCT is the implant design. Intraoral scanners capture the scan body for precise positioning of implants. This scanning procedure has a positive impact on the digital impression accuracy of implant restorations in the edentulous jaw [76]. Based on analysis of obtaining digital data, computer-aided design (CAD) enables virtual implantation while relative parameters are aligned with STL files for computer-aided manufacturing (CAM) [77]. The individualized surgical template is then designed by CAD/CAM [78].

Subsequently, static computer-aided implant surgery (s-CAIS) not only achieves virtual implant process by its software but preforms flapless surgery under guidance of the template. Flapless s-CAIS is suggested to relieve postoperative pain in fully edentulous cases compared with flap methods [32], meanwhile a safety margin of 2mm from adjacent anatomical structures is supposed to be maintained in partially edentulous cases [79]. These techniques effect on different steps. CBCT is mainly used in preoperative evaluation and screening. Intraoral scanners are responsible for prosthesis design. CAD/CAM and s-CAIS are cores of intraoperative process which determine final outcomes. Taken together they become a powerful tool to meet patients' demanding.

Computer-guided flapless surgery via advanced digital methods is proved to be more accurate than the traditional protocol [80]. It also guarantees the best outcomes including safety, comfort, and aesthetics in various clinical situations, which should be widespread popularized.

Discussion

Currently, dental implant surgery is no longer just confined to satisfactory implant osseointegration and fewer complications, but also emphasizes aesthetical results [66, 81]. Here, we introduce different aspects of flapless surgery and provide a comprehensive overview refer to recent consensus and technical advancements.

Since flapless surgery was first presented, it was soon put into clinical use due to the advantages of less postoperative bleeding, shorter surgery and healing time, well preservation of tissues, etc. [10, 27, 82]. Considering implant time, early studies believed that implants under a load-free condition for some months could avoid a fibrous repair at the bone-implant interface produced by micromotion [83]. However, the immediate loading with a provisional restoration has evidenced a favorable esthetic outcome in treating single or multiple teeth rehabilitation patients even in facial bone defect cases [19]. With the development of assistive technology, flapless surgery has been recommended as a minimally invasive technique combined with an immediate implant.

Nevertheless, there are several limitations within. For instance, the lack of visibility largely interferes with the flapless procedure towards site preparation and drilling accuracy [84]. Although flapless surgery gains higher safety than the open-flap method, some complications or even life-threatening emergencies exist in different situations yet. Implant failure is regarded as a notable complication and flapless surgery is proved to be inferior to tradition [49, 50, 53].

We analyze several factors, showing some of them have non-negligible impacts on implant survival including implant time period, position, loading protocols, and smoking. One of our shortcomings is unable to consider individual hygiene and the degree of following medical instruments which shouldn't be ignored. Beyond that, we notice that few studies focus on deviations caused by digital workflows between the visual and actual implant position. Digital techniques involved in flapless surgery indeed bring better accuracy but they can't eliminate deviations [85]. During scanning and operation, micromotion from patients, digital technology itself, and other factors contribute to mild errors. Taking together, respective values from tomography and software associated with other errors add up to general deviations. Thus we suggest that more investigations are needed to reduce deviations from each stage of computer-guided flapless surgery separately.

Flapless surgery is not appropriate for all situations, requiring adequate bone and sufficient keratinized gingiva [13, 63]. Similarly, flapless superiority is not clear in the level of bone and soft tissue changes compared with flap protocol [36, 86], implying that flapless surgery is not preferred sometimes. To optimize the implant scheme, screening suitable clinical cases is primary by assessing related parameters obtained from CBCT, such as the buccal wall, tooth angulation, and alveolar ridge [74, 75]. Furthermore, dentition defects may lead to different degrees of bone absorption or soft tissue atrophy. We suppose that edentulous level should also be considered into precise treatment. As far as we can determine, maxillary cases are suitable for a flapless implant according to composite information of both anterior and posterior maxilla areas [64-66]. In the future, the flapless approach is supposed to be allaround for different oral regions so that further retrospective trials are needed to verify the outcome in the mandible.

Nowadays, flapless surgery is developing rapidly with the help of accessory techniques. The Piezosurgery-associated flapless protocol is used frequently because piezosurgery effectively improves implant success and favorable prognosis [67-72]. Moreover, computer-guided surgery based on digital techniques is gaining more attention on accuracy and simplicity in surgical procedures [87]. 3D imaging and software make virtual prosthesis placement a reality that appears preferably precise than freehand or flapped surgery in the planned implant position [88, 89]. Despite the assistance, the final implant position still leads to a shift towards a facial orientation by a small margin, thus clinicians should plan carefully to reduce deviations and prevent additional damage [89].

Although flapless surgery is still at the stage of continuous improvement, computer-guided flapless surgery combined with surgical techniques like piezosurgery has become a trend and more advanced methods may involve in. Therefore, long-term results about the combination of various techniques, resolutions towards deviations, and prevention of complications will be requisite. Besides, acceptance and willingness of our dentists towards new technology is another noticeable thing. At present, the flapless approach asks for knowledgeable and skillful surgeons compared to conventional methods. We look forward that mature flapless surgery will not merely be more suitable for inexperienced clinicians but further improve accuracy and safety to cater to patients' expectancy.

Conclusion

By reviewing the literature published mainly in the implantology field, we demonstrate the whole estimation of flapless surgery including advantages and disadvantages, implant time, complications and suitable cases, etc. The scientific evidence also shows that accessory flapless surgery is reliable refers to the latest advancements such as piezosurgery and digital technologies. Yet, surgical prevention against complications should be paid attention and implant failure caused by deviations needs further investigations.

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