Flapless dental implant surgery and use of cone beam computer tomography guided surgery

D. P. Laverty,*[1] J. Buglass[2] and A. Patel[3]

Key points

Provide an overview of flapless implant surgery and CBCT guided flapless implant surgery.	Describe the advantages, disadvantages, clinical indications, contraindications of using flapless implant surgery.	Provide the evidence on implant survival and complications associated with flapless implant surgery and CBCT guided implant surgery where possible.

Flapless implant surgery is increasing in popularity, particularly due to advances and increased usage of cone beam computed tomography (CBCT) and dental implant treatment planning software allowing three-dimensional assessment of the implant site. It is the aim of the article to provide an overview of flapless implant surgery and CBCT guided flapless implant surgery and summarise the literature with regard to the effectiveness of this surgical technique.

Introduction

The surgical placement of a dental implant fixture is constantly changing and in recent years, there has been some interest in developing techniques that minimise the invasive nature of the procedure, with flapless implant surgery being advocated. The original surgical protocol as proposed by Brånemark involved placing incisions in the oral vestibule and mucosa in an attempt to prevent infection by placing the incisions away from the implant fixture site. A mucoperiosteal flap was then raised to expose and visualise the underlying bone for implant placement, and then closed, burying the implant fixtures for a period of time to allow osseointegration to occur before restoration.[1] Since then a variety of incisions and flap designs have been described in the literature for surgical implant placement to optimise soft tissue aesthetics and improve tissue healing to create a healthy and aesthetic peri-implant soft tissue profile.[2–8] However, the raising of a mucoperiosteal flap has been associated with a degree of morbidity, discomfort and requires subsequent suturing. There is also evidence to demonstrate that bone resorption and subsequent soft tissue recession can occur as a result.[9–13] Flapless implant surgery has been suggested to alleviate these issues and involves placing an implant fixture without elevation of the epithelium, connective tissue or periosteum covering the alveolar bone. In recent years, flapless implant surgery has increased in popularity as a result of technological advances in radiographic imagery such as cone beam cross-sectional tomography (CBCT) and implant planning software. These advances have allowed the clinician to place and even restore the dental implants virtually before surgical placement, with an ability to produce surgical guides transferring these planned CBCTs into the surgical field. A flapless implant surgical technique can be used to place single or multiple implants, with immediate, early and delayed implant placement and varying loading protocols being reported within the literature.[14]

It is the aim of this article to provide an overview of flapless implant surgery and CBCT guided flapless implant surgery and report on the advantages and disadvantages, implant survival rates, patient satisfaction and complications associated with this surgical technique.

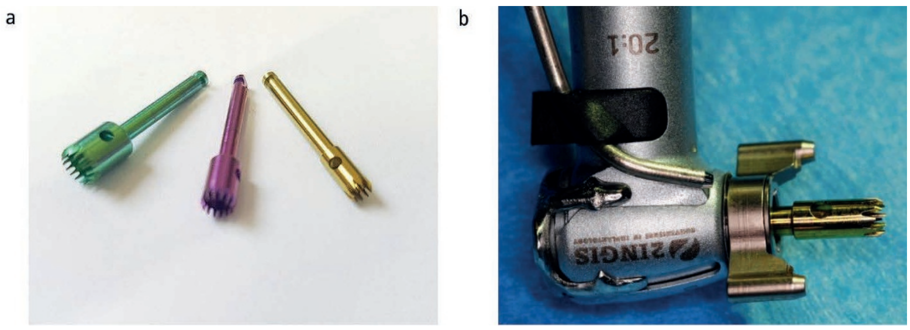

Fig. 1 Burs used to resect the tissue using a flapless technique and a bur in the surgical handpiece

[1]Academic Clinical Fellow & Speciality Registrar in Restorative Dentistry, Birmingham Dental Hospital, Pebble Mill Road, Birmingham, B5 7SA; [2]Dental Practitioner, Oracle Dental, 10 Long bow Close, Harlescott Lane, Shrewsbury, SY1 3GZ; [3]Specialist in Periodontology, Birmingham Dental Specialists, Birmingham
*Correspondence to: Dominic Laverty
Email: dominiclaverty560@hotmail.co.uk

Refereed Paper. Accepted 24 January 2018
DOI: 10.1038/sj.bdj.2018.268

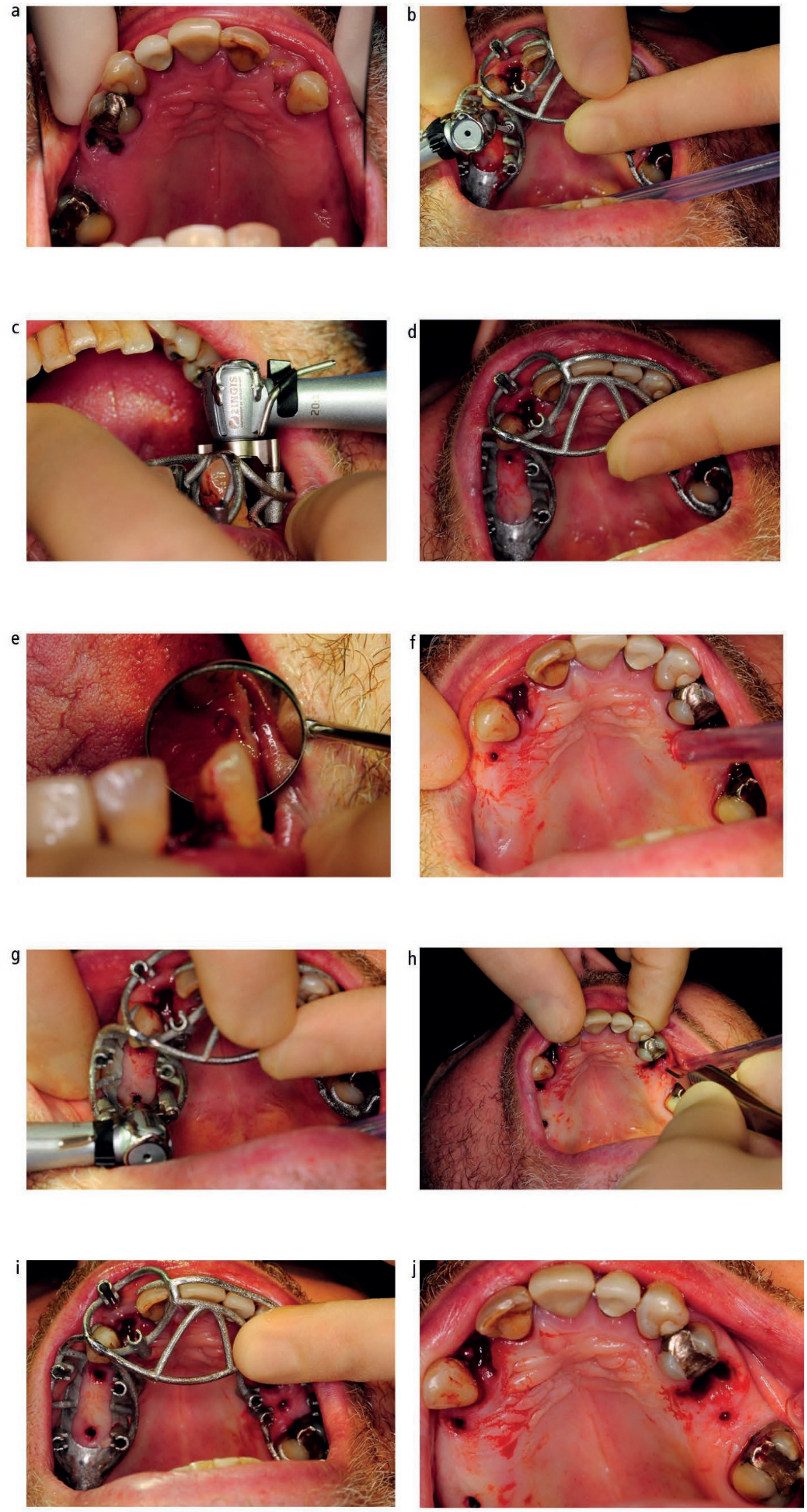

Fig. 2 **Soft tissue management with resection of the soft tissue as part of a flapless implant surgical technique using a mucosa and tooth supported surgical guide (ImplantPilot system) constructed from a planned CBCT with immediate placement at the 12, 25 sites and delayed placement in the 26, 14 and 16 sites**

Flapless surgical technique

Flapless implant surgery involves placing an implant fixture without elevation of the epithelium, connective tissue or periosteum overlying the alveolar bone. However, to place the implant fixture, surgical access to the underlying bone is required and a variety of soft tissue techniques have been utilised. These include, a soft tissue punch excision,[15–18] a small/mini incision or by direct preparation through the soft tissue when preparing the osteotomy site.[19,20]

The soft tissue punch technique excises a small specific diameter of overlying soft tissue which corresponds to the planned diameter of the implant fixture. It is resective in nature and (Figs 1 and 2) is commonly carried out using a soft tissue punch or bur. Another resective method is the direct soft tissue technique and involves removal of the soft tissue during the preparation of the implant bed using the surgical osteotomy drills. As these techniques are both resective in nature they do not allow primary closure and submergence of the implant fixture and as such can only be used when a single stage surgical technique is desired and appropriate. Their resective nature means that careful assessment of the quality and quantity of the keratinised tissue is required. A minimum of 1.5 mm of circumferential peri-implant keratinised tissue is needed around the implant after surgery to provide epithelial and connective tissue elements for soft tissue integration and the development of biological width[21] (Figs 3 and 4); it also provides tissues that are more stable and resistant to soft tissue recession which in turn helps facilitate good oral hygiene measures,[22–25] thereby minimising the risk of peri-implant disease.[26]

The mini-incision technique is non-resective and involves placing a small incision to access the underlying alveolar bone. This incision should be of an adequate size to accommodate the osteotomy drills and allow placement of the implant fixture. Due to this being a non-resective technique it can be used as either a single or two-stage surgical procedure as the soft tissue is still present to cover the surgical site and submerge the implant fixture during healing. It is particularly useful when there is limited peri-implant keratinised tissue which is preserved using this technique and can alleviate the need for further surgical intervention such as a connective tissue graft.

When considering surgical flap design for the surgical placement of dental implants, Sclar[27] proposed a set criteria which is shown in Box 1. However, Sclar's criteria cannot be fully met when a flapless implant surgical technique is used and it is therefore imperative that surgeons are aware of the limitations that a flapless surgical technique has in comparison to raising a mucoperiosteal flap which should be considered very early in the planning stages of treatment to ensure optimal and predictable treatment outcomes are achieved.

Box 1 Sclar's proposed surgical flap design for implant dentistry

- Preserve circulation and alveolar ridge topography
- Provide access for required implant instrumentation
- Allow identification of vital structures
- Provide access for modifying osseous contours and/or local bone harvest when indicated
- Provide for closure away from submerged fixture installation or augmentation sites
- Minimise post-surgical bacterial contamination
- Facilitate flap elevation, retraction, and wound closure
- Achieve circumferential adaptation of good-quality tissues around the emerging implant restoration

Advantages and disadvantages of a flapless surgical technique

A number of advantages and disadvantages of using a flapless surgical technique over raising a mucoperiosteal flap have been proposed in the literature and are summarised in Table 1. The majority of the advantages of using a flapless technique pertain to the minimally invasive nature of the surgical technique and the majority of the disadvantages are related to the lack of direct visualisation of the surgical site at the time of the surgery.

CBCT-guided flapless implant surgery

The planning and placement of dental implants and their subsequent prosthodontic restoration needs to be carefully considered and planned three-dimensionally. With decreasing cost and increased access of CBCT imagery to dental practitioners this type of imagery is being readily used in implant dentistry. CBCT imagery allows a 3D volumetric image of potential implant sites to be visualised and allows a more accurate assessment of the bone quantity, quality and topography as well as the proximity to adjacent structures in comparison to conventional radiographs.[39] Interactive CBCT implant planning software can be used to virtually plan the placement of implant fixtures to optimise their position and avoid adverse trauma to adjacent structures (Fig. 5). These planned CBCTs can then be transferred to the patient via surgical guides which are produced by a variety of automated manufacturing processes (CAD/CAM) (Figs 6 and 7). These surgical guides are manufactured in such a way that the location, trajectory, and depth of the planned implant fixture can be transferred from the planned CBCT to the surgical guides with a high degree of precision,[40] and enables accurate and consistent positioning and orientation of the implants (Figs 8–13). These guides can be used in the preparation of the implant bed (Figs 6, 14 and 16) and/or the placement of the implant fixtures (Figs 15 and 16).[41–43] Use of computer-assisted surgery is advocated as being more predictable, precise and safer in flapless dental implantology,[41,44] and has been the driving force behind the increasing use of this surgical technique.[45] Despite this, however; these systems are not 100% accurate and errors in the positioning and angulation of the implant fixtures can occur.[49,50] Tahmaseb *et al.*,[49] (as part of the Fifth International Team of Implantology Consensus conference) reviewed the literature assessing the accuracy and clinical performance of static computer-assisted implant surgical guides and carried out a meta-analysis of a number of *in-vitro* and *in-vivo* studies. This meta-analysis revealed a total mean error in the position of the implant fixture of 1.12 mm at the entry point (with a maximum of 4.5 mm) and 1.39 mm at the apex (with a maximum of 7.1 mm). This working group also reported that of the 38 studies included, ten studies reported changes in the surgical plan at the time of surgery, with an overall implant incidence of 2.0%.[49] These issues have also been reported by Van Assche *et al.*,[50] who as part of a working group for the European Association of Osseointegration (EAO) carried out a review and a meta-analysis on the accuracy

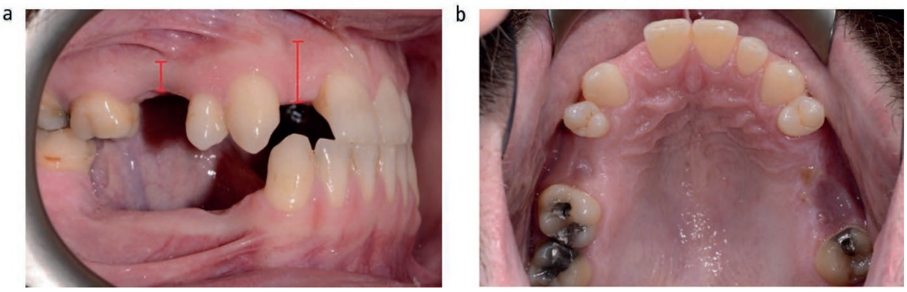

Fig. 3 Assessment of keratinised tissue (marked in red) – in this case there is ample keratinised tissue available

Fig. 4 Assessment of keratinised tissue (marked in red) – in this case there is a lack of keratinised tissue available. Measurements with a graduated periodontal probe are being taken to measure the amount of available keratinised tissue before implant placement and simultaneous connective tissue grafting

Table 1 Proposed advantages and disadvantages of using a flapless surgical implant technique over conventional mucoperiosteal flap

Advantages[14,28–35]	Disadvantages[9,29,36–38]
Preservation of hard tissues	Inability to save keratinised mucosa – when a resective soft tissue surgical flap technique is used.
Maintenance of the vascular supply	Increased planning with a flapless technique – which often entails the use of CBCT radiographic imagery (to identify any potential complications/risks that could have been visualised/assessed clinically by raising a mucoperiosteal flap).
Decreased surgical procedure time and the potential need for suturing.	Inability to visualise the drilling depth – due to difficulties in visualising depth indicators on the drills at the bone crest particularly if surgical guides are used.
Reduced clinical work load.	Inability to visualise the vertical endpoint of the implant fixture placement.
Reduction of postoperative complications such as pain, swelling, infection, or dehiscence.	Inability to visualise the location of the implant – as there is no direct visualisation of the bone.
Reduction of intraoperative bleeding.	Inability to visualise the true topography of the underlying bone – increasing the risk of complications such as unwanted bone perforations.
Potential for reduced peri-implant tissue loss and thus the need for soft and hard tissue management (for example, grafting)	Decreased access to bony contours that may require an alveoloplasty
	Difficulties in performing an internal sinus lift with a stabilised template (screw fixated)
	Inability to correct peri-implant defects – as these areas are not exposed during surgery.
	Potential for thermal damage secondary to reduced access for external irrigation during osteotomy preparation.
	Reduced ability to manipulate the soft tissue – particularly in aesthetic areas where raising a mucoperiosteal flap may be advantageous.
	Medico-legal issues – the ability to justify using a flapless technique if complications or sub-optimal/failure of treatment were to occur particularly if a conventional surgical flap technique would have alleviated such issues.

Box 2 Proposed factors that can lead to errors and inaccuracies in the production of CBCT surgical implant guides[13,40,49–56]

CBCT scan quality.[51]

File conversion and reformatting of the CBCT scan.[51]

The CBCT implant planning software used.[51]

The type of production methods used for the surgical guide – with CAM manufactured CBCT surgical guides having been shown to be more accurate than lab constructed guides (non-CAM).[49]

The material used to construct the surgical guides – as there are reports of surgical guide fracturing during surgical use.[54]

The ability to position the surgical guide accurately at the time of surgery.[40]

The type of support of the surgical guide has (tooth, bone or mucosa/soft tissue born) with tooth-supported guides being shown to have more accurate implant positioning in comparison to bone-supported guides.[13,52,53]

The ability of the surgical guide to remain stable during use with increasing use of fixation screws having been shown to reduce implant deviations (Fig. 17).[50]

The surgeon's experience of using such guides.[51,55,56]

Ability to access to the surgical site/position of the edentulous area have also been reported as sources of inaccuracies leading to implant deviations.[51,55,56]

a b

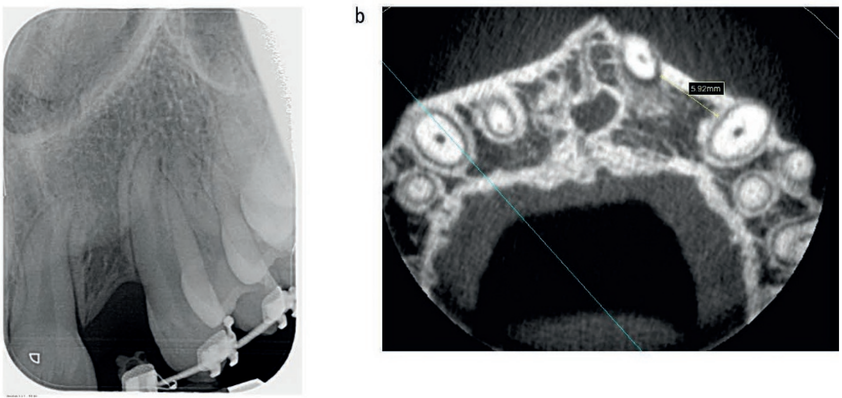

Fig. 5 Radiograph and CBCT – revealing a lack of mesio-distal space to accommodate an implant fixture

of computer-aided implant placement. The meta-analysis revealed a positioning mean error of 0.99 mm at the entry point (ranging from 0 to 6.5 mm) and 1.24 mm at the apex (ranging from 0 to 6.9 mm) at the apex with a mean angular deviation of 3.81° (ranging from 0 to 24.9°).[50] The causes of such errors leading to inaccurate implant positioning when using a CBCT surgical implant guide can occur at any stage of treatment and include: the planning and diagnostic work up of the patient; the design and production of the surgical guide; and/or the surgical processes involved in the placement of the implant fixture. Greater deviations and inaccuracies in the positioning of the implant fixture are generally seen when the degree of the error is large or when multiple errors have occurred potentiating to a greater overall error.[49] A number of causes leading to such errors have been proposed and are summarised in Box 2.[13,40,49–56] Clinicians therefore need to be aware of the potential sources of error that can lead to inaccuracies and deviations in the placement of the implant fixtures when using a CBCT surgical guide and where possible minimise or reduce these potential errors. Clinicians should also consider the potential for inaccuracies and deviations in implant positioning during the planning and surgical stages of treatment[46–50] as a failure to give due consideration to these potential issues can lead to a variety of surgical and prosthodontic complications including damage to vital structures.[55,57,58]

Implant survival

High implant survival rates have been reported for flapless implant surgery with implant survival rates of over 90% reported in a number of studies[9,29,31,37,59–67] review and systematic review articles[29,36,68,69] (see Tables 2 and 3). Two separate systematic reviews by Lin *et al.*,[69] and Chracnovic *et al.*,[36] reported on implant survival rates comparing conventional and flapless implant surgery. Both reported higher implant failure rates when using a flapless surgical technique with Lin *et al.*,[69] reporting implant survival rates of; 97.0% for flapless implant surgery and 98.6% for conventional open flap surgery; however, this was not found to be statistically significant. Chracnovic *et al.*,[36] reported a higher implant failure when using

Table 2 Reported implant survival using a flapless technique: studies

Author and year of publication	Type of study	Patient no. (where applicable)	Implant no. (where applicable)	Follow up	Survival (%)/reported failure
Campelo *et al.* (2002)[9]	Retrospective	359	770	Up to 10 Years	91%(Cumulative survival at 10 years)
Van Steenberhe *et al.* (2005)[62]	Prospective	24	164	12 months	100%
Cannizzaro *et al.* (2007)[63]	Prospective	35	202	12 months	2 Implant failures
Sanna *et al.* (2007)[64]	Retrospective	30	183	Mean average: 2.2 years	91.5% (Cumulative survival at 5 years)
Wittwer *et al.* (2007)[65]	Prospective	22	88	24 months	97.7% (Cumulative survival at 2 years)
Sennerby *et al.* (2008)[59]	Retrospective	N/A	N/A	1-18months	Flapless higher failure rate 7.9% and 0% into flap
Malo *et al.* (2008)[60]	Prospective	20	32	Between 6-12months	98.6% (Cumulative survival at 1 year)
Becker *et al*. (2009)[66]	Retrospective	57	79	Mean average: 3 years 8 months	98.7% (Cumulative survival at 3-4 years
Rosseau *et al.* (2010)[67]	Retrospective	121	174	Up to 2 years	98.3%
Berdougo *et al.* (2010)[61]	Retrospective	99	271	Between 1-4 years	96.3% (Cumulative survival)
Sunitha *et al.* (2013)[37]	Retrospective	20	20	Up to 2 years	100%

Table 3 Reported implant survival using a flapless technique: review articles

Author and year of publication	Type of study	Title	Results	Conclusion
Brodala (2009)[29]	Review article	Flapless Surgery and Its Effect on Dental Implant Outcomes	Overall implant survival for collective: Prospective cohort studies -98.6%. Retrospective studies or case series – 95.9%.	Flapless surgery appears to be a plausible treatment modality for implant placement, demonstrating both efficacy and clinical effectiveness. However, these data are derived from short-term studies with a mean interval of 19 months. A successful outcome with this technique is dependent on advanced imaging, clinical training, and surgical judgement
Chrcanovic *et al.* (2014)[36]	Review article	Flapless versus Conventional Flapped Dental Implant Surgery: A Meta-Analysis	The test for overall effect showed that the difference between the procedures (flapless vs. open flap surgery) significantly affected (P = 0.03) the implant failure rates with high implant failure when flapless implant surgery was used, with a RR of 1.75 (95% CI 1.07–2.86).	There was a statistical difference between flap vs flapless procedure on implant survival with flapless implant surgery having a higher implant failure rate. However, the results must be interpreted carefully, as a sensitivity analysis revealed differences when the groups of studies of high and low risk of bias were pooled separately.
Lin *et al.* (2014)[69]	Systematic review	The Effect of Flapless Surgery on Implant Survival and Marginal Bone Level: A Systematic Review and Meta-Analysis	Average implant survival rate: - 97.0% (range: 90%-100%) for flapless procedures - 98.6% (range: 91.67%-100%) for flap procedures.	This systematic review revealed that the survival rates and radiographic marginal bone loss of flapless implant surgery was comparable with conventional (flap) surgery approach.
Moraschini *et al.* (2015)[68]	Systematic review	Implant survival rates, marginal bone level changes, and complications in full-mouth rehabilitation with flapless computer-guided surgery: a systematic review and meta-analysis	Overall survival rate of 97.2% and a mean marginal bone loss of 1.45 mm were found during 1–4 years of follow up. However, associated complications were common.	A high implant survival rate and minimal marginal bone loss was found. However, associated complications such as implant loss, low primary stability and fracture of the prosthesis and the surgical guides were often found. There was also a reported learning curve by the clinician to attain treatment success when using a flapless surgical approach.

Official journal of the British Dental Association.

a flapless surgical technique in comparison to open flap surgery which was found to be statistically significant (P = 0.03). They also reported a risk ratio of 1.75 which implies that implants inserted using a flapless technique are 1.75 times likely to fail in comparison to those implants placed when using an open flap technique.[36]

Marginal bone loss

It has been suggested that marginal bone loss can be minimised around the implant fixture during the initial stages of healing by using a flapless implant surgical technique with this being attributed to a reduction in the disturbance of the blood supply at the surgical site. The vascularisation of bone at an edentate site is provided by blood vessels of the periosteum and the alveolar bone. A flapless technique reduces the disturbance to the periosteal blood supply (as a mucoperiosteal flap is not raised) and thus minimises bone resorption during the initial stages of healing[9] with this being shown in both animal and human studies.[70–73] When reviewing studies assessing marginal bone loss around implant fixtures placed using a flapless implant technique, the results are variable. Studies by Kan *et al.*,[75], Becker *et al.*,[20,31], Cosyn *et al.*,[76], Sennerby *et al.*,[59] and a systematic review by Moraschini *et al.*,[68] all reported favourable minimal crestal bone loss when a flapless technique was used. Cosyn *et al.*,[76] also concluded that there was enhanced papilla soft tissue regrowth which resulted in an improved aesthetic outcome in single implant placement when using a flapless technique.[76] However, a comparative randomised control trial by Pisoni *et al.*,[74] comparing conventional flap to flapless implant surgery reported no influence on bone resorption when comparing the two surgical techniques.[74] Furthermore, a systematic review by Chrcanovic *et al.*,[36] reported that five studies[60,77–80] (included in their systematic review) reported increased marginal bone loss around the implant fixture when a flapless technique was used. The proposed explanation for this was that that the implant fixture could have been placed more apical than the desired position due to reduced visibility at the time of surgery,[77,80] with the transmucosal portion of the implant being slightly below the crestal bone causing rearrangement/resorption of the peri-implant bone around the neck of the implant.[80]

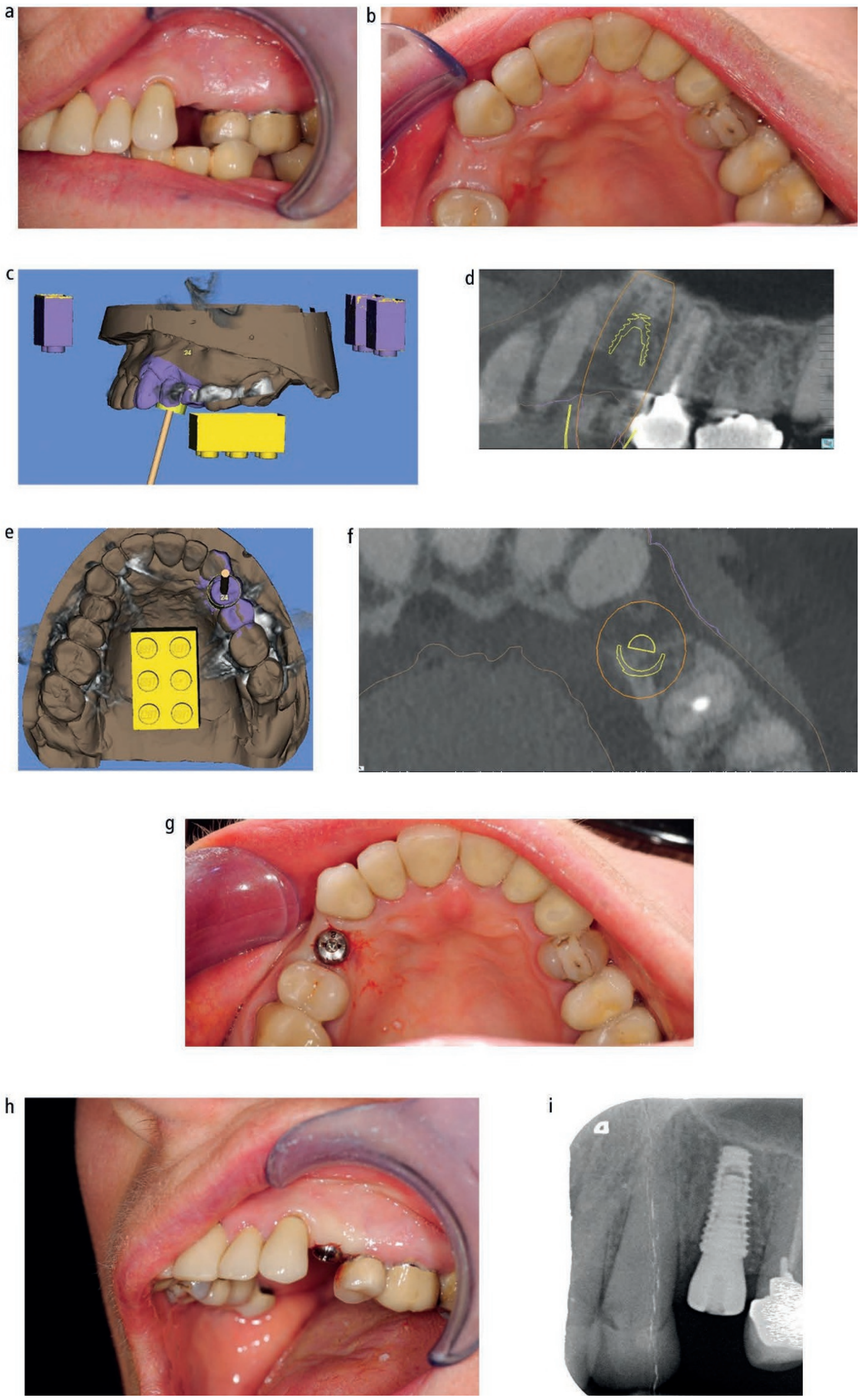

Fig. 6 Single implant placement in the 24 site using CBCT guided flapless implant surgery (ImplantPilot system). A CBCT scan of the patient and a CBCT scan of a waxed-up study cast model have been combined as a dual scan to plan this case. (To approximate the two CBCT scans a LEGO brick has been used)

Osseointegration and contamination of the implant fixture

It has been hypothetically proposed that osseointegration can be impaired when using a flapless surgical technique due to the risk of soft tissue contamination of the implant bed and/or implant fixture during the process of implant surgery due to the close proximity of the soft tissues during surgery.[18,61] However, evidence for this is lacking and an animal study by Becker *et al.*,[81] who evaluated the histology of implants placed using conventional and flapless implant surgery in dogs found no histological evidence of gingival tissue or foreign body intrusion at the implant site using either surgical technique.[81]

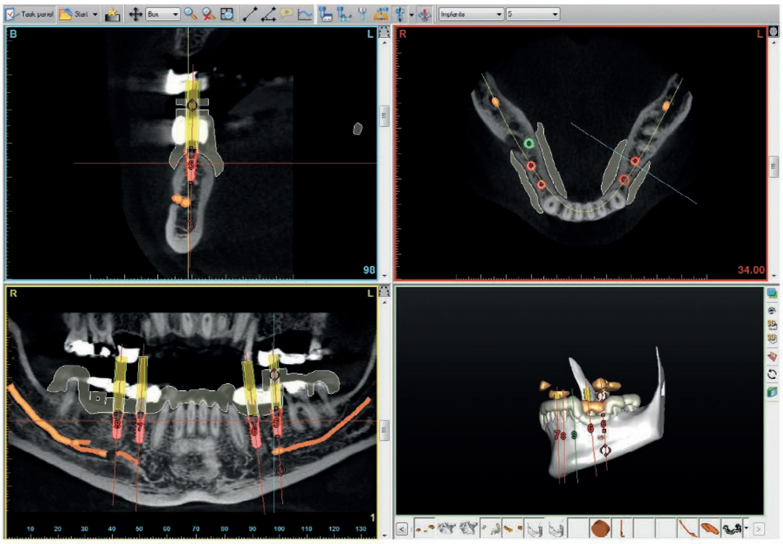

Fig. 7 CBCT Simplant planning software used to plan implant placement in a patient with hypodontia

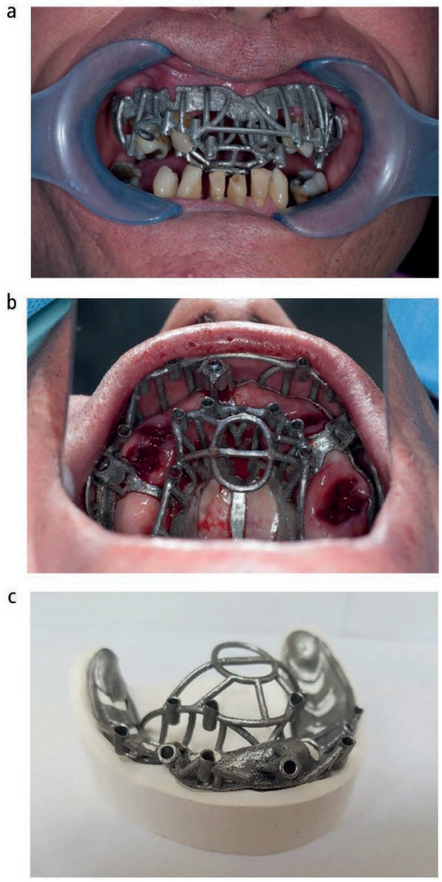

Fig. 8 Tissue supported surgical implant guide – pre and post- extraction (ImplantPilot system)

Irrigation of osteotomy site

Another concern of using a flapless implant surgical technique is the minimal and reduced surgical access for irrigation of the implant bed[38] which is necessary to cool and prevent heat generation at the surgical site. This heat generation can lead to the risk of heat induced necrosis of the bone[82] which can subsequently lead to bone resorption and implant failure. This may also be particularly true when a surgical drilling guide is used which can further impede and restrict delivery of irrigant to the osteotomy site (Figs 10 and 18 – the surgical guide design in Figure 18 also improves access for irrigation and visualisation at the implant bed site).[45] There are a number of factors which can contribute to heat generation during the preparation of the implant bed which include; the presence and temperature of irrigant,[82] the amount of bone being prepared,[83] drill sharpness and design,[84] the preparation time, the depth of the osteotomy,[85] pressure on the drill,[84] drill speed[86] and the thickness of the cortical bone.[87] On reviewing the literature relating to heat generation during the preparation of the implant bed using a flapless implant surgical technique, there are very few studies reporting on this. An *in-vitro* study by Jeong *et al.*,[88] who assessed heat generation at implant osteotomy sites when using a surgical drilling guide comparing open flap and flapless implant surgery reported a greater temperature increase when a flapless surgical technique was used in comparison to open flap surgery, but this was not found to be statistically significant (This study however, only carried out 20 drilling procedures in total).

Surgical technique: Free-hand, CBCT-guided and CBCT-guided and navigated flapless implant surgery

There are a variety of flapless implant surgical techniques which can be used for flapless implant surgery, these include, free hand, CBCT guided and CBCT guided and navigated flapless implant surgery. A systematic review by Voulgarakis *et al.*,[89] compared the outcomes of these three different flapless surgical procedures assessing implant survival rates and marginal bone loss. Twenty-three studies with a minimum of 1-year follow-up were included. The following results were reported; free hand flapless implant surgery demonstrated implant survival rates of 98.3–100% and mean marginal bone loss of between 0.09 and 1.40 mm at 1-4 years after implant insertion. Flapless CBCT guided surgery (without 3D navigation) had an implant survival rate of between 91-100% and mean marginal bone loss of 0.89 mm after an observation period of 2-10 years and CBCT guided and navigated flapless surgery showed implant survival rates of between 89-100% and mean marginal bone loss of between 0.55-2.6 mm over a follow-up period of 1-5years. This systematic review concluded that there are several methods to facilitate implant placement via a flapless approach and that none of the methods demonstrated has advantages over the other with regard to implant survival and marginal bone loss.[89] However, D'hase *et al.*,[54] suggested that free hand flapless implant surgery can only be advocated in specific pre-planned cases by experienced surgeons where there is adequate bone volume.[54]

Loading protocols

Immediate, early and delayed loading protocols have been reported with flapless implant surgery. A systematic review by Xu *et al.*,[14] compared immediate and early loading of implants placed using a flapless technique. The review reported on six articles which included four randomised controlled trials with 180 patients cumulatively included within their analysis. The review reported an implant failure rate of 0% to 3.3% for both immediate and early loaded implants when using a flapless surgical technique. The review reported no statistically significant outcome with regard to implant failure rates, peri-implant marginal bone levels or complications between the two groups. The only reported differences between the groups was that patients preferred immediate rather than early implant loading.[14] A retrospective study by Doan *et al.*,[103] reported on predictors for implant survival based on 1,241 consecutive implants placed using a flapless implant surgical technique. They reported on early (6-8 weeks and at 10-12 weeks) and delayed

Official journal of the British Dental Association.

(at six months) loading protocols; however, the loading protocols were not reported as being predictors for implant survival.[103] Additionally, a study by Oh *et al.*,[104] reported on soft tissue changes on implants placed in the anterior maxilla using a flapless surgical technique comparing immediate and delayed loading (after four months). Patients were followed up for six months with no statistical significance in the soft tissue profile being found between the two groups. However, statistical significance in the papillary index score was found in the immediate loading group where score increased from baseline to month two which was maintained at month six and could indicate that creeping attachment (that is, soft tissue recovery) might occur within two months after immediate loading.[104]

Complications associated with flapless implant surgery

The most commonly reported complication when using a flapless implant surgical technique is the perforation or fenestration of the peri-implant bone during surgery.[90,91] This is due to the procedure effectively being carried out blind without direct visualisation of the surgical site. A review by Brodala *et al.*,[29] reported an overall incidence of intraoperative complications of 3.8% for flapless implant surgery. All of these were related to perforation or dehiscences, with four of the 16 studies included within this review reporting on such complications.[29] Of these four studies, two used CBCT surgical stents for all patients,[65,92] whilst the other two studies did not routinely use them;[9,93] this demonstrates that this surgical complication can occur even with the use of CBCT surgical guides and should not be solely relied upon to alleviate this complication. There is also the strong possibility that the incidence of such events could be much higher due to such complications not being readily apparent to the clinician as a consequence of the lack of direct visualisation of the surgical site at the time of implant placement. To minimise the risk of this occurring, care must be taken when planning and placing the implants to ensure correct positioning and angulation. This is particularly true at high risk sites such as those with reduced alveolar ridge width and where bony concavities are present which commonly occur on the lingual aspect of the posterior mandible and the buccal aspect of the anterior maxilla.[94] Where such anatomical risks are present and in the presence of inadequate bone volume,[9] a flapless technique is not recommended. CBCT guided implant surgery can be used to minimise such risks, however, as discussed earlier these risks can and do still occur and should not be solely relied on to alleviate such risks.[46,47,49,95] Other reported complications include: reduced primary stability of the implant fixture; sub-optimal implant positioning and angulation; implant failure; challenges in restoring the implant fixtures; fracture of surgical guide and complications associated with the implant prosthesis,[68] however, such complications also occur when a conventional surgical technique is utilised with a review article by Brodala *et al.*,[29] reporting that the immediate postoperative and delayed complications appear to be similar for both flap and flapless implant surgery.[29]

Training and experience

There are a number of articles that state that there is a learning curve to achieving treatment success when using a flapless implant surgical technique.[9,68] This was reported by Campelo *et al.*,[9] who attributed their improved implant survival rate over a ten-year follow up period to their increased clinical experience of using a flapless surgical technique.[9] This was also suggested by Jain *et al.*,[96] who stated that placing implants without raising a mucoperiosteal flap requires a certain level of experience, fine

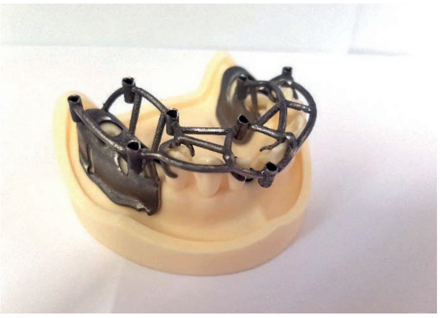

Fig. 9 Tooth and mucosa supported surgical implant guide (ImplantPilot system)

Fig. 10 A stereolithographic tooth supported surgical guide

Fig. 11 Stereolithographic tooth supported Simplant surgical guides used to accommodate each osteotomy drill used in the drilling sequence for placement of Straumann implants (from planned CBCT Fig. 15)

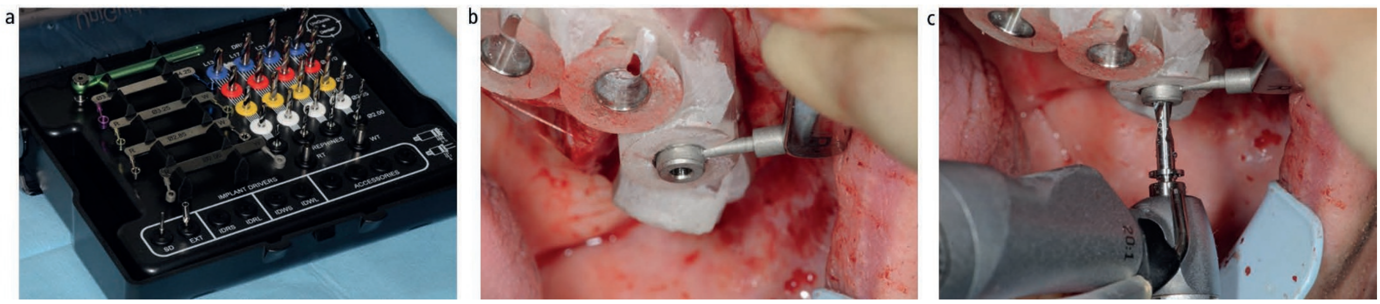

Fig. 12 CBCT guided surgical guide with interchangeable sleeves to accommodate each osteotomy drill used in the drilling sequence

Official journal of the British Dental Association.

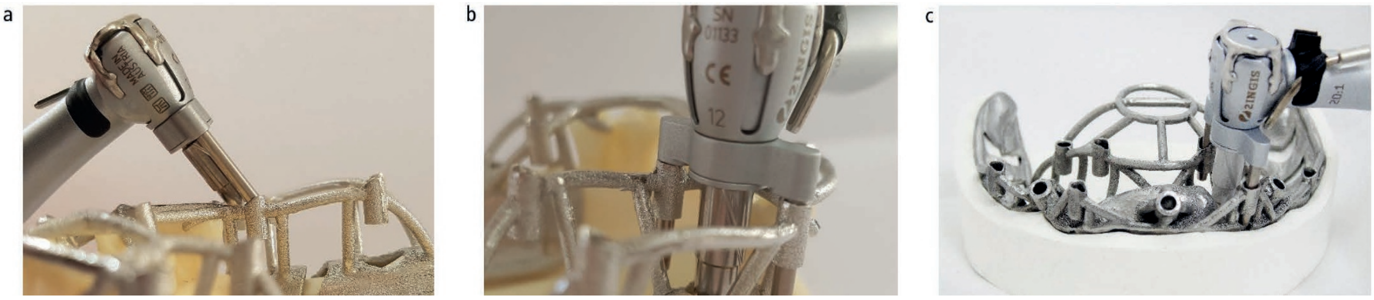

Fig. 13 Shows a ImplantPilot system surgical stent constructed from cobalt chromium which utilises bilateral tubes to guide the preparation of the implant bed/implant placement to minimise deviation from the planned CBCT implant position

motor skills, and sensitivity of the surgeon's hand, which only can come with practice.[96] Clinical experience has also been reported as being vital when using CBCT implant surgical guides for flapless implant surgery by Höckl *et al.*,[97] stating that 'in the hands of an inexperienced clinician there can be a blind reliance on surgical guides when using a flapless technique.'[97] It makes perfect sense that clinicians with less clinical experience of using such surgical techniques are more likely to have a lack of insight to identify any potential issues or errors and also a lack of experience to be able to alleviate or deal with these as they present themselves, with this being particular true in clinicians with limited implant surgery experience.[97] For example, one of the ways to deal with a surgical complication may be to abandon a flapless surgical technique and to raise a mucoperiosteal flap to visualise the site.

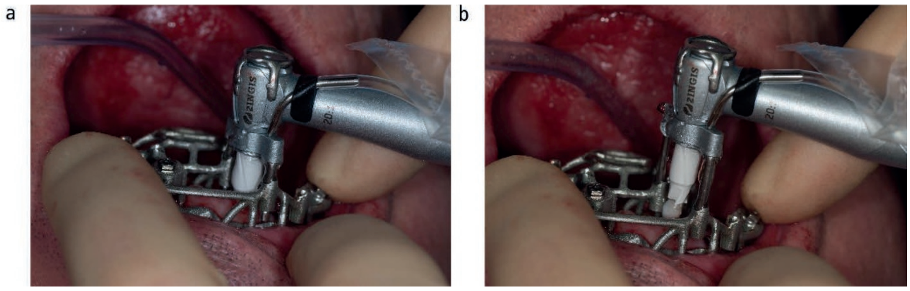

Fig. 14 An ImplantPilot surgical guide used for the preparation of the implant bed using zirconia drills

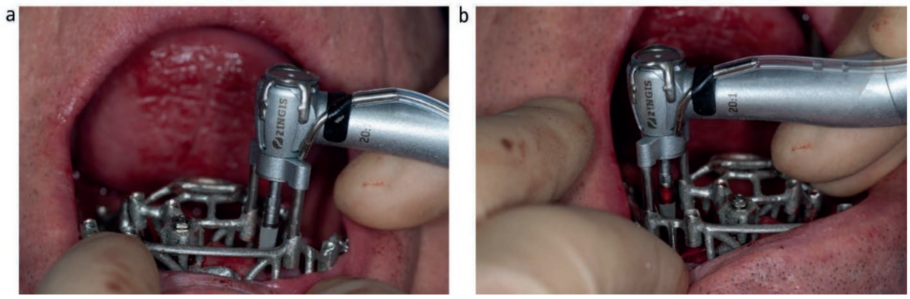

Fig. 15 An ImplantPilot surgical guide used to guide the position and angulation of the implant fixture placement

Patient satisfaction and perceived pain

A flapless implant surgical technique is minimally invasive in comparison to conventional flap surgery and has been shown to have improved rates of healing due to reduced surgical trauma and, with this, reduced postoperative complications such as pain, infection, swelling or dehiscence. It has also been suggested that bleeding is reduced both at the time of surgery (allowing a clean surgical field) and also postoperatively.[98] When assessing patients' satisfaction with using a flapless technique, a review article by Poomer *et al.*,[99] reporting on patients' preferences towards minimally invasive treatment alternatives for implant rehabilitation of edentulous jaws reported that patient satisfaction was high for implant surgery (average 91% [range: 77 to 100%]).[99] when using a flapless surgical technique.[99] This was also reported by Youk *et al.*,[100] who reported that patients who had undergone computer-guided flapless implant surgery employing a surgical template felt less pain and had higher satisfaction than those who had undergone conventional implant surgery.[100] When assessing patients' perceived pain and discomfort, studies by Nkenke *et al.*,[101] and Fortin *et al.*,[18] both reported reduced patient morbidity and a reduction in the intensity of pain for shorter periods of time when using a flapless technique.[18,101] This is weakly backed up by a Cochrane systematic review by Esposito *et al.*,[102] who concluded that there is limited weak evidence to suggest that flapless implant surgery shows reduced post-operative discomfort in adequately selected patients.[102]

Conclusion

Flapless implant surgery is increasing in popularity with its use being driven by advances in CBCT guided implant surgery. However, this surgical technique requires further education, training and experience to enable clinicians to learn and apply the requisite skills necessary for this surgical approach as there is a learning curve to achieving treatment success.[9,68] Clinicians using CBCT surgical guides should have a good understanding of the system being used and appreciate potential inaccuracies and deviations (both average and maximal) for each specific system used and consider this in the planning and surgical stages of treatment to minimise potential risks and complications occurring.

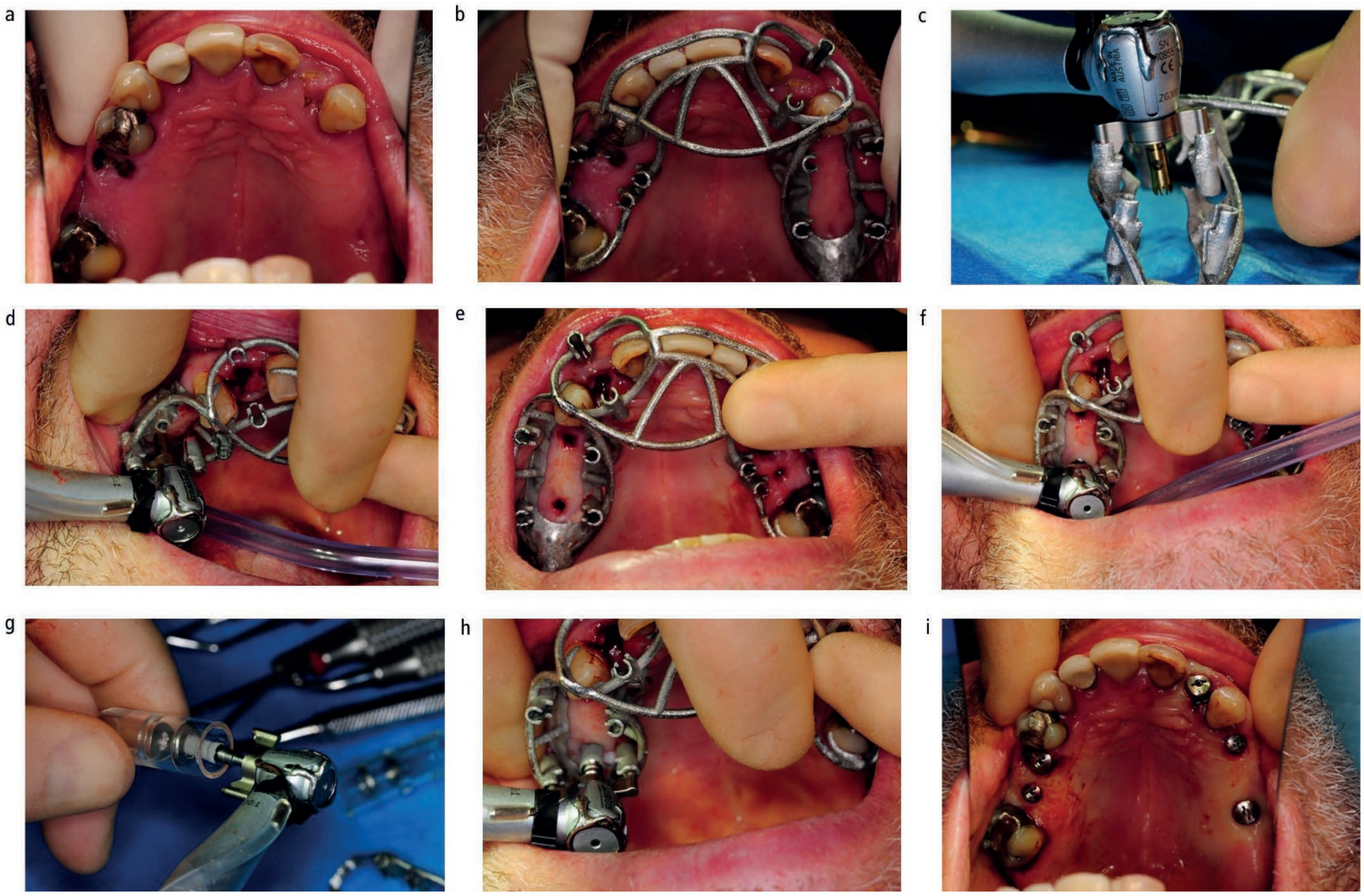

Fig. 16 Multiple implant placement (including immediate placement) in the 25, 26, 12, 14 and 16 sites using the ImplantPilot system

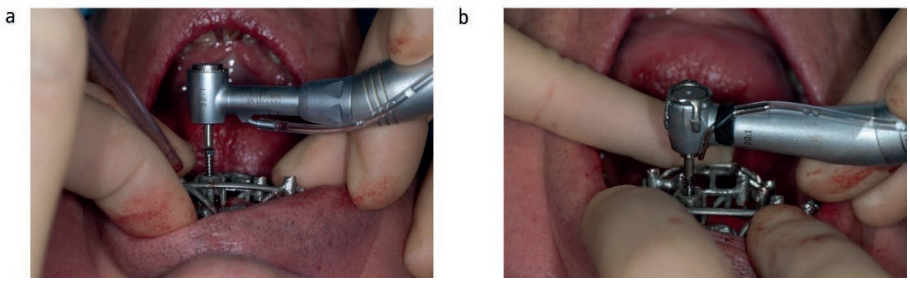

Fig. 17 Placement of a fixation screw to stabilise the surgical stent during preparation of the implant bed (ImplantPilot system)

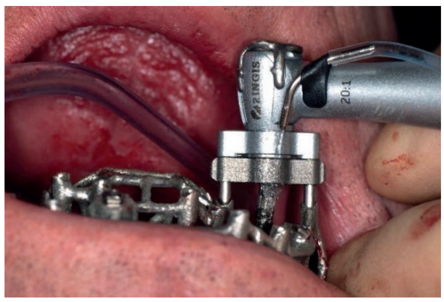

Fig. 18 External irrigation system being used during flapless implant surgery

Like any aspect of implant surgery, careful patient selection, proper diagnosis and appropriate treatment planning[29] are key factors in achieving predictable treatment outcomes;[9,29,31] this is particularly true for flapless implant surgery as this technique is effectively a 'blind procedure'. It has been suggested that a flapless implant surgical technique should only be considered where there is sufficient bone volume, adequate keratinised soft tissue, (when resection of the soft tissue is planned), an absence of significant hard tissue undercuts[5,9,16,75] and when the clinician is appropriately aware of the anatomy and location of vital structures.[31]

This surgical technique has promise, however, for more definite conclusions further well-designed long-term clinical trials need to be carried out to determine the real effect of flapless implant surgery on patient outcome variables. Further research and development is also needed to improve the accuracy of CBCT surgical guides with this improvement being predicted to increase the usage and uptake of this surgical technique by dental practitioners.

1. Brånemark P I, Hansson B O, Adell R, Breine U, Lindström J, Hallén O. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg Suppl* 1977; **16:** 1–132.
2. Han T J, Park K B, Klokkevold P R. *Standard implant surgical procedures. In: Carranza's Clinical Periodontology*. 10th ed. pp. 1120–1132. St.Louis: Saunders, 2006..
3. Cranin A N, Sirakian A, Russell D, Klein M. The role of incision design and location in the healing processes of alveolar ridges and implant host sites. *Int J Oral Maxillofac Implants* 1998; **13:** 483–491.
4. Cranin A N. Implant surgery: The management of soft tissues. *J Oral Implantol* 2002; **28:** 230–237.
5. Sclar A G. Guidelines for flapless surgery. *J Oral Maxillofac Surg* 2007; **65:** 20–32.
6. Gomez-Roman G. Influence of flap design on peri-implant interproximal crestal bone loss around single tooth implants. *Int J Oral Maxillofac Implants* 2001; **16:** 61–67.
7. Takei H H, Han T J, Carranza FA Jr, Kenney E B, Lekovic V. Flap technique for periodontal bone implants: papilla preservation technique. *J Periodontol* 1985; **56:** 204–210.
8. Rosenquist B. A comparison of various methods of soft tissue management following the immediate placement

of implants into extraction sockets. *Int J Oral Maxillofac Implants* 1997; **12:** 43–51.
9. Campelo L D, Camara J R. Flapless implant surgery: A 10-year clinical retrospective analysis. *Int J Oral Maxillofac Implants* 2002; **17:** 271–276.
10. Van der Zee E, Oosterveld P, Van Waas M A. Effect of GBR and fixture installation on gingiva and bone levels at adjacent teeth. *Clin Oral Implants Res* 2004; **15:** 62–65.
11. Wood D L, Hoag P M, Donnenfeld O W, Rosenfeld L D. Alveolar crest reduction following full and partial thickness flaps. *J Periodontol* 1972; **43:** 141–144.
12. Van der Zee E, Oosterveld P, Van Waas M A. Effect of GBR and fixture installation on gingiva and bone levels at adjacent teeth. *Clin Oral Implants Res* 2004; **15:** 62–65.
13. Staffileno H. Significant differences and advantages between the full thickness and split thickness flaps. *J Periodontol* 1974; **45:** 421–425.
14. Xu L, Wang X, Zhang Q, Yang W, Zhu W, Zhao K. Immediate *versus* early loading of flapless placed dental implants: a systematic review. *J Prosthet Dent* 2014; **112:** 760–769.
15. Campelo L D, Camara J R. Flapless implant surgery: A 10-year clinical retrospective analysis. *Int J Oral Maxillofac Implants* 2002; **17:** 271–276.
16. Hahn J. Single-stage, immediate loading, and flapless surgery. *J Oral Implantol* 2000; **26:** 193–198.
17. Casap N, Tarazi E, Wexler A, Sonnenfield U, Lustmann J. Intraoperative computerized navigation for flapless implant surgery and immediate loading in the edentulous mandible. *Int J Oral Maxillofac Implants* 2005; **20:** 92–98.
18. Fortin T, Bosson J L, Isidori M, Blanchet E. Effect of flapless surgery on pain experienced in implant placement using an image-guided system. *Int J Oral Maxillofac Implants* 2006; **21:** 298–304.
19. Al-Ansari B H, Morris R R. Placement of dental implants without flap surgery: A clinical report. *Int J Oral Maxillofac Implants* 1998; **13:** 861–865.
20. Becker W, Wikesjo U M, Sennerby L *et al.* Histologic evaluation of implants following flapless and flapped surgery: A study in canines. *J Periodontol* 2006; **77:** 1717–1722.
21. Berglundh T, Lindhe J: Dimension of the peri-implant mucosa: Biologic width revisited. *J Clin Periodontol* 1996; **23:** 971.
22. Schroeder A, van der Zypen E, Stich H, Sutter F. The reactions of bone, connective tissue, and epithelium to endosteal implants with titanium-sprayed surfaces. *J Maxillofac Surg* 1981; **9:** 15–25.
23. Buser D, Weber H P, Lang N P. Tissue integration of non-submerged implants. 1-year results of a prospective study with 100 ITI hollow-cylinder and hollow-screw implants. *Clin Oral Implants Res* 1990; **1:** 33–40.
24. Meffert R M, Langer B, Fritz M E. Dental implants: a review. *J Periodontol* 1992; **63:** 859–870.
25. ten Bruggenkate C M, Krekeler G, van der Kwast W A, Oosterbeek H S. Palatal mucosa grafts for oral implant devices. *Oral Surg Oral Med Oral Pathol* 1991; **72:** 154–158.
26. Block M S, Kent J N. Factors associated with soft-and hard-tissue compromise of endosseous implants. *J Oral Maxillofac Surg* 1990; **48:** 1153–1160.
27. Sclar A G: Surgical techniques for management of peri-implant soft tissues. *In* Motamedi M *Soft Tissue and Esthetic Considerations in Implant Therapy*. P. 43. Chicago, I L: Quintessence, 2003.
28. Bidra A S. Consequences of insufficient treatment planning for flapless implant surgery for a mandibular overdenture: a clinical report. *J Prosthet Dent* 2011; **105:** 286–291.
29. Brodala N. Flapless surgery and its effect on dental implant outcomes. *Int J Oral Maxillofac Implants* 2009; **24:** 118–125.
30. Turkyilmaz I. Immediate provisional restoration of implant placed using flapless surgery and ridge mapping. *N Y State Dent J* 2011; **77:** 21–23.
31. Becker W, GoldsteinM, Becker B E, Sennerby L. Minimally invasive flapless implant surgery: a prospective multicentre study. *Clin Implant Dent Relat Res* 2005; **7:** S21–S27.
32. Sclar A G. Guidelines for flapless surgery. *J Oral Maxillofac Surg* 2007; **65:** 20–32.
33. Fortin T, Bosson J L, Isidori M, Blanchet E. Effect of flapless surgery on pain experienced in implant placement using an image-guided system. *Int J Oral Maxillofac Implants* 2006; **21:** 298–304.
34. Komiyama A, Klinge B, Hultin M. Treatment outcome of immediately loaded implants installed in edentulous jaws following computer-assisted virtual treatment planning and flapless surgery. *Clin Oral Implants Res* 2008; **19:** 677–685.
35. Rocci A, Martignoni M, Gottlow J. Immediate loading in the maxilla using flapless surgery, implants placed in predetermined positions, and prefabricated provisional restorations: a retrospective 3-year clinical study. *Clin Implant Dent Relat Res* 2003; **5 Suppl 1:** 29–36.
36. Chrcanovic B R, Albrektsson T, Wennerberg A. Flapless *versus* conventional flapped dental implant surgery: a meta-analysis. *PLoS One* 2014; e100624.
37. Sunitha R V, Sapthagiri E. Flapless implant surgery: a 2-year follow-up study of 40 implants. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2013; **116:** e237–e243.
38. De Bruyn H, Atashkadeh M, Cosyn J, van de Velde T. Clinical outcome and bone preservation of single TiUnite™ implants installed with flapless or flap surgery. *Clin Implant Dent Relat Res* 2011; **13:** 175–183.
39. Orentlicher G, Abboud M. Guided surgery for implant therapy. *Dent Clin North Am* 2011; **55:** 715–744.
40. Chrcanovic B R, Oliveira D R, Custodio A L. Accuracy evaluation of computed tomography-derived stereolithographic surgical guides in zygomatic implant placement in human cadavers. *J Oral Implantol* 2010; **36:** 345–355.
41. Lindeboom J A, van Wijk A J. A comparison of two implant techniques on patient-based outcome measures: a report of flapless vs. conventional flapped implant placement. *Clin Oral Implants Res* 2010; **21:** 366–370.
42. Soares M M, Harari N D, Cardoso E S, Manso M C, Conz M B, Vidigal G M Jr. An *in vitro* model to evaluate the accuracy of guided surgery systems. *Int J Oral Maxillofac Implants* 2012; **27:** 824–831.
43. Brief J, Edinger D, Hassfeld S, Eggers G. Accuracy of image-guided implantology. *Clin Oral Implants Res* 2005; **16:** 495–501.
44. Van Assche N, van Steenberghe D, Quirynen M, Jacobs R. Accuracy assessment of computer-assisted flapless implant placement in partial edentulism. *J Clin Periodontol* 2010; **37:** 398–403.
45. Sclar A G. Guidelines for flapless surgery. *J Oral Maxillofac Surg* 2007; **65:** 20–32.
46. D'haese J, Van De Velde T, Elaut L, De Bruyn H. A prospective study on the accuracy of mucosally supported stereolithographic surgical guides in fully edentulous maxillae. *Clin Implant Dent Relat Res* 2012; **14:** 293–303.
47. Di Giacomo GA, da Silva JV, da Silva A M, Paschoal G H, Cury P R, Szarf G. Accuracy and complications of computer-designed selective laser sintering surgical guides for flapless dental implant placement and immediate definitive prosthesis installation. *J Periodontol* 2012; **83:** 410–419.
48. D'haese J, Van De Velde T, Komiyama A, Hultin M, De Bruyn H. Accuracy and complications using computer-designed stereolithographic surgical guides for oral rehabilitation by means of dental implants: a review of the literature. *Clin Implant Dent Relat Res* 2012; **14:** 321–335.
49. Tahmaseb A, Wismeijer D, Coucke W, Derksen W. Computer technology applications in surgical implant dentistry: a systematic review. *Int J Oral Maxillofac Implants* 2014; **29 Suppl:** 25–42.
50. Van Assche N, Vercruyssen M, Coucke W, Teughels W, Jacobs R, Quirynen M. Accuracy of computer-aided implant placement. *Clin Oral Implants Res* 2012; **23 Suppl 6:** 112–123.
51. Lee D H, An S A, Hong M H, Jeon K B, Lee K B. Accuracy of a direct drill-guiding system with minimal tolerance of surgical instruments used for implant surgery: a prospective clinical study. *J Adv Prosthodont* 2016; **8:** 207–213.
52. Ozan O, Turkyilmaz I, Yilmaz B. A preliminary report of patients treated with early loaded implants using computerized tomography-guided surgical stents: flapless *versus* conventional flapped surgery. *J Oral Rehabil* 2007; **34:** 835–840.
53. Turbush S K, Turkyilmaz I. Accuracy of three different types of stereolithographic surgical guide in implant placement: an *in vitro* study. *J Prosthet Dent* 2012; **108:** 181–188.
54. D'haese J, Ackhurst J, Wismeijer D, De Bruyn H, Tahmaseb A. Current state of the art of computer-guided implant surgery. *Periodontol 2000* 2017; **73:** 121–133.
55. Pettersson A, Komiyama A, Hultin M, Näsström K, Klinge B. Accuracy of virtually planned and template guided implant surgery on edentate patients. *Clin Implant Dent Relat Res* 2012; **14:** 527–537.
56. Behneke A, Burwinkel M, Behneke N. Factors influencing transfer accuracy of cone beam CT-derived template-based implant placement. *Clin Oral Implants Res* 2012; **23:** 416–423.
57. Schneider D, Marquardt P, Zwahlen M, Jung R E.A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. *Clin Oral Implants Res* 2009; **20 Suppl 4:** 73–86.
58. Hultin M, Svensson K G, Trulsson M. Clinical advantages of computer-guided implant placement: A systematic review. *Clin Oral Implants Res* 2012; **23 Suppl. 6**: 124–135.
59. Sennerby L, Rocci A, Becker W, Jonsson L, Johansson L A, Albrektsson T. Short-term clinical results of Nobel Direct implants: A retrospective multicentre analysis. *Clin Oral Implants Res* 2008; **19:** 219–226.
60. Malo P, Nobre M D. Flap vs. flapless surgical techniques at immediate implant function in predominantly soft bone for rehabilitation of partial edentulism: a prospective cohort study with follow-up of 1 year. *Eur J Oral Implantol* 2008; **1:** 293–304.
61. Berdougo M, Fortin T, Blanchet E, Isidori M, Bosson J L. Flapless implant surgery using an image-guided system. A 1-to 4-year retrospective multicentre comparative clinical study. *Clin Implant Dent Relat Res* 2010; **12:** 142–152.
62. van Steenberghe D, Glauser R, Blombäck U *et al*. A computed tomographic scan-derived customized surgical template and fixed prosthesis for flapless surgery and immediate loading of implants in fully edentulous maxillae: a prospective multicentre study. *Clin Implant Dent Relat Res* 2005; **7 Suppl 1:** S111–S120.
63. Cannizzaro G, Leone M, Consolo U, Ferri V, Esposito M. Immediate functional loading of implants placed with flapless surgery *versus* conventional implants in partially edentulous patients: a 3-year randomized controlled clinical trial. *Int J Oral Maxillofac Implants* 2008; **23:** 867–875.
64. Sanna AM, Molly L, van Steenberghe D. Immediately loaded CAD-CAM manufactured fixed complete dentures using flapless implant placement procedures: a cohort study of consecutive patients. *J Prosthet Dent* 2007; **97:** 331–339.
65. Wittwer G, Adeyemo WL, Wagner A, Enislidis G. Computer-guided flapless placement and immediate loading of four conical screw-type implants in the edentulous mandible. *Clin Oral Implants Res* 2007; **18:** 534–539.
66. Becker W, Goldstein M, Becker B E, Sennerby L, Kois D, Hujoel P. Minimally invasive flapless implant placement: follow-up results from a multicentre study. *J Periodontol* 2009; **80:** 347–352.
67. Rousseau P. Flapless and traditional dental implant surgery: an open, retrospective comparative study. *J Oral Maxillofac Surg* 2010; **68:** 2299–2230.
68. Moraschini V, Velloso G, Luz D, Porto Barboza E. Implant survival rates, marginal bone level changes, and complications in full-mouth rehabilitation with flapless computer-guided surgery: a systematic review and meta-analysis. *Int J Oral Maxillofac Surg* 2015; **44:** 892–901.
69. Lin G H, Chan H L, Bashutski J D, Oh T J, Wang H L. The effect of flapless surgery on implant survival and marginal bone level: a systematic review and meta-analysis. *J Periodontol* 2014; **85:** e91–e103.
70. Wilderman M N, Wentz F M. Repair of a dentogingival defect with a paedicle flap. *J Periodontol* 1965; **36:** 218–231.
71. Pennel B M, King K O, Wilderman M N, Barron J M. Repair of the alveolar process following osseous surgery. *J Periodontol* 1967; **38:** 426–431.
72. Wilderman M N, Pennel B M, King K, Barron J M. Histogenesis of repair following osseous surgery. *J Periodontol* 1970; **41:** 551–565.
73. Wood D L, Hoag P M, Donnenfeld O W, Rosenfeld L D. Alveolar crest reduction following full and partial thickness flaps. *J Periodontol* 1972; **42:** 141–144.

Official journal of the British Dental Association.

74. Pisoni L, Ordesi P, Siervo P *et al*. Flapless Versus Traditional Dental Implant Surgery: Long-Term Evaluation of Crestal Bone Resorption. *J Oral Maxillofac Surg* 2016; **74:** 1354–1359.
75. Kan J Y, Rungcharassaeng K, Ojano M, Goodacre C J. Flapless anterior implant surgery: a surgical and prosthodontic rationale. *Pract Periodontics Aesthet Dent* 2000; **12:** 467–474.
76. Cosyn J, Hooghe N, De Bruyn H. A systematic review on the frequency of advanced recession following single immediate implant treatment. *J Clin Periodontol* 2012; **39:** 582–589.
77. De Bruyn H, Atashkadeh M, Cosyn J, van de Velde T. Clinical outcome and bone preservation of single TiUnit implants installed with flapless or flap surgery. *Clin Implant Dent Relat Res* 2011; **13:** 175–183.
78. Covani U, Cornelini R, Barone A. Buccal bone augmentation around immediate implants with and without flap elevation: a modified approach. *Int J Oral Maxillofac Implants* 2008; **23:** 841–846.
79. Van de Velde T, Sennerby L, De Bruyn H. The clinical and radiographic outcome of implants placed in the posterior maxilla with a guided flapless approach and immediately restored with a provisional rehabilitation: a randomized clinical trial. *Clin Oral Implants Res* 2010; **21:** 1223–1233.
80. Rousseau P. Flapless and traditional dental implant surgery: an open, retrospective comparative study. *J Oral Maxillofac Surg* 2010; **68:** 2299–2306.
81. Becker W, Wikesjo¨ UM, Sennerby L *et al.* Histologic evaluation of implants following flapless and flapped surgery: A study in canines. *J Periodontol* 2006; **77:** 1717–1722.
82. Eriksson R A, Albrektsson T: The effect of heat on bone regeneration: an experimental study in the rabbit using the bone growth chamber. *J Oral Maxillofac Surg* 1984; **42:** 705–711.
83. Eriksson R A, Adell R: Temperatures during drilling for the placement of implants using the osseointegration technique. *J Oral Maxillifac Surg* 1986; **44:** 4–7.
84. Matthews J, Hirsch C. Temperatures measured in human cortical bone when drilling. *J Bone Joint Surg*. 1972; **45:** 297–308.
85. Ercoli C, Funkenbusch P D, Lee H J. The influence of drill wear on cutting efficiency and heat production during osteotomy preparation for dental implants: a study of drill durability. *Int J Oral Maxillofac Implant* 2004; **19:** 335–349.
86. Brisman D L. The effect of speed, pressure, and time on bone temperature during the drilling of implant sites. *Int J Oral Maxillofac Implant* 1996; **11:** 35–37.
87. Hobkirk J, Rusiniak K: Investigation of variable factors in drilling bone. *J Oral Surg* 1977; **35:** 968–973.
88. Jeong S M, Yoo J H, Fang Y, Choi B H, Son J S, Oh J H. The effect of guided flapless implant procedure on heat generation from implant drilling. *J Craniomaxillofac Surg* 2014; **42:** 725–729.
89. Voulgarakis A, Strub J R, Att W. Outcomes of implants placed with three different flapless surgical procedures: A systematic review. *Int J Oral Maxillofac Surg* 2014; **43:** 476–486.
90. Chiapasco M, Zaniboni M. Clinical outcomes of GBR procedures to correct peri-implant dehiscences and fenestrations: a systematic review. *Clin Oral Implants Res* 2009; **20 Suppl 4:** 113–123.
91. Annibali S, Ripari M, La Monaca G, Tonoli F, Cristalli M P. Local accidents in dental implant surgery: Prevention and treatment. *Int J Periodontics Restorative Dent* 2009; **29:** 325–331.
92. Wittwer G, Adeyemo W L, Schicho K, Gigovic N, Turhani D, Enislidis G. Computer-guided flapless transmucosal implant placement in the mandible: A new combination of two innovative techniques. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006; **101:** 718–723.
93. Cannizzaro G, Leone M, Esposito M. Immediate functional loading of implants placed with flapless surgery in the edentulous maxilla: 1-year follow-up of a single cohort study. *Int J Oral Maxillofac Implants* 2007; **22:** 87–95.
94. Campelo L D, Camara J R. Flapless implant surgery: a 10-year clinical retrospective analysis. *Int J Oral Maxillofac Implants* 2002; **17:** 271–276.
95. Puig C P. A retrospective study of edentulous patients rehabilitated according to the 'all-on-four' or the 'all-on-six' immediate function concept using flapless computer-guided implant surgery. *Eur J Oral Implantol* 2010; **3:** 155–163.
96. Jain D, Gaur G. Flapless implant placement: a case report. *J Oral Implantol* 2014; **40:** 321–324.
97. Höckl K, Stoll P, Stoll V, Bähr W, Bach G. Flapless implant surgery and its effect on periimplant soft tissue. *Int J Oral Maxillofac Surg* 2011; **40:** e24.
98. Romero-Ruiz M M, Mosquera-Perez R, Gutierrez-Perez J L, Torres-Lagares D. Flapless implant surgery: A review of the literature and 3 case reports. *J Clin Exp Dent* 2015; **7:** e146–e152.
99. Pommer B, Mailath-Pokorny G, Haas R, Busenlechner D, Fürhauser R, Watzek G. Patients' preferences towards minimally invasive treatment alternatives for implant rehabilitation of edentulous jaws. *Eur J Oral Implantol* 2014; **7 Suppl 2:** 91–109.
100. Youk S Y, Lee J H, Park J M *et al*. A survey of the satisfaction of patients who have undergone implant surgery with and without employing a computer-guided implant surgical template. *J Adv Prosthodont* 2014; **6:** 395–405.
101. Nkenke E, Eitner S, Radespiel-Tröger M, Vairaktaris E, Neukam FW, Fenner M. Patient-centred outcomes comparing transmucosal implant placement with an open approach in the maxilla: a prospective, non-randomized pilot study. *Clin Oral Implants Res* 2007; **18:** 197–203.
102. Esposito M, Maghaireh H, Grusovin M G, Ziounas I, Worthington H V. Interventions for replacing missing teeth: management of soft tissues for dental implants. *Cochrane Database Syst Rev* 2012; **18:** CD004970.
103. Doan N V, Du Z, Reher P, Xiao Y. Flapless dental implant surgery: a retrospective study of 1,241 consecutive implants. *Int J Oral Maxillofac Implants* 2014; **29:** 650–658.
104. Oh T J, Shotwell J L, Billy E J, Wang H L. Effect of flapless implant surgery on soft tissue profile: a randomized controlled clinical trial. *J Periodontol* 2006; **77:** 874–882.