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USES OF THE OPERATING MICROSCOPE IN MINIMALLY INVASIVE IMPLANTOLOGY

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Minimally invasive procedures are ubiquitous in medicine and now show an increased presence in invasive disciplines of dentistry. In implantology, this requires three-dimensional diagnostics, microsurgical instruments and suture materials, and especially optical magnification with axially aligned illumination. The operating microscope (OPMI) combines these last two requirements, which are essential even at high magnification. Customized sterile draping sheets allow the OPMI to be used even under the aseptic conditions of implant surgery. The advantages of the OPMI in implantology are numerous and are apparent especially in clinical assessment, diagnosis, management of the esthetic zone, sinus lift procedures, soft tissue management, and photographic and video documentation. Technical developments such as autofocus, xenon illumination, magnetic fixation, and charge-coupled device and high-definition digital cameras enhance the precision of the OPMI while also improving ergonomics. This article describes the main indications for using the OPMI in minimally invasive implantology. *Int J Microdent* 2010;2:28–41

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Since the development of the operating microscope (OPMI) by Dr Littmann and Professor Wullstein in 1953, it is no longer possible to imagine surgery on fine anatomical structures without optical magnification. The first clinical attempts to use the OPMI intraorally date back to the 1970s, when microscopic magnification was used for maxillofacial surgical nerve reconstruction.[1] Shortly thereafter, new applications in the early diagnosis of precancerous lesions of the oral mucosa and visualization of non-tight filling margins were described.[2]

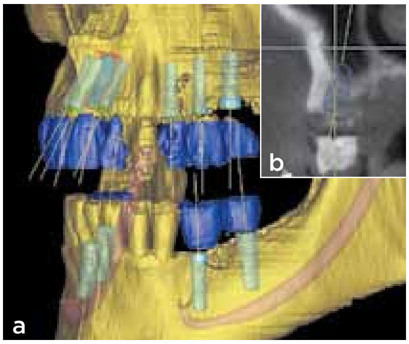
A few years later, endodontologists began to recognize the advantages of the OPMI, and since the 1990s, systematic use of the OPMI in endodontics has been documented and is now fully accepted.[3–5] In 1998, training with the OPMI became a requirement in postgraduate education in the United States.

Finally, microscopic magnification has also been described as promising in periodontology.[6–8] The main indications are mucogingival plastic surgery, papilla reconstruction, and connective tissue and mucosal grafts. Fenestration of the sinus floor and implant exposure have also been mentioned, but only peripherally.

Supported by new technical achievements, minimally invasive treatment methods are the current topic in the operative disciplines of medicine and dentistry. Minimally invasive surgery means injuring as little healthy anatomical tissue as possible. This assumes that the margins of the surgical procedure in the tissue can be precisely determined

Fig 1 Use of the operating microscope OPMI Proergo (Carl Zeiss, Oberkochen, Germany) in an implantological procedure.

Figs 2a to 2d Comparison of the size of conventional and microsurgical instruments and needle/suture.



Figs 3a and 3b *(right)* Three-dimensional radiography and implant planning (coDiagnostiX planning software, IVS Solutions).

visually and monitored continuously. For this purpose, the naked eye is no longer sufficient, and the use of loupes is basically unavoidable. However, loupes offer limited magnification—usually up to 3×—and a lack of axially aligned illumination at the edges.

In minimally invasive implantology, high optical magnification using the OPMI is just one component, albeit the most important one, of an overall treatment concept (Fig 1). Along with a surgeon experienced in microsurgery and specially trained assistants, the following are further components:

- Microsurgical instruments and needle/suture combinations (Fig 2)
- Scientifically documented alloplastic augmentation materials
- An innovative implant system
- Three-dimensional radiography and implant planning (Fig 3)
- Digital photography and video recording equipment

The primary aim of minimally invasive treatment is to minimize tissue trauma while maximizing tissue preservation and/or reconstruction.[9]

ASSESSMENT AND DIAGNOSIS

Like all disciplines in dentistry, implantology requires precise assessment and diagnosis, due in part to the growing importance of esthetic and functional predictability. These are often the most important criteria for the patient when deciding on an expensive treatment.

The aim is to accurately differentiate the various biologic variations of the relevant tissue structures and to distinguish them from pathologic changes. Therefore, precise visual extra- and intraoral clinical examination is necessary.

The optical magnification of an OPMI is very useful during clinical examination of the esthetic zone prior to implant placement. Important findings such as different gingival biotypes (Fig 4), suspicious discoloration of the dental enamel or soft tissue, and the three-dimensional course of the alveolar ridge can be documented precisely and shown to the patient (Fig 5). This allows for tooth extraction or preservation and bone grafting or soft tissue augmentation to be proposed more reliably.

Figs 4a to 4d *(a and b)* Tooth 11 with an internal root granuloma needs to be extracted. On the initial frontal views, one gets the impression of a thick gingiva biotype (B). *(c and d)* It is apparent only in the incisal view under 8× optical magnification that the healthy tooth 21 with a tissue thickness of 1.5 mm can be classified as gingiva biotype (B). Tooth 11 has a tissue thickness predominantly < 0.5 mm, so it is classified as gingiva biotype (A).

Figs 5a to 5e *(a to c)* Tooth 23 with a coronal internal granuloma is not worth preserving. The red color transparency at the cervicopalatal aspect of 23 only becomes clearly apparent at a magnification factor of 12. *(d)* Vestibular concavity in the course of the alveolar ridge as a sign of a horizontal bone defect. The dark mucosal discoloration in the crestal region of 21 suggests that the postextraction gingiva is not yet completely keratinized. *(e)* Determination of the mucogingival margin line by the probe rolling test. In this case, a lack of keratinized gingiva is found at the vestibular margin of 14.

Fig 6 Two versions of imaging documentation using the example of the Proergo operating microsope (on the left with a CCD digital camera and on the right with a digital mirror reflection camera).

Fig 7 Examples of variations in aseptic draping of the operating microscope for performing implant procedures (OPMI Proergo).

DIGITAL PHOTOGRAPHY AND VIDEO

Photographic or video documentation of implant surgery is becoming increasingly important, including for medicolegal reasons. This type of documentation is the basis of scientific evaluation and is the most important means of monitoring the outcome when surgical and prosthetic innovations are incorporated into an individualized implant treatment concept.

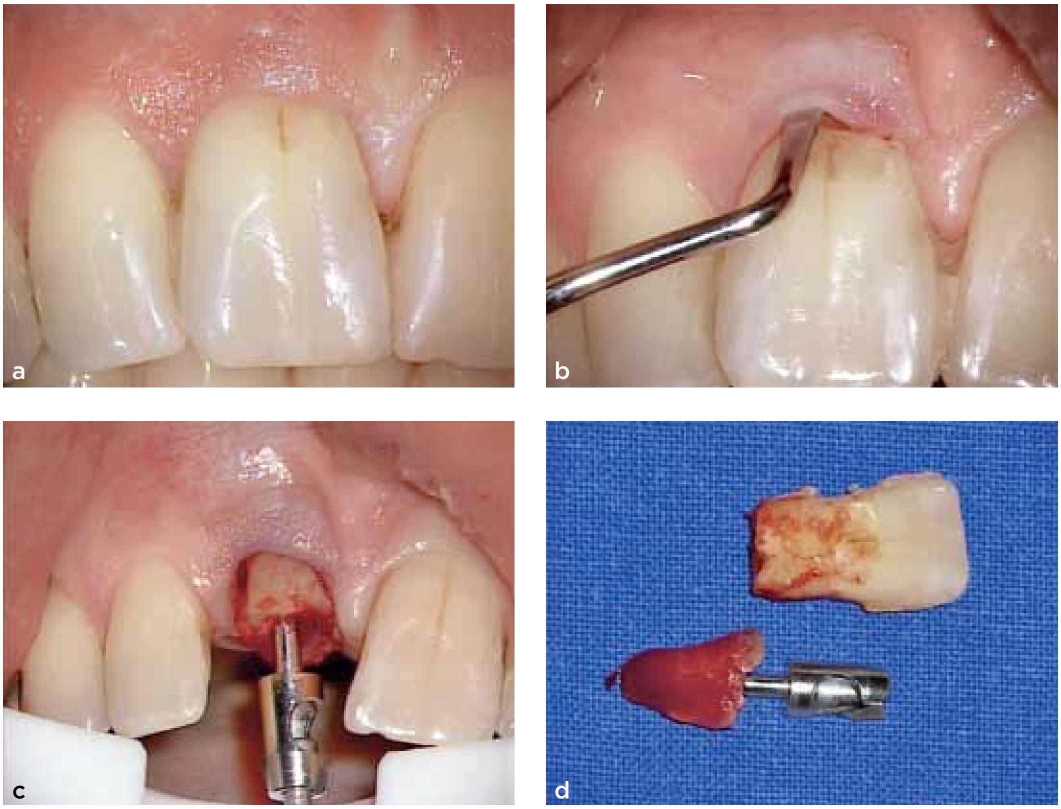
At the same time, complete continuous visualization of the patient's intra- and extraoral situation throughout implant-supported prosthetic treatment is also an effective marketing tool. Naturally, preoperative consultation of the patient is more effective when a clinician's own case reports are used.[10]

High-quality dental digital photography and filming with conventional cameras is time-consuming and requires a lot of materials. Optimally, a specially trained photographer is used for this purpose, from the initial assessment through the surgical procedure to the concluding assessment. However, one difficulty when a photographer is used is that the pictures are not taken from the surgeon's point of view and may differ from what he or she has in mind. The alternative option, in which the surgeon takes the photographs, often conflicts with the need for intraoperative sterility. In addition, clinical documentation recorded with a digital camera must be archived subsequently or transferred to the patient's virtual file.

These difficulties can be minimized or eliminated by using an OPMI with integral 3-chip charge-coupled device or high-definition cameras (Fig 6). Naturally, sterilizable intraoral reflection-free photo mirrors, soft tissue retractors, a trained assistant, and experience are needed for this purpose as well. The images are reproduced as video screenshots with a resolution of approximately 2 to 3 megapixels. The surgeon takes the picture under sterile conditions by using sterile disposable sleeves or drapes (Fig 7). Using suitable dental software such as Evident, the images can be stored directly in the virtual patient file and exported and processed if necessary.

The following features are recommended for the OPMI:

- **Autofocus.** The autofocus saves time during the operation while also increasing the precision of the image.



Figs 8a to 8d *(a)* Preoperative appearance before starting extraction of tooth 11 because of an internal granuloma. *(b)* Microscopically assisted division of the circular ligament by means of a microelevator at 14× magnification. *(c)* Gentle vertical extraction of the apical root fragment by means of the Benex system. *(d)* Appearance after successful extraction of the two root fragments of tooth 11.

- **Xenon illumination.** The xenon illumination is helpful especially when taking pictures of surgical procedures because it allows for clear images despite the high light absorption by blood in the surgical field.
- **Magnet fixation system.** The magnetic fixation system ensures that the OPMI is absolutely free from wobble at the touch of a button, which is especially crucial for photographs at high magnification.

MINIMALLY INVASIVE IMPLANTOLOGY IN THE ESTHETIC ZONE

Most of the scientific achievements in implantology in the last 10 years involve management of the esthetic zone.[11] The optical magnification of the OPMI can be used effectively at the following stages of treatment:

1. Minimally invasive extraction
2. Visual assessment of the bony extraction socket and perialveolar soft tissue to determine whether immediate implantation is indicated
3. Incision and flap design
4. Implant bed preparation and positioning
5. Augmentation
6. Microsurgical wound closure

The use of the OPMI will now be described in detail using an example of immediate implantation in the esthetic zone.

Minimally Invasive Extraction (6× to 14× Magnification)

The indication for immediate implantation is usually decided immediately after tooth extraction. Tissue-sparing extraction is therefore of great importance.[12] Horizontal dislocation of the extracted tooth is increasingly advised against because this increases the risk of fracture of the alveolar margin.[13] Instead, vertical extraction methods such as using the Benex system (DCV) are becoming more popular.

The extraction begins with microscopically assisted fine division of the circular ligament using a microelevator. After the crown

Figs 9a and 9b Intra-alveolar microscopic evaluation of the vestibular bone and the interproximal bone walls to decide whether immediate implantation or reconstructive measures are indicated at 8× to 12× magnification.

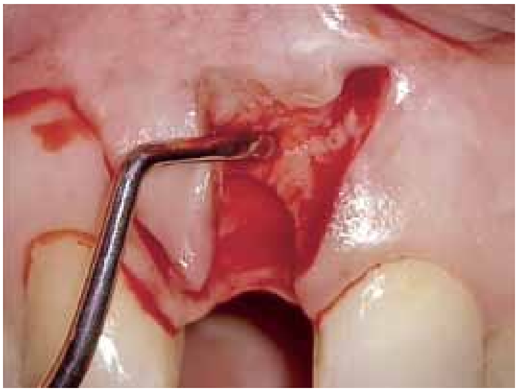


Fig 10 *(right)* Marginal preparation of the mucoperiosteal flap with a microelevator to avoid microfractures of the esthetically critical alveolar margin after microsurgical incision at 8× magnification.

is removed and the Benex root anchor is secured, gradual vertical dislocation of the root can be monitored under the microscope (Fig 8).

If there is an obstruction to extraction, for instance due to ankylosis of the root, fine movements of the root visible under the microscope would be absent despite the pull of the cable. The procedure could then be interrupted in good time and the extraction could alternatively be continued with fine dislocators such as those of the XTool system (DCV).

Even in the case of intra-alveolar extraction,[13] possible root fragments can be shown indirectly by means of a mirror and dislocated more reliably.

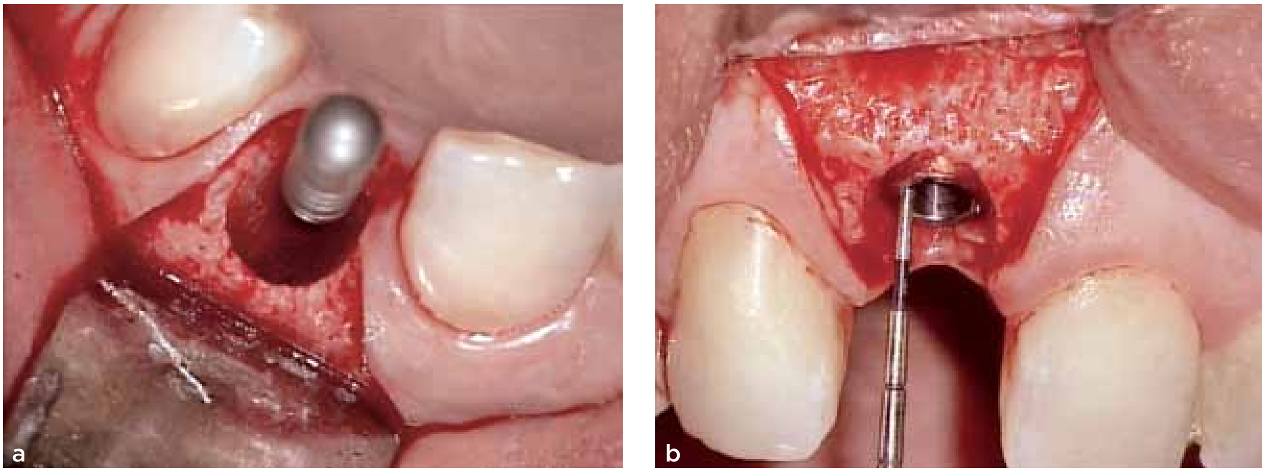
Visual Assessment of the Bony Extraction Socket and Perialveolar Soft Tissue (8× to 12× Magnification)

Following successful tooth extraction, the OPMI is an extremely effective instrument for assessing the (residual) bone structure of the socket. The level of preservation of the vestibular bone and the amount of interproximal bone are crucial esthetic factors (Fig 9).[14]

If there are bone deficits, a procedure in two or more stages may be needed depending on the morphology of the defect, and immediate implantation may be contraindicated. Any inflamed residual tissue can also be removed more precisely using the OPMI. If immediate implantation is indicated, this can be decided more safely and predictably with optical magnification.

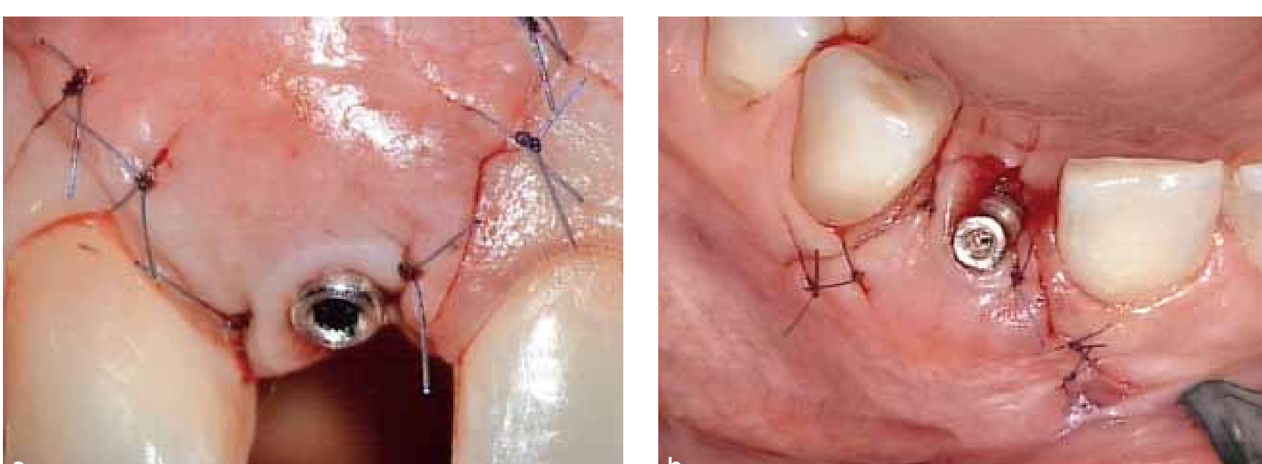
Incision and Flap Design (5× to 10× Magnification)

An incision with microsurgical scalpels can be made much more precisely with the OPMI. Controlled division of anatomical layers such as epithelium, connective tissue, and periosteum can be performed. More precise definition of the incision means it is easier to spare esthetically relevant structures such as the papillae of the adjacent teeth. Initial flap preparation in the crestal region, where it is important to preserve the fine alveolar margin, is performed with microelevators. This is the only way to minimize the risk of iatrogenic fracture of the thin crestal alveolar bone (Fig 10).



Figs 11a and 11b *(a)* Horizontal check of direction after pilot drilling using a Camlog Implant System direction indicator. *(b)* Vertical position check after immediate implantation in region 12 of a Camlog Screwline implant.

Figs 12a to 12c *(a)* Minimal perforation of the vestibular compact bone prior to augmentation to promote perfusion after insertion of a Camlog Bottleneck gingiva former. *(b)* Vestibular augmentation and filling of the "jumping gap" with BioOss granules using a microelevator (12× magnification). *(c)* Covering the graft with the contoured BioGide membrane for the purpose of GBR.



Figs 13a and 13b *(a)* Frontal view afer microsurgical tension-free wound closure with 6/0 Seralon (14× magnification). *(b)* Occlusal view after microsurgical wound closure with 6/0 Seralon.

Implant Bed Preparation and Positioning (Average of 8× Magnification)

The main goal of implant bed preparation in the esthetic zone is reliable positioning of the implant in an esthetically acceptable region.[11] The orally directed pilot drill hole and subsequent hole enlargement are monitored microscopically in the horizontal and vertical planes. With intra-alveolar visual control, the changes in drilling direction can be made promptly. With the OPMI, the surgeon is better able to maintain the required distance between the implant and adjacent teeth and can manage this if necessary by adjusting the drilling direction and the choice of implant diameter (Fig 11).

Augmentation (6× to 12× Magnification)

Particularly in the case of immediate implantation in conjunction with vestibular augmentation to prevent future resorption,[15] augmentation of the jumping gap (distance between the implant and vestibular alveolar wall) can be performed with a microelevator and assisted microscopically. A slowly absorbable alloplastic bone substitute is especially suitable. The microscope can provide great assistance for further augmentation measures in combination with membranes for guided bone regeneration, such as during membrane contouring and placement (Fig 12).

Microsurgical Wound Closure (6× to 14× Magnification)

Microsurgical tension-free wound closure in the esthetic zone without optical magnification is no longer state of the art. Naturally, the absence of tension in the wound flap should be checked and, if necessary, ensured by slitting the periosteum. Assuming good suction, the mucobuccal fold of the periosteal layer can be visualized precisely under the microscope so it can be divided with one cut to promote subsequent wound healing. Detailed approximation of corresponding parts of the flaps or repositioning of papillary structures requires a minimum of 8× magnification (Fig 13).

MICROSCOPICALLY GUIDED EXTERNAL SINUS LIFT

Accidental rupture of the sinus membrane is regarded as the complication of external sinus lifts with the most consequences.[16,17] In addition, single-step implantation with a sinus lift is classified as risky when advanced alveolar ridge atrophy is present.[18]

The indications for previously described alternative minimally invasive treatment methods such as the internal sinus lift[19] or balloon dilatation technique[20] are limited because of the need for impact-driven osteoelevation or the lack of visual control of the sinus membrane.

In 2008, the current author[21] described a new, minimally invasive variation of the external sinus lift using the OPMI. Using specially developed microsurgical sinus lift instruments (DCV) with 8× to 18× magnification, the external sinus lift access is reduced to a minimum (4 to 5 mm), and the rate of membrane perforation is significantly reduced.

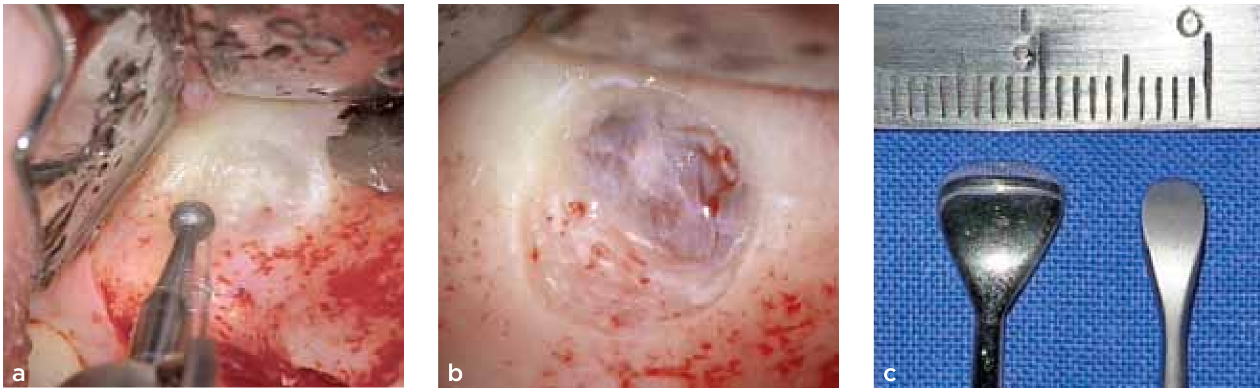
The operation is performed as follows:

1. The rotating osteotomy in the region of the sinus lift window is made under the microscope using 1.2- to 1.6-mm round diamond burs (DCV) (Fig 14a).
2. The dark cuff and the opening of the first subperiosteal sinus vessels signal the vicinity of the sinus membrane so the osteotomy can be stopped in good time (Fig 14b).
3. Using the newly developed instruments, which have been sharpened, the surgeon is able to fracture the parchment-thin layer of residual bone in the antral direction precisely and with little pressure (Figs 14c and 14d).
4. Further elevation of the sinus membrane is performed chronologically with the numbered instruments with minimal trauma through the sinus lift window, which measures an average of 5 mm (Figs 14e and 14f).
5. The subantral space is augmented with BioOss granules (Geistlich) using specially developed, miniaturized plugging and filling instruments, and the sinus lift window is covered with a contoured Bio-Gide membrane (Geistlich) (Figs 14g to 14i).

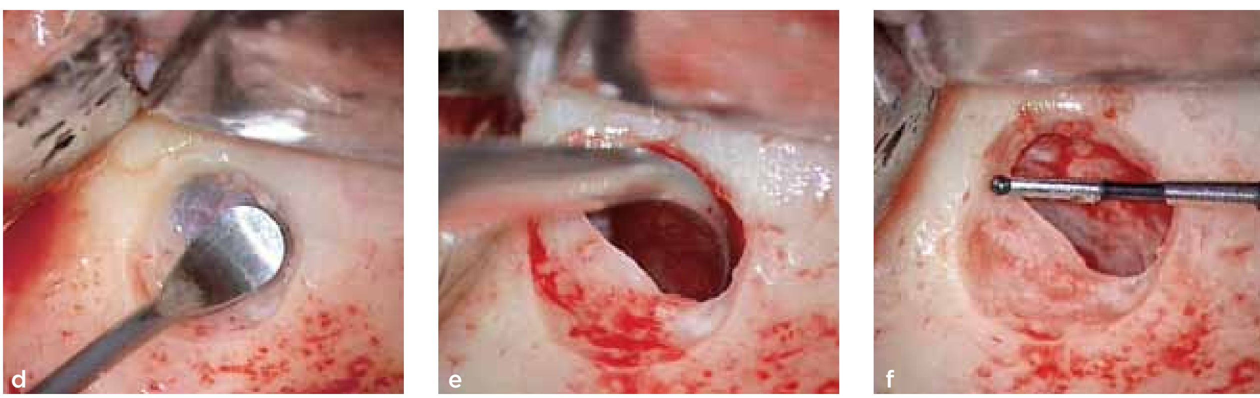
Along with the reduced rate of membrane perforation with this technique, the primary stability of implants placed simultaneously is increased because of the significant preservation of the bone of the vestibular alveolar process. The nutrition of the subantral graft is improved, and the rate of postoperative complications is diminished.[21]

MINIMALLY INVASIVE PERI-IMPLANT SOFT TISSUE MANAGEMENT

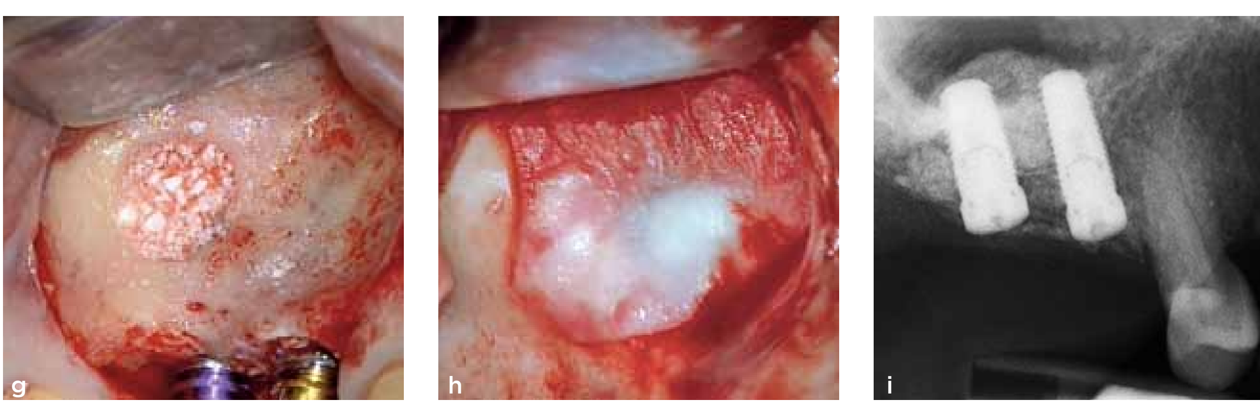
Although there is no consensus in the literature on whether the presence of keratinized gingiva instead of alveolar mucosa around implant-supported restorations confers a demonstrable advantage in the long term, a growing number of authors are convinced that attached peri-implant gingiva has the following clinical advantages[22–24]:



Figs 14a to 14c *(a)* Preparation of the external sinus lift window using a diamond round bur with a diameter of 1.2 mm (10× magnification). *(b)* Prompt conclusion of the osteotomy when the first subperiosteal blood vessels in the sinus are opened (18× magnification). *(c)* Comparison of the working ends of the instruments. *Left:* Conventional sinus lift instrument, *right:* microsurgical instrument.



Figs 14d to 14f *(d)* Initial circular fracturing of the parchment-thin bone of the sinus lift window in the antral direction (12× magnification). *(e)* Continuing elevation of the Schneiderian membrane with further angled microsurgical instruments (18× magnification). *(f)* Appearance after conclusion of membrane elevation through the 4- to 5-mm sinus lift window (18× magnification).



Figs 14g to 14i *(g)* Appearance after insertion of 2 Camlog screwline implants in region 15 and 16 and augmentation of the subantral space with BioOss granules (8× magnification). *(h)* Covering the sinus lift window with the contoured BioGide membrane (10× magnification). *(i)* Postoperative radiograph with preoperative residual bone height of approximately 2 to 5 mm.

Figs 15a to 15d *(a)* Marked vestibulomarginal color darkening after removal of the temporary crown in region 12 because of horizontal bone atrophy with a thin gingival biotype (A) and good vertical implant positioning, 6 months after implantation (6× magnification). *(b)* The incisal view shows clearly the obvious combined hard and soft tissue deficit in region 12 with suboptimal horizontal positioning of the implant (6× magnification). *(c)* Cautious start of gingiva tunnelling from the marginal aspect using a microscalpel (10× magnification). *(d)* Apical continuation of gingival tunnelling as far as the mucogingival margin to mobilize the pocket using a microscalpel (12× magnification).

- Diminished mechanical vulnerability of the peri-implant soft tissue
- Simplified peri-implant hygiene
- Better potential for prosthetic restoration
- Greater resistance to recession
- Greater patient satisfaction with function and appearance

Plastic reconstructive procedures are often necessary, and these should be performed according to a microsurgical protocol. The use of optical magnification will minimize tissue trauma and provide more predictable treatment outcomes.[25]

Microscopic assistance is effective in the following measures for management of peri-implant soft tissue:

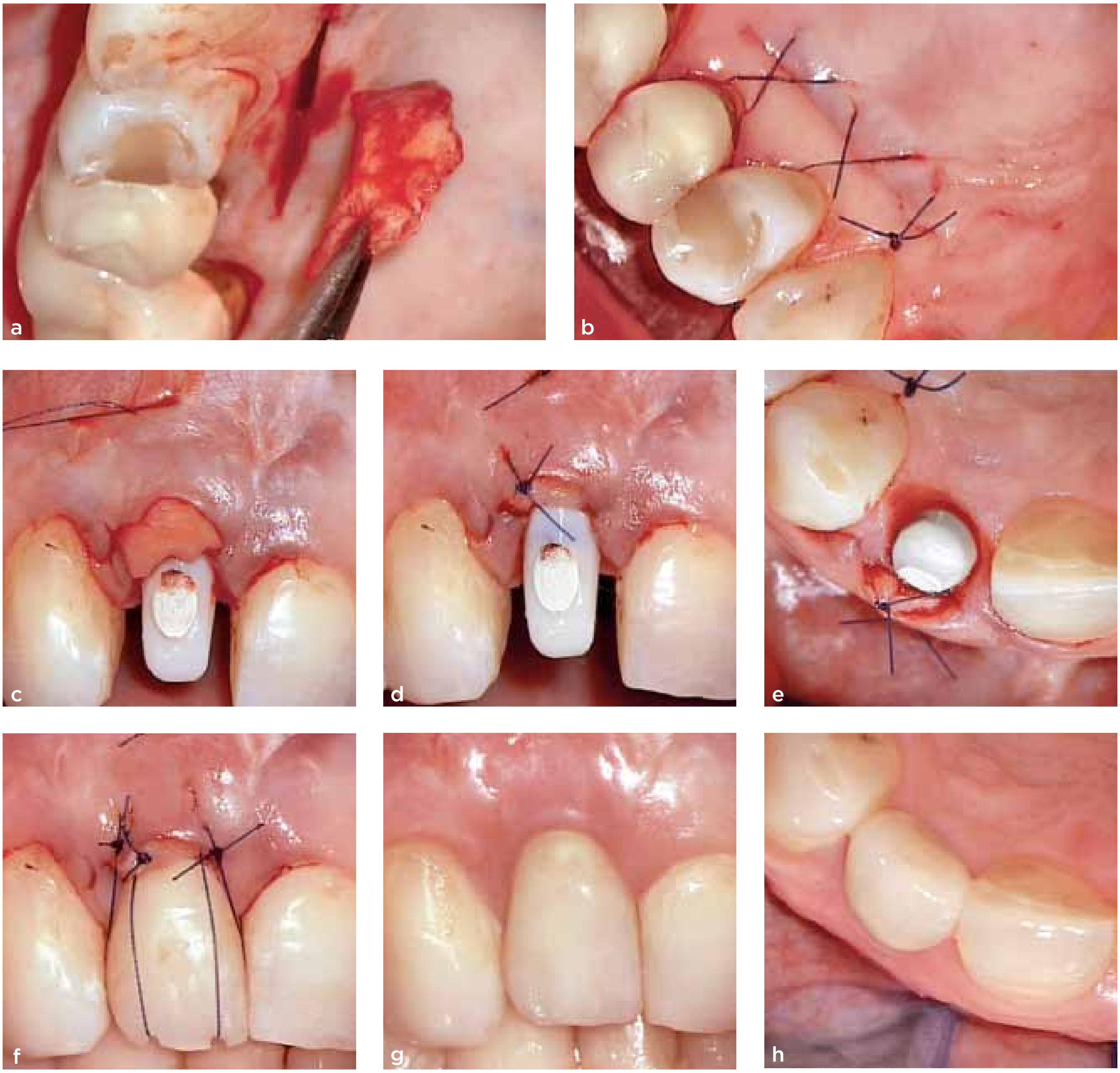
1. Dissection of split flaps
2. Tunneling technique
3. Soft tissue augmentation with connective tissue grafts or free gingival grafts
4. Incision for definition of the flap shape for implant exposure
5. Flap transfer and insertion of gingiva formers
6. Microsurgical wound closure

Dissection of Split Flaps and Tunneling Technique (5× to 12× Magnification)

Elevation of a purely mucosal flap or sharp dissection in the mucosal connective tissue layer, regardless of the location, requires a lot of experience. These measures are not feasible in the case of a thin gingival biotype without appropriate microsurgical instruments and optical magnification. Under the OPMI, the cutting tip of the instrument can move safely and parallel to the periosteal layer to avoid iatrogenic perforation of the overlying mucosa (Fig 15).

Soft Tissue Augmentation (6× to 10× Magnification)

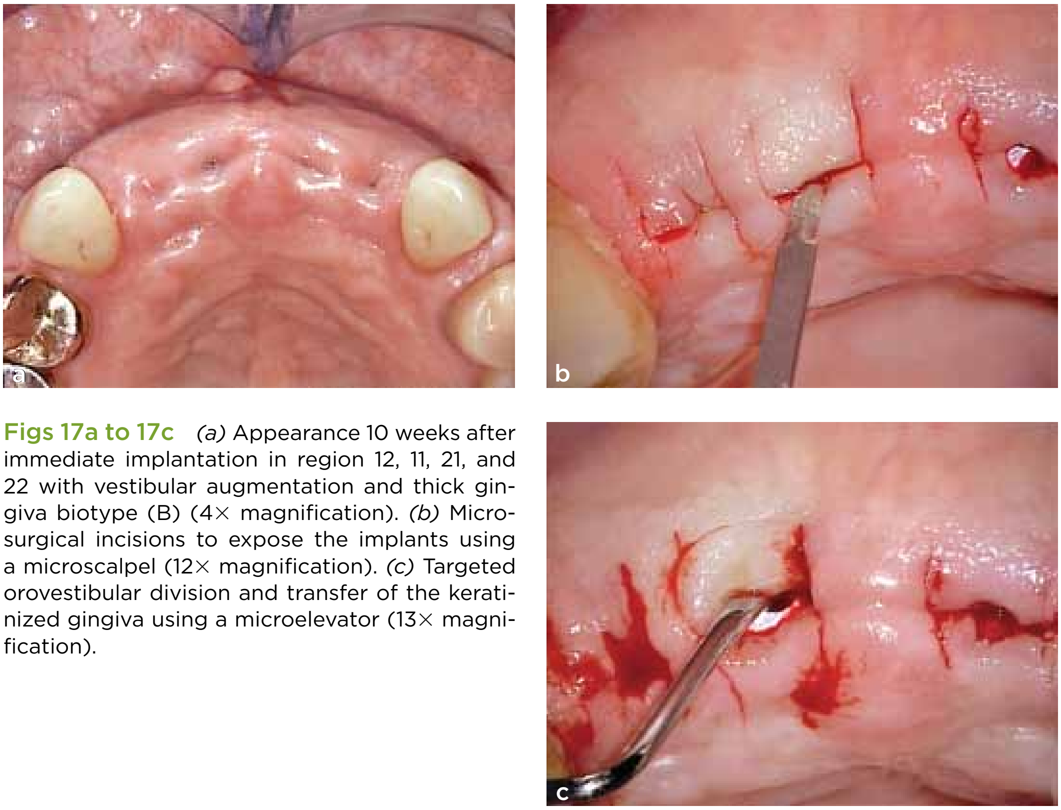
If the apicocoronal width of the fixed gingiva on the buccal flap is less than 2 mm or if the thickness of the soft tissue encircling the implant is insufficient, soft tissue augmentation should be carried out. For this purpose, palatal pedicled or unpedicled connective tissue or free epithelialized grafts have proven effective. The assistance of the microscope proves useful particularly in the delicate dissection of a palatal mucosal flap of uniform thickness for grafting. Correct three-dimensional placement and fixation of these grafts at the recipient site can be done much more precisely under the microscope (Fig 16).



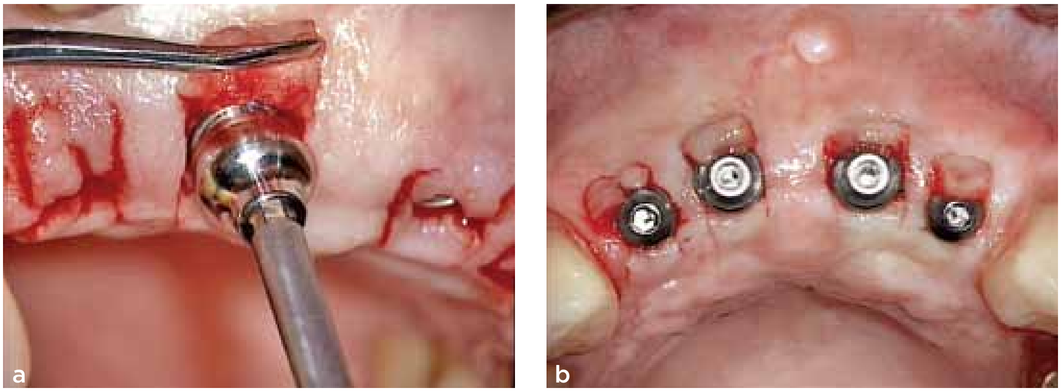
Figs 16a to 16h *(a)* Removal of a subepithelial connective tissue graft from the palate in region 14 to 15 (8× magnification). *(b)* Appearance after palate wound closure in region 14 to 15 with 4/0 Seralon (6× magnification). *(c)* Apical advancement of the looped connective tissue graft into the prepared tissue pocket using 4/0 Seralon (8× magnification). *(d)* Fixation of the connective tissue graft in the correct position using 6/0 Seralon (8× magnification). *(e)* The incisal view shows the desired increase in thickness of the vestibular gingiva in region 12 after introduction of the connective tissue graft (8× magnification). *(f)* Coronal repositioning of the vestibular gingiva after preparation of retention grooves on the incisal aspect of the temporary crown in region 12 with 6/0 Seralon (9× magnification). *(g)* Appearance 6 months after gingival thickening by means of a connective tissue graft, frontal view (9× magnification). *(h)* The incisal view shows that horizontal tissue filling is not complete but is esthetically acceptable (8× magnification).

Incision for Definition of Flap Shape (6× to 14× Magnification)

When making an incision for peri-implant soft tissue management, the existing keratinized gingiva should be distributed as evenly as possible and flap perfusion should be optimal to minimize scarring and resorption. Optical magnification facilitates precise incision making, especially where the amount of keratinized mucosa is limited. In conjunction with a microsurgical scalpel, sensitive areas such as the vestibular marginal gingiva or papillae can be carefully preserved (Fig 17).



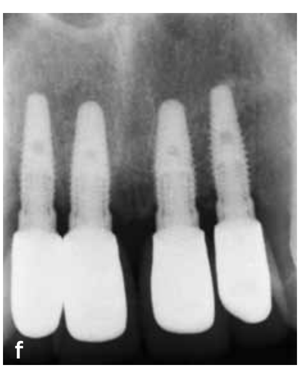
Figs 17a to 17c (a) Appearance 10 weeks after immediate implantation in region 12, 11, 21, and 22 with vestibular augmentation and thick gingiva biotype (B) (4× magnification). (b) Microsurgical incisions to expose the implants using a microscalpel (12× magnification). (c) Targeted orovestibular division and transfer of the keratinized gingiva using a microelevator (13× magnification).



Figs 18a and 18b (a) Insertion of the Camlog Bottleneck gingiva former without crushing the tissue (14× magnification). (b) Appearance prior to microsurgical roll flap technique after insertion of gingiva formers in region 12 to 22 (8× magnification).

Flap Transfer and Insertion of Gingiva Formers (6× to 14× Magnification)

If the width of the attached gingiva is sufficient for circumferential cover of transmucosal implant structures (at least 3 mm), the flap is dissected without tension using microscope-guided incisions so an even transfer of the keratinized parts of the gingiva can be achieved. Especially when replacing implant cover screws with gingiva formers, crushing of the connective tissue between the implant and gingiva former can be avoided (Fig 18).



Figs 19a to 19f *(a)* Microsurgical suture to fix the rolled flap with 6/0 Seralon (14× magnification). *(b)* Occlusal view after conclusion of exposure (8× magnification). *(c)* Noninflamed, keratinized peri-implant soft tissue profile 3 weeks after exposure (9× magnification). *(d)* Frontal view 1 year after fitting the final implant-supported crowns in the right and left incisor regions (9× magnification). *(e)* The incisal view reveals negligible vestibular resorption 1 year after conclusion of the prosthetic restoration (6× magnification). *(f)* Radiographic follow-up confirms normal peri-implant bone structures 1 year postoperatively.

Microsurgical Wound Closure (6× to 14× Magnification)

Optical magnification during microsurgical tension-free approximation of the peri-implant soft tissues after plastic surgical treatment should be regarded as the standard in modern-day implantology. An optical loupe is helpful, but further visual magnification of the operation site, as with all measures described above, leads to greater reproduction of detail. This is often the only way to ensure the correct use and guidance of the microsurgical instruments and needle/suture combinations to promote tissue-sparing wound approximation and superior esthetic results (Fig 19).

CONCLUSIONS

The optimal illumination and high magnification of the operating microscope offers the implantologist entirely new visual dimensions, just as in endodontics or periodontics.

The identification of fine anatomical structures allows for greater precision in diagnosis and during surgery. While this method does require more time and expense and greater surgical skill, this is balanced by increased safety and predictability of treatment. This method diminishes surgical trauma, shortens the postoperative healing period, and produces better esthetic and functional results. Photographic and video documentation can also be carried out more easily and with more authentic results. However, this gradual improvement of the quality of implant treatment using an operating microscope is only one part of a routinely observed minimally invasive microsurgical treatment concept performed with a specially trained team.

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