mucoderm®

3D-REGENERATIVE TISSUE GRAFT

Scientific and clinical evidence

native
stable
three-dimensional

soft tissue
Periodontal surgery and soft tissue grafts

Importance of periodontal plastic surgery

The growing demand for aesthetic procedures has recently led to an increased interest in periodontal plastic surgery, resulting in the development of new surgical techniques and concepts. Gingival recessions as well as reductions of the mucosa around pontics/dental implants or the reduced width of the keratinized gingiva may have a significant impact on the patient’s smile. Besides aesthetic reasons, several indications require the treatment of soft tissue deficiencies.

Clinical consequences of soft tissue reduction

Despite the ongoing debate about the meaning of keratinized gingiva, most scientists and clinicians agree that a sufficiently broad band of keratinized tissue exerts a positive effect on the tooth health and long-term prognosis of dental implants. Not only does the attached gingiva provide protection against mechanical traumas, it also acts as a barrier against the penetration of bacteria and food particles. Studies are still debating whether a reduction in the width of the keratinized gingiva is associated with an increased risk of infections, loss of attachment, and higher plaque accumulation. Such situations may favor gingival recessions, which in turn may lead to hypersensitivity of tooth roots, root caries, and, at worst, tooth loss.

Mucosal- and connective tissue grafts

Today, modern techniques of plastic-aesthetic periodontal surgery ensure a satisfactory regeneration of soft tissue deficiencies in the majority of cases. Free mucosal- and subepithelial connective tissue grafts, both commonly harvested from the palate, are frequently used. Despite their clinical success, their use is associated with significant disadvantages. For instance, when harvesting autologous tissue a second surgical site is created, which may result in increased post-operative pain as well as a higher risk of infections and complications. In addition, the quality of the harvested tissue varies from patient to patient, and its limited availability may become an issue, particularly for the correction of larger soft tissue defects or multiple recessions.

In order to overcome these issues, allogenic and porcine acellular collagen matrices have been developed. mucoderm® is a xenogenic matrix produced by botiss that offers a valid alternative to autologous soft tissue grafts.
mucoderm®
3D-REGENERATIVE TISSUE GRAFT

mucoderm® is a natural, non-cross-linked tissue matrix, consisting of collagen type I and III, which strongly resembles the native structure of the human dermis. In a natural enzymatic process mucoderm® is integrated into the surrounding tissue and replaced by the patient’s own connective tissue. The natural collagen network of mucoderm® that results from the multistep purification process acts as a scaffold for soft tissue cells and blood vessels.

During the healing process, mucoderm® is vascularized and integrated into the surrounding tissue. For a broad range of indications mucoderm® serves as a safe alternative to autologous connective tissue grafts.

Natural, three-dimensional collagen structure
The mucoderm® matrix is made of pure porcine collagen without any artificial/chemical cross-linking. Scanning electron microscopic pictures of mucoderm® show its rough surface and open-porous collagen network that acts as a guiding structure for soft tissue cells and blood vessels.

PROPERTIES
- Native collagen matrix
- Fast vascularization and integration
- Soft tissue graft avoiding the need for autograft harvesting
- Complete remodeling into patient’s own tissue in ~six to nine months
- Rapid hydration
- Easy handling
- Thickness ~1.2 to 1.7 mm

The porous structure of the mucoderm® surface enables the ingrowth of micro-vessels and soft tissue cells

Corrosion preparation showing a vascular network running through the mucoderm® matrix

Handling Tips
- Hydration
  - from five to 20 minutes
- Trimming
  - use a scalpel or a pair of scissors to cut to the desired shape
- Exposure
  - mucoderm® should only be left for open healing, if a revitalization from the surrounding or underlying wound bed is ensured
- Fixation
  - suturing of mucoderm® helps to prevent micromovements

General product handling of mucoderm®

HYDRATION
A sufficiently long hydration of mucoderm® prior to application is necessary. Hydration should be performed in sterile saline solution or blood for five to 20 minutes, depending on the technique used and the desired flexibility of the matrix—the flexibility of the mucoderm® graft increases with hydration time.

TRIMMING
The size and shape of the matrix should be adapted to the size of the defect. After hydration, mucoderm® can be easily trimmed to the desired size with a scalpel or a pair of scissors. Rounding off the edges following brief hydration of the matrix can prevent a perforation of the gingival tissue during flap closure.

For the coverage of multi-recession defects, the surface of mucoderm® can be extended by cutting the matrix on alternating sides (mesh-graft technique) and pulling it.

EXPOSURE
mucoderm® should only be left for open healing, if a revitalization from the surrounding or underlying wound bed is ensured. Exposure should always be avoided when used for recession coverage. Open healing is feasible in the case of a vestibuloplasty, if mucoderm® is sutured to the periosteum.

Fixation
When a split-thickness flap is used, a close contact between the periosteal wound bed and the immobilized mucoderm® matrix should be ensured by suturing the matrix to the intact periosteum using single-interrupted- or crossed sutures.

SUTURING
A tension-free flap closure is always recommended.

Convenient handling of mucoderm® after hydration in blood

mucoderm® trimmed for application with the mesh-graft technique

Compact collagen structure of mucoderm®

Hydration from five to 20 minutes
Trimming
use a scalpel or a pair of scissors to cut to the desired shape
Exposure
mucoderm® should only be left for open healing, if a revitalization from the surrounding or underlying wound bed is ensured
Fixation
sutura of mucoderm® helps to prevent micromovements
mucoderm® is characterized by a high interconnected porosity and natural collagen structure.

Visualization of the open porous collagen structure of mucoderm® by the innovative synchrotron-based x-ray tomography.

The unique structure of the matrix strongly resembles that of the human dermis and supports the ingrowth of cells and blood vessels, thereby promoting a fast tissue integration of mucoderm®.

**Scientific results**

**Biocompatibility** affirmed by MTT-based viability assay

The viability assay supports the high biocompatibility of the mucoderm® three-dimensional collagen matrix in vitro.

The MTT test demonstrated a significantly higher viability of gingival fibroblasts, endothelial cells, and osteoblasts on mucoderm® compared to the control at day six in vitro (p<0.05).

**Tissue integration and degradation of mucoderm®**

**Results from Prof. Dr. Dr. Daniel Rothamel after subcutaneous implantation of mucoderm® in rats**

After only two weeks, mucoderm® showed an extensive ingrowth of blood vessels as well as an inflammation-free healing with superficial cell invasion. In the following four to eight weeks, a continuous degradation with an increasing homogeneous cell distribution can be observed. After eight weeks, 20% of the original matrix volume functioning as scaffold for the formation and reorganization of the connective tissue.

After 12 weeks, mucoderm® was almost completely replaced by newly formed connective tissue (please note that a period of one month in

**Biomechanics and hydration of mucoderm®**

The hydration protocol and its influence on the biomechanical properties of mucoderm® were analyzed in a study of Prof. Dr. Adrian Kasaj. mucoderm® demonstrated optimal mechanical properties after hydration for ten to 20 minutes. A rehydration in blood can improve the biomechanical properties of mucoderm®. Notably, prolonged hydration (30 to 60 minutes) showed only minor effects on the biomechanical properties of the collagen matrix.
Indications for mucoderm®

Implantology,
Oral Surgery and CMF

- Thickening of peri-implant soft tissue
- Soft tissue augmentation in combination with GBR
- Widening of attached gingiva
- Closing of extraction sockets (socket seal technique)

Periodontology
mucoderm® is indicated for guided tissue regeneration procedures as well as for periodontal and recession defects for periodontal plastic surgery. It can be used in conjunction with:
- Coronally advanced flap technique
- Envelope technique
- Tunnel technique

Product Specifications

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Peri-implant soft tissue thickening

Studies have shown that the initial thickness of the mucosa plays an important role in the etiology of early bone loss around dental implants. It has been demonstrated that a thickness of 2 mm or less increases the risk of crestal bone lack. In order to prevent bone loss and to improve the long-term stability of dental implants, it is recommended to thicken the peri-implant soft tissue in cases of thin gingiva biotypes. Soft tissue thickening can be performed prior or simultaneously to implant placement. The application of a xenogeneic soft tissue matrix, such as mucoderm®, helps to avoid soft tissue harvesting from the palate. For simultaneous implant placement and soft tissue augmentation, mucoderm® can be applied as a “poncho” over the healing cap. In that indication, mucoderm® should be covered by vital tissue (flap) to guarantee revitalization of the matrix by ingrowing cells and blood vessels. Prevention of tension is crucial for a complication-free wound healing.

CLINICAL CASE BY
Dr. Algirdas Puisys, Vilnius, Lithuania

MUCOSAL THICKENING AROUND BONE LEVEL IMPLANTS

Crestal incision of the edentulous ridge and raising a full-thickness flap bucally and lingually
Bone preparation for Straumann® Bone Level implant placement
Implant insertion and crestal bone contouring with a straight handpiece
Hydrated mucoderm® perforated and pulled over the healing cap

The margins of the flap are adapted and sutured leaving the abutment open
Situation after suture removal one week post-operative
Wider healing abutment after four months
Smooth emergence profile visible after removal of the healing abutment

Final restoration five months post-operative
Stable clinical situation after five years

**CLINICAL CASE BY**
Dr. Hassan Maghaireh, Leeds, UK

**PERI-IMPLANT SOFT TISSUE AUGMENTATION WITH MUCODERM® FOR PONTIC**

- X-ray of the initial clinical situation
- Lost ridge bone and lack of keratinized tissue after tooth extraction
- Primary stability of two placed Straumann® BLT implants
- Mucoderm® cut in half and inserted buccally to increase the tissue thickness
- Second half of mucoderm® positioned to correct the anatomical shape of the soft tissue
- Tension-free wound closure with a slightly exposed area
- Healing three months post-op with larger layer of keratinized tissue
- Placement of standard ceramic-metal bridge
- X-ray control shows stable tissue for pontic

**GBR AND SOFT TISSUE AUGMENTATION WITH CERABONE® AND MUCODERM®**

- Initial situation: missing teeth 11 & 12 and badly broken tooth root 21
- Bone defect after extraction, occlusal view
- Immediate implant placement of tooth 21 and delayed implant placement of tooth 11
- GBR with autologous bone chips covered with small cerabone® particles and two mucoderm® as barrier membrane and for soft tissue augmentation.
- Augmentation site occlusal view
- Mucoderm® stabilized with titanium pins and sutured together to achieve maximum stability
- Closure without tension using sling sutures
- Complete closure of the wound
- 12 weeks after surgery: satisfactory convexity
- 18 weeks after surgery: regenerated and matured soft tissue
- Final screw retained restoration five months after surgery
- Final clinical outcome
ATTACHED GINGIVA—protection of teeth and implants

Under healthy conditions, the teeth are lined by a band of attached gingiva of about five millimeters in width, which is anchored to the underlying alveolar bone and cementum through connective tissue fibers. This particular arrangement creates a barrier around the teeth, protecting the tooth roots against penetration of bacteria and food particles.

Moreover, the attached gingiva reduces the mechanical strain from the lip-, cheek-, and mimic muscles, shielding the teeth from the strain. A reduction or lack of attached gingiva may cause root recessions and inflammation (periodontitis), which may lead to bone resorption and tooth loss. Likewise, a sufficient width of attached gingiva around dental implants may improve their survival by facilitating plaque control in the peri-implant area and preventing recessions at the implant. In particular, prior to or immediately after implant placement, an augmentation of the attached gingiva is indicated.

AUGMENTATION OF THE ATTACHED GINGIVA

The current standard technique to widen the attached gingiva is called vestibuloplasty, which is performed in combination with a free mucosal graft. Following the preparation of a mucosal flap, the soft tissue graft is fixed to the exposed periosteum (donor bed) and left for open healing. However, the harvesting of the graft causes additional discomfort for the patient and may cause further post-operative discomfort, an increased risk of swelling, post-operative bleeding, parasthesia, and inflammation. In some cases, post-operative discomfort may persist for several weeks. The application of a xenogenic collagen matrix, such as mucoderm®, can avoid the painful harvesting procedure and consequently increase the patient’s acceptance of the treatment plan.

APPLICATION OF MUCODERM® IN PLACE OF A FREE MUCOSAL GRAFT

mucoderm® matrix may be applied instead of a free mucosal graft to cover the prepared donor bed during vestibuloplasty. Following hydration and shaping, the matrix is adapted to the periosteum and fixed with sutures. A close contact between the periosteum and mucoderm® is essential to ensure fast integration and revitalization of the matrix by the ingrowth of blood vessels and cells. mucoderm® serves as a scaffold for the formation of connective tissue and is completely remodeled into the patient’s own tissue within weeks following surgery.

CLINICAL CASE BY

Dr. Attila Horváth, Semmelweis University, Budapest, Hungary

TREATMENT WITH MUCODERM® TO INCREASE THE PERI-IMPLANT KERATINIZED MUCOSA

Lack of sufficient keratinized mucosa is visible as a result of considerable horizontal ridge augmentation. The split-thickness flap was prepared; the buccal peri-implant mobile mucosa was positioned apically, creating an immobile periosteal recipient bed. The xenogenic dermal matrix (mucoderm®) was trimmed and rehydrated in sterile saline. mucoderm® was immobilized with modified deep periosteal and superficial mattress sutures to attain a tight contact to the periosteum.

No signs of allergy, rejection, suppuration, or ulceration were detected; following maturation of the graft, three Straumann SLActive® implants were inserted according to the prosthetic indication. Sufficient peri-implant keratinized mucosa and deep vestibulum were achieved around all implants.

Six months after insertion of the xenogenic dermal matrix, the new peri-implant keratinized mucosa showed matured and stable properties.

Six years follow-up

9 Horvath et al., (2014): Comparison of different approaches aiming at increasing peri-implant keratinized mucosa. ITI Poster presentation.
CLINICAL CASE BY
Dr. Bálint Mólnar and Prof. Dr. Péter Windisch, University of Budapest, Hungary

AUGMENTATION OF THE ATTACHED GINGIVA WITH MUCODERM®

Full arch reconstruction of insufficient vestibular depth and lack of keratinized tissues. Application of mucoderm® with an apically repositioned split-thickness flap.

Insufficient keratinized mucosa and extremely shallow vestibulum on the edentulous maxilla following bilateral sinus floor elevation and horizontal GBR therapy.

Apically repositioning of the flap by palatal incision along the maxilla. Split-thickness flap preparation with an intact periosteal layer over the augmented bone.

Fixation of the buccal flap to the exposed periosteum deep in the vestibular fold. Fixation of mucoderm® with resorbable monofilament (Monolac) single and cross-typed sutures.

mucoderm® fixed to the periosteum with single and cross-sutures.

Clinical situation one week post-operative: secondary epithelization and newly formed capillary vessels detectable.

Clinical situation six months post-operative: excellent tissue maturation, favourable color and thickness of the newly formed soft tissue around the implants.

Two weeks post-operative: secondary healing continued over mucoderm® treated areas, remaining sutures were removed.

Two weeks post-operative: secondary healing completed.

The socket seal technique aims to maintain the soft tissue volume as well as ridge contour. After an atraumatic tooth extraction, the socket is closed with a soft tissue graft. The extraction socket may be filled with a bone substitute material prior to sealing. The sealing stabilizes the blood clot, while the grafting material (if used) protects the socket from contamination and helps to maintain the topography of the alveolus. An autologous mucosal transplant harvested with a punch from the palate is typically used to close the alveolus. In this situation, mucoderm® might be applied as an alternative that spares grafting of the tissue from the palate. After rehydration, the matrix may be easily cut to shape and sutured to the marginal gingiva. For this particular indication, botiss has designed a pre-shaped mucoderm®, called mucoderm® punch which does not need further cutting and is ready to use.

CLINICAL CASE BY
Dr. Hassan Maghaireh, Leeds, UK

SOCKET SEALING WITH MUCODERM® PUNCH

Extraction of tooth 21

Atraumatic extraction

Hydration of mucoderm® punch in sterile saline

Fixation of mucoderm® punch with single interrupted sutures

Healing after 12 weeks

In recent years, a variety of treatment concepts has been developed to prevent/minimize the loss of hard and soft tissue structures following tooth extraction and to create optimal conditions for later implantation or conventional prosthetic restoration.10,11


Application of mucoderm®
in plastic-aesthetic
periodontal surgery

Gingival recessions are not only an aesthetic issue. They can also cause clinical problems, such as root hypersensitivity, cervical root caries, and root abrasion. Today, autologous connective tissue grafts are considered the “gold standard” for the treatment of periodontal recessions; however, harvesting is often associated with pain and discomfort for the patient. The application of a regenerative tissue graft avoids autologous connective tissue harvesting, thereby enhancing the patient’s acceptance for a surgical procedure.

The correct application and handling of the graft material is a prerequisite for aesthetically optimal clinical results. The following application guidelines, based on clinical results, have been developed together with Prof. Dr. Adrian Kasaj, specialist for Periodontology at the Department of Operative Dentistry and Periodontology at the University of Mainz.

Selection of patients
mucoderm® offers a safe and effective alternative for covering recession defects, especially when patients do not agree to undergo palatal autograft harvesting. Nevertheless, expectations concerning the clinical and aesthetic outcome of the surgery should be carefully considered and discussed with the patient. Compliance with the post-operative treatment plan, as well as an unimpaired or controlled state of health, are indispensable for a successful treatment.

Product Specifications
Regardless of the applied technique, the clinical success of the treatment of Miller class I/II defects is more predictable than that of class III/IV defects. In principle, a complete recession coverage can only be obtained for Miller class I/II defects. Likewise, the predictability and success rate for the treatment of defects in the maxilla are higher than those of mandibular defects.

Post-operative treatment
After the surgery, it is necessary to avoid any mechanical trauma of the treated site. Patients should be instructed not to brush their teeth at the respective side for four weeks following surgery. Plaque accumulation can be prevented by rinsing with a 0.2% chlorhexidine solution. Post-operatively, the patient should be recalled weekly for plaque control and healing evaluation.
CLINICAL CASE BY
Prof. Dr. Adrian Kasaj, University of Mainz, Germany

RECESSION COVERAGE WITH THE MODIFIED CORONALLY ADVANCED FLAP TECHNIQUE (ZUCCHELLI TECHNIQUE)

Multiple gingival recessions at teeth 12, 13 and 14 before treatment with mucoderm®

A sulcular incision from tooth 11 to 15 is made and a split-full-split-thickness flap is raised

Hydrated mucoderm® is trimmed and placed over the denuded roots and fixed on the periosteum

The flap is coronally repositioned over the root surfaces and the matrix fixed with sling sutures

Handling Tips
- Contact of mucoderm® with the periosteal wound bed and immobilization should be ensured by suturing the matrix to the periosteum using single-interrupted or crossed sutures
- Rounding off the edges of a briefly hydrated matrix prevents perforation of the gingival tissue after flap closure

Clinical situation 18 months post-operative

Three months post-operative: Significant coverage of the roots and increased thickness of the marginal tissue

Handling Tips
- For the tunnel technique a prolonged hydration of mucoderm® is recommended (ten to 20 minutes)
- Fixation of the matrix can be done with single interrupted or cross-sutures

Situation after gingival plastic for leveling of the FGG

Three months post-operative: previously exposed roots are significantly covered; in addition, the thickness of the marginal tissue has increased

RECESSION COVERAGE WITH THE CORONALLY ADVANCED FLAP TECHNIQUE

Initial situation with gingival recession and muscle strain on tooth 24

mucoderm® hydrated, cut-to-shape, and sutured to the periosteum

Repositioning and suturing of the flap over mucoderm® and the tooth root

Situation after a healing period of three months

Clinical view before treatment with mucoderm®, gingival recessions at teeth 23 and 24

Preparation of roots by scaling and planning with sonic scaler

Conditioning of roots with 24% EDTA gel for two minutes

Subcicular incisions around teeth 22 to 25; a partial-thickness dissection by undermining the papillae using tunneling instruments

Hydrated and trimmed mucoderm® is checked to fit into the defect and placed over the roots by pulling it through the tissue tunnel

The flap is repositioned over the mucoderm® and sutured

Three months post-operative: previously exposed roots are significantly covered; in addition, the thickness of the marginal tissue has increased

Clinical situation 12 months post-operative

COVERING OF MULTIPLE RECESSIONS WITH MUCODERM® BY THE ENVELOPE TECHNIQUE

Gingival recession at tooth 19 before the treatment with mucoderm®; previous surgery with FGG is visible

mucoderm® is hydrated and cut to shape for placement over the root

A subepithelial pouch is prepared by a partial thickness incision; mucoderm® is placed in the pouch

Clinical situation at three months: significant root coverage and increased thickness of marginal tissue

Handling Tips
- For the tunnel technique a prolonged hydration of mucoderm® is recommended (ten to 20 minutes)
- Fixation of the matrix can be done with single interrupted or cross-sutures

Situation after positioning of mucoderm®, the flap is fixed to completely cover the graft

Clinical situation three months: significant root coverage and increased thickness of marginal tissue
COVERING OF MULTIPLE RECESSIONS IN THE LOWER JAW WITH THE MODIFIED TUNNEL TECHNIQUE AND MUCODERM®

Clinical situation before surgery: multiple recessions

Using a microsurgical blade and tunneling knives, mucoperiosteal flaps were raised beyond the mucogingival junction at each involved tooth.

Hydration of mucoderm® for about five minutes in sterile saline or blood and adapting its shape according to the width of the recession defects.

For a tension free coronal movement of the flap all muscle insertions and collagen fibres were cut. Mucoderm® is pulled into the tunnel by mattress sutures and fixed to the inner aspect of the flap.

Stable clinical situation at 24 months post-surgery.

Multiple gingival recessions at teeth 21, 22 and 23 prior to surgery

Sulcular incision from teeth 21 to 23

Preparation of a split-full-split-thickness flap and de-epithelialization of the anatomical papillae

Application of Emdogain® to the conditioned root surfaces

Adaptation of the hydrated and cut-to-shape mucoderm®, and suturing to the periosteum

Repositioning of the flap over mucoderm® and the root surface

Wound closure, occlusal view

Healing four weeks after surgery

Clinical situation eight weeks post-operative

Handling Tip
Emdogain® can be directly applied to the tooth roots and then covered with mucoderm®. Alternatively, mucoderm® may be coated with Emdogain® prior to application.

Satisfactory coverage of the roots and thickening of the marginal gingiva, nine months post-operative
