Higher Vascularisation with Tissue Expanders

The use of osmed expanders prior to vertical augmentation of resorbed edentulous ridges reduces the mean incidence of post-operative graft exposure from 25% to 4% and increases mean vertical bone gain from approx. 4.0 mm to 7.5 mm compared to augmentations without prior tissue expansion,* as by the use of expanders the surrounding soft tissue is well vascularized and a tension-free closure is facilitated.

Following studies state a better vascularisation with the use of tissue expanders:

- **higher functional microvessel density**
  - von See (2009) A:
    - Study on 16 Lewis rats:
    - Comparison after augmentation with and without prior tissue expansion

- **more rapid osseointegration**
  - von See (2010) B:
    - Study on 48 Lewis rats:
    - Comparison: fast, slow and no tissue expansion

- **no periosteal microcirculation, but**
  - formation of connective tissue with significantly higher microvessel density than healthy periosteum
  - Kaner (2012) C:
    - 10 beagle dogs:
    - Effect of tissue expansion vs. untreated tissue

- **submucosal implantation of soft tissue expanders does not affect microcirculation**
  - Kaner (2014) D:
    - 10 beagle dogs:
    - Effect of tissue expansion vs. untreated tissue

- **reduces the impairment of microcirculation caused by vertical ridge augmentation**
  - Kaner (2012) C:
    - 10 beagle dogs:
    - Effect of tissue expansion vs. untreated tissue

- **decreases the incidence of wound dehiscences**

* Soft tissue expansion with self-filling osmotic tissue expanders before vertical ridge augmentation: a proof of principle study
Doğan Kaner and Anton Friedmann
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| Bone augmentation after soft-tissue expansion using hydrogel expanders: effects on microcirculation and osseointegration (A) |


**Objective:** The success of bone augmentation, for example of the alveolar ridge, might be endangered by dehiscence of the soft tissue that covers the augmented bone. Soft-tissue coverage can be achieved without tension through pre-augmentation tissue expansion with hydrogel expanders. We used a periosteal chamber to study the influence of tissue expansion on microcirculation and osseointegration in an in vivo animal model.

**Material and Methods:** Sixteen isogenic Lewis rats were randomised into two groups. Additional eight animals served as donors of isogenic bone grafts (Group 3, n=8). The bone grafts were harvested and implanted into Group 1 animals (n=8) (without tissue expansion) and Group 2 animals (after tissue expansion). In Group 2 (n=8), hydrogel expanders were inserted subperiosteally at the site to be augmented for 21 days. We used intravital microscopy to monitor microcirculation in vivo for 19 days after implantation. Specimens from both groups were evaluated histologically.

**Results:** During the entire study period, functional microvessel density in the region above the augmentation material was significantly higher after previous tissue expansion (P < 0.05). Both groups showed physiological microcirculation around the augmentation material. Histology revealed bone osseointegration of the bone graft in the group with tissue expansion and the presence of connective and granulation tissue in the group without tissue expansion.

**Conclusion:** Pre-augmentation soft-tissue expansion with hydrogel expanders leads to higher functional microvessel density in the tissue above the augmentation material and thus, to more rapid osseointegration. The use of hydrogel expanders appears to increase the probability of success, especially of pre-implant bone augmentation.

| Microvascular Response to the Subperiosteal Implantation of Self-inflating Hydrogel Expanders (B) |


**Purpose:** Excessive stretching of the overlying soft tissue often occurs during the attempt at primary closure after bone augmentation. Preliminary soft tissue expansion may prevent such perfusion disturbances caused by stretching. The purpose of this study was to investigate the effects of using self-inflating expanders at different rates to expand overlying soft tissue prior to the bone-grafting procedure.

**Material and Methods:** Two different hydrogel expanders with different inflation curves were used. For the experiments, 48 Lewis rats were divided into six groups of eight animals each. In four groups, the different expanders were implanted subperiosteally on the calvarium. In two of these groups, an observation window was implanted for intravital microscopy. In the other two groups, histologic analysis of the covering skin was performed. Intravital microscopy of the unexpanded periosteum and histologic analyses of unaugmented rats served as control groups.

**Results:** Following implantation of the expanders, intravital microscopic examinations showed that, irrespective of the expansion curve, peristomial microcirculation had stopped completely without reperfusion within 14 days. Histologic analyses of the soft tissues, however, showed a well-vascularized connective tissue layer clinging to the expander. The microvessel density measured was significantly higher above slowly inflating expanders (91.2 ± 8.8 vessels/mm²) than above rapidly inflating expanders (48.4 ± 2.7 vessels/mm²) or unoperated periosteum (60.4 ± 4.8 vessels/mm²).

**Conclusion:** Subperiosteal implantation of self-inflating expanders leads to complete ischemia of the periosteum. However, replacement of the periosteum by connective tissue takes place within 14 days as a result of subcutaneous angiogenesis. This tissue may have a significantly higher microvessel density than healthy periosteum.

| Submucosal implantation of soft tissue expanders does not affect microcirculation. (C) |


**Aim:** To investigate the effect of submucosal implantation of self-filling osmotic tissue expanders on mucosal microcirculation.

**Material and Methods:** In ten beagle dogs, all premolars were extracted on both sides of the mandible. Tooth-supporting bone and excess soft tissue were removed to mimic a severely resorbed edentulous ridge. Six weeks later, tissue expanders with 0.7 ml final volume were implanted into a submucosal pouch at randomly selected test sites, while contralateral sites served as untreated controls. Microcirculation was assessed in perfusion units (PU) before surgery, after local anaesthesia, directly after surgery, and after 1 and 3 days, using Laser Doppler flowmetry.

**Results:** Local anaesthesia caused a significant decrease of blood flow from baseline (zero) to -6.4 PU (median; Q1 -10.5; Q3 -9.9; P = 0.006); however, no additional significant decrease was recorded after completion of surgery. Blood flow showed significant increases to -3.6 PU (median; Q1 -11.3, Q3 2.1; P = 0.02) and -4.0 PU (median; Q1 -9.2, Q3 1.1; P = 0.013) after 1 and 3 days, respectively, when compared to the measurements obtained after application of local anaesthesia and completion of surgery. Blood flow had returned to unoperated baseline levels 1 day after surgery (P > 0.05).

**Conclusion:** Submucosal implantation of self-filling osmotic tissue expanders results in only momentary disturbance of microcirculation. The minor impairment of perfusion may explain the consistently good outcomes of submucosal implantation of these tissue expanders.

| Improvement of microcirculation and wound healing in vertical ridge augmentation after pre-treatment with self-inflating soft tissue expanders – a randomized study in dogs (D) |


**Objective:** We investigated the effect of soft tissue expansion (STE) on vertical ridge augmentation with regard to the incidence of wound dehiscences and the impairment of microcirculation in dogs, and the applicability of laser Doppler flowmetry (LDF) to explore the relation between microcirculation and wound healing.

**Material and Methods:** Bone defects were created on both mandibular sides in ten beagle dogs by extraction of premolars and removal of bone. Six weeks later, self-filling tissue expanders were implanted in randomly assigned test sites. After 5 weeks of expansion, vertical augmentation was carried out in test and control sites using calvarial onlay grafts side by side with granular biphasic calcium phosphate covered with a resorbable polyethylene glycol membrane. Microcirculation was evaluated with laser Doppler flowmetry (LDF). The incidence of wound dehiscences was evaluated after 2 weeks. The validity of LDF to predict dehiscences was evaluated by construction of receiver operating characteristic (ROC) curves.

**Results:** After augmentation, test sites showed significantly better perfusion than control sites without preceding STE (P = 0.0012). Three days after surgery, perfusion was still significantly decreased in control sites (P = 0.005), while microcirculation in test sites had returned to presurgical levels. After 2 weeks, healing in test sites was good, whereas eight dehiscences were found in control sites (P = 0.002). ROC curves showed that microcirculation levels immediately after augmentation surgery significantly predicted subsequent wound dehiscences (AUC = 0.799, CI 0.642–0.955, P = 0.006). Conclusions: Laser Doppler flowmetry is suitable for evaluation of soft tissue microcirculation after ridge augmentation. STE reduced the impairment of microcirculation caused by vertical ridge augmentation and decreased the incidence of wound dehiscences in the investigated animal model.

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