Reconstruction of different tissue defects by means of various flaps in plastic surgery

Ph.D. Thesis

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INTRODUCTION

It is the cornerstone of reconstructive surgery to provide a safe coverage for tissue defects of different origin and to restore original shape and function. For these goals, careful defect analysis, clear definition of surgical goals, thorough consideration of surgical options, precise performance and appropriate post-operative follow-up are required. Several various techniques are available for reconstruction and in many cases it may be difficult to choose the best method. According to the presently accepted paradigm, it is now suggested to make surgical decision on the basis of quality instead of simplicity. More complex techniques may produce better results in terms of shape and function and are not necessarily accompanied by an increased rate of complications. Different techniques are often combined in order to provide individualized treatment for specific defects.

Various types of tumors and their excision may lead to large tissue defect which often requires reconstructive intervention. Non-melanoma skin cancers (NMSC) localized to the tibial region can be treated with several methods.

If an NMSC with a diameter under 1 cm is excised, primary wound closure is possible. NMSC of medium size (10-35 mm) may require coverage with flap or skin transplantation. However, surgical management of large NMSC in this region is problematic. The tighter skin, the higher age and the potential comorbidities may result in decreased blood supply that leads to impaired wound healing.

Similarly, treatment of tissue loss in the region of head and neck raises special questions. In reconstruction of soft tissue lesions in the neck, the primary goal is to appropriately cover the exposed vital organs with well-vascularized tissue harvested from a distant donor site. Thorough defect analysis, evaluation of the patient's general condition and the anatomy of the defect site shall support the surgical decision on the applied method. The extended lower trapezius myocutaneous flap (LTMF) and latissimus dorsi myocutaneous flap (LDMF) seem to provide good solution since these muscle compartments can be transferred on a reliable vascular pedicle to suprascapular and neck regions. The flap shall be selected after consideration of their anatomy, their way rotation and an analysis of the size, extension and site of the defect.

Perioral defects may originate in malignancies, traumas and congenital disorders. Reconstruction of the upper lip is a difficult surgical problem because of its prominent location, elegant form and important functions. If small and full-thickness defects affect only one-fourth to one-third of the lip (the width does not exceed 2 cm), primary wound closure is possible. Larger lip defects require application of flaps. In such cases, local flaps shall be

chosen because they minimize donor site morbidity and these provide the best functional and esthetic outcome. If the defect involves 1/3-2/3 of the lip, cross-lip flaps (e.g. *Abbé* or *Estlander* flaps), circular-rotational flaps (*Karapandzic* or *Gillies*), nasolabial flap and *Kazanjian* reverse flap can be chosen. If reconstruction is performed in more steps, combined local flaps are applied. In the first step, the oral sphincter is reconstructed e.g. with the extended *Karapandzic* flap or the *Kazanjian* flap. Subsequently, the volume and symmetry of the upper and lower lips are restored with the cross-lip flap.

Immediate one-stage breast reconstruction is becoming a widely-accepted and preferred method after the removal of breast tumors. However, radiotherapy, inappropriate surgical technique and infection may lead to implant protrusion. Interventions aiming the salvage of implant may often fail. For such cases, capsuloplasty seems to be an appropriate technique. The capsule appearing around the implant is a reaction to foreign material. In human, several areas of application of capsule flap have already been reported. However, the blood flow in capsule flap has not yet been quantitatively determined *in vivo*.

In addition to reconstruction, it is also important to provide appropriate treatment in order to avoid different complications. After application of skinflaps, trapdoor effect is a possible complication. The trapdoor effect is the bulging elevation of the tissues within the confines of a semicircular or circular scar and is common with subcutaneous pedicle flaps. The causes and successful treatment modalities have not been clarified. Combination of different methods can improve appearance but it may be exhausting for the patients.

These special surgical problems and questions let us design individual treatment modalities and assess their applicability and efficacy for reconstruction and for sustaining the results of surgical intervention.

AIMS

Our primary aim was to find appropriate solutions for injuries which are difficult to cover due to their size and/or anatomical localization. For this goal, special flaps were designed, performed and the healing of the patients were monitored. Moreover, a new therapeutic approach was tested in order to retain the esthetic result achieved by the flaps and to decrease trapdoor deformity. The study comprises 5 parts with different objectives. The detailed aims are listed below:

- to cover a large defect in the anterior tibial region, which affected the cortical region of the bone, with application of a muscle flap and skin graft (Part 1),

- to find an optimal solution for the reconstruction of a deep tissue loss in the cervical region, which was exposed to irradiation and an earlier flap reconstruction has failed, utilizing myocutaneous flap (Part 2),
- to reconstruct a large upper lip defect due to dog bite by using combined flaps (Part 3),
- to treat exposed breast implants with capsule flap (Part 4), and
- to reduce trapdoor effect in subcutaneous island pedicle flaps with manual lymph drainage (MLD) (Part 5).

METHODS

Reconstruction of a defect on the tibia using tibialis anterior turnover flap combined with skin graft

A 58-year-old male patient was admitted to our department with an ulcerating lesion on the anterior part of the right tibia that was found to be squamous cell carcinoma. The tumor was excised and the periosteum with a thin cortical layer was also removed. In order to cover the wound, the anterior tibial muscle flap was applied and the flap was partially rotated onto the bone surface. Onto this flap, a split-thickness meshed skin graft was placed.

A new application of the extended lower trapezius myocutaneous flap (LTMF)

A 49-year old male patient was admitted to our head and neck surgery department with a diagnosis of squamous cell carcinoma in the right tonsillar region and the soft palate. The tumor was excised. However, late metastases appeared the removal of which led to large and deep tissue defect on the neck. This was covered with a LDMF, but it slowly necrotized. Thus, another solution was required. For this aim, the extended LTMF was chosen. The trapezius and the rhomboid muscles and the contour of the scapula were marked. The rotation point was marked next to the medial-superior edge of the scapula where the supplying vessels enter the muscle. Finally, above the end of the trapezius muscle a skin island – equivalent in size to the defect (5x12 cm) – was determined. After excision, the muscle pedicle of the flap was dissected up to the rotation point at the medial-superior edge of the scapula. On the lower surface of the pedicle, the supplying vessels were identified. The recipient site was prepared for the new flap. The extended LTMF was rotated laterally into the defect and the donor site was closed free of tension after mobilization of the wound edges.

Reconstruction of a large upper lip defect due to dog bite by Kazanjian flaps

A 57-year-old female patient was attacked by her dog in her home. The patient suffered serious scalp and facial injuries. Later she was transferred to our department for the reconstruction of the upper lip. Due to the injuries, approximately 70% of the upper lip was missing. Adhesions were found in the lateral sides, the upper denture was exposed and the oral mucosa was dry and painful. Further, the patient's ability for nutrition and speech was limited. For reconstruction, a *Kazanjian* flap was rotated from the left lower lip area to repair the upper lip defect. The repaired upper lips made it possible to close the mouth and provided coverage for the teeth. In the second stage of the lip reconstruction, a cross-lip flap (*Abbe*) was used in order to restore the symmetry and volume of the upper and lower lips. After the treatment, microstoma developed, which was corrected by commisurotomy and mucosa plasty of the series of operations.

Reconstruction of exposed breast implant with capsule flap

Capsuloplasty was performed in 19 females between January 2016 and November 2017. These patients underwent earlier mastectomy and immediate breast reconstruction with implantation. Each intervention was preceded by careful consideration of the following parameters: quality and thickness of the breast skin, presence of inflammation, discharge and fistula, previous radiotherapy, localization of tissue damage, patient requirements and the extension of necrosis and wound separation. Signs of serious inflammation and large tissue defect were considered exclusion criteria. The tissue defect in our patients appeared 8-13 weeks after the mastectomy (median interval: 9 weeks). When the complication was recognized, the patients started to be prepared for the reconstruction which was performed within 3-5 days. In 3 cases, an attempt was made to close the wound primarily after removal of the necrotic tissue. The operation involved the following steps: after opening the wound the necrotic parts were excised, the implant was removed and capsulotomy was performed, the base of the flap remained intact, the planned flap was dissected free. After that, the implant was positioned and covered with the capsule flap. In 3 cases, thoraco-epigastrial fasciocutaneous flaps were used together with capsule flap in order to complete the reconstruction due to a large defect.

Microcirculation of the flaps was monitored by means of the PeriFlux System 5000. Measurements were performed at 4 different time points: before the incision of the intact capsule (baseline), after capsulotomy, after preparation of the capsule flap and after

fixation of the flap. The data are given as perfusion unit (P.U.). At later time points, perfusion values are given in percentage referred to the baseline.

During operation, biopsies were taken from the capsule. In addition to routine hematoxylin-eosin staining, sections were processed for immunohistochemical localization to highlight CD34 positive vessel density. Data analysis was performed with SigmaStat for Windows. Since the normality test (Shapiro-Wilk) failed in few cases, nonparametric test was chosen. Friedman repeated-measures analysis of variance on ranks was applied. Data are given as median values (M) with the 25^{th} and 75^{th} percentiles (25p, 75p, respectively).

MLD for reduction of trapdoor effect in subcutaneous pedicle island flaps

This part of the study involved 2 patients. The first patient was a 54-year-old woman, who underwent an excision of a nominal 11x6 mm basal cell carcinoma on the left cheek. The skin defect was covered with a subcutaneous island pedicle flap from the lateral side. After 2 months the trapdoor deformity developed. The second patient was a 58-year-old woman who developed a nominal 22x24 mm basal cell carcinoma on the right cheek. It was surgically removed and the defect was reconstructed with a subcutaneous pedicle island flap. The patient noticed swelling of the reconstruction 3 weeks post-operatively. Both patients were treated with a daily 30-min MLD 3 times/ week for a 1-month period. The MLD consisted of drainage of the neck region followed by the stimulation of the lymph nodes of the corresponding area. The drainage of the flap included standing circles around the scar and superficial linear manual drainage parallel to the lymph collectors. The patients were followed up over the preceding 4 months. The efficacy was photographically assessed by a visual analog scale (VAS).

RESULTS

Successful reconstruction of the defect on the anterior part of the tibia

2 days after surgery, the viability of the skin graft placed onto the anterior tibial muscle flap was visible. The entire operation site was found to be healed 2 months later and the cosmetic result was good. The histological analysis revealed an ulcerated squamous cell carcinoma which infiltrated also the deeper dermal layers. The margins were found to be tumor-free.

Reconstruction of the deep neck defect

The operation was successful, the flap remained viable and the wound healed primarily.

Restored upper lip with the Kazanjian flap

In the operation site, the sensory function returned in 3 months. After 6 months, the movements of the lip were intact. The patient was able to pucker the lips, open the mouth and to eat. The intervention led to both functionally and esthetically satisfactory results.

Breast implantation salvage with capsule flap

Attempts at the primary closure of wounds after removal of necrotic tissue failed in the above mentioned 3 cases: the implants were exposed again. However, application of capsule flaps led to the healing of these patients without complication. Postoperative follow-up (ranging from 2 months to 19 months) showed that capsule flaps survived in each case. No signs of inflammation, infection, hematoma, wound separation and implant protrusion were found. Slight erythema was detected in 2 cases. In few cases, uneven surface and wrinkling were detected. However, our examinations excluded the capsular contracture and all of these signs ceased within 3 months.

As concerns microcirculation of the flaps, the baseline median value in capsule flaps was 98.97 P.U. (25p=73.56, 75p=124.09). The perfusion in the capsule did not change after the capsulotomy (M=106.96%, 25p=62.82, 75p=157.07) as referred to the baseline values. Although a slight decrease was measured after preparation of the capsule (M=64.08%, 25p=33.36, 75p=135.99) and fixation of the flap (M=51.41%, 25p=32.7, 75p=96.99), this change was not statistically significant.

The baseline values of the thoraco-epigastrial fasciocutaneous flaps: M=14.87 P.U., 25p=10.37, 75p=32.15. No decrease was found in their blood flow after incision (M=95.56%, 25p=48.14, 75p=127.44), after preparation of the flap (M=120.27%, 25p=45.32, 75p=173.77) or after fixation of the flap (M=62.52%, 25p=31.58, 75p=108.59).

Histological analysis revealed that capsules were well-vascularized and several vessels were present in the connective tissue which may provide sufficient blood supply for the capsule. Immunohistochemistry confirmed this finding: the CD34-positive structures demonstrated angiogenesis in the capsule.

Successful therapy of trapdoor effect

On completion of the MLD and the follow-up period, the trapdoor deformity of 2 patients was effectively restored. The VAS showed a drastic improvement in both patients' quality of life (69-84-84 and 74-87-87, respectively).

DISCUSSION

Prior to direct restorative interventions, ablative procedures are often necessary to be performed in order to eliminate the underlying disease or injury. Complete ablative procedures are required for a successful reconstruction and the extension of tissue loss due to ablative intervention can be considered in advance when designing the method of recontraction. Different techniques can be used to eliminate tumors depending on their histological type and size. In the tibial region, only minor NMSC can be treated by means of simple excision. Different flaps can be used to cover defects originating in the removal of bigger tumors. In the present case, the periosteum and the cortical layer of the tibia had to be removed since the tumor reached the deeper layers. Thus, the wound basis was the bone which is not ideal for the survival of a skin graft. Accordingly, the partial transposition of the anterior tibialis muscle was chosen in order to provide a good basis for the skin graft and to cover the bone. Use of the muscle itself, instead of utilization of it as a musculocutaneous flap, leads only to a moderate weakness in the movements of the ankle. This technique is safe, reliable, not difficult and is not accompanied by loss of function. The present case confirms that a deep defect after the removal of an extended tumor over the proximal and middle part of the tibia can effectively be reconstructed with a combination of the anterior tibialis turnover flap and a skin graft.

It seemed to be a technically difficult problem to find an optimal covering option for the deep lesion in the cervical region, as well. Decades ago, the trapezius myocutaneous flap was described. The cornerstone of LTMF technique is the vascular supply from the dorsal scapular artery, which originates either directly from the subclavian artery as an independent branch or from the trunk of the transverse cervical artery. The extended LTMF flaps are characterized by many advantages: the donor site can usually be closed easily, the flap fills the defect created by the neck dissection and covers the cervical vessels, preventing their damage; and the long, thin musculocutaneous pedicle allows for easy transfer of the island flap, which can even be tunneled into a defect if necessary. As concerns LDMF (which was our first solution), it was found that tunneling of the flap may be difficult. However, the supplying vessels of the trapezius muscle and the muscle itself remained intact therefore it was possible to use this flap for the secondary reconstruction.

Another complex question was the reconstruction of the lips after a severe trauma. Lips are necessary for speech, non-verbal communication, and social interactions. Further, they also determine the esthetic appearance of the face. Several methods are known for the reconstruction of upper lip defects. The neurovascular myocutaneous flap described by

Kazanjian is also a safe and accepted technique both for lower- and upper lip reconstruction. Contrary to other flaps, motor- and sensory innervation can be saved, and intersection of orbicular oris muscle can be avoided. Hence, sphincter denervation and atrophy is minimized, sensory- and motor functions are improved. Moreover, this method is free of problems characterizing distant and microvascular flaps. *Kazanjian*'s flap harmonizes with the adjacent tissue and the new sphincter functions well. Combination of this technique with *Abbe*'s flap seems to be an excellent method to restore subtotal or total loss of lips. Our patient has lost approximately 75% of the total volume of the upper lip due to the above described injury. Although the reconstruction resulted in a slight decrease in the size of the orifice, the subsequent mucosa plasty led to a functionally and esthetically acceptable size. Oral movements, liprounding, speaking, eating and use of cutlery were fully possible. The satisfactory cosmetic results allowed the patient's social reintegration. For such cases, application of combined flaps may be considered because it seems to be a good choice which can have functionally and esthetically acceptable outcome.

Salvage of exposed implant is a great challenge in reconstructive surgery. Different factors may lead to implant protrusion e.g. errors in planning, thermal and mechanic injuries as surgical complications, smoking in the patient's history or previous radiotherapy. Traditional therapeutic approaches may fail in cases of decreased tissue viability and irradiation. Several methods are known for the covering of implants e.g. acellular dermal matrix (ADM), abdominal fascial flaps, autologous dermal graft and polyglycol mesh, extended larger flaps. However, they may have disadvantages: ADM is expensive and patients often refuse more radical surgical flap techniques. Capsule flaps provide a less invasive and cost-effective solution. Our results, in accordance with findings in the literature, show that capsule flaps provide a well-vascularized layer which prevents protrusion of the implant and decreases tension, thereby promoting wound healing and reduced risk of inflammation and superinfection. An important novel aspect of our study is the *in vivo* determination of microcirculatory status during the operation. We have found that surgical preparation does not decrease the blood supply of flaps. Thus, the capsule flap seems to be appropriate for salvage of exposed implants and for enhancement of implant cover in case of thin and injured tissue.

After reconstructive interactions, it is an important question how to retain the achieved esthetic results and to avoid complications. Subcutaneous pedicle island flaps often develop trapdoor type deformity, with several possible causes. The MLD is a method of

choice to treat head and neck swellings and causes cosmetologic improvement. Furthermore, MLD improves microcirculation and tissue perfusion, reduces lymph stasis, increases protein resorption and softens fibrosis and scars. Nevertheless, optimal choice of surgical technique may also contribute to the prevention of trapdoor deformity.

In conclusion, careful defect analysis and thorough preoperative design provide possibility for a reconstruction which is esthetically and functionally satisfactory. In several cases, combination of different techniques and individualized therapy seem to be necessary for a good result. The continuous evolution of flap techniques may broaden the toolbox of treatment strategies and hereby contribute to a better healing of complicated tissue defects.

SUMMARY AND NEW FINDINGS

Our study was focused on the treatment of various difficult-to-heal injuries by means of special flaps. We have demonstrated that such carefully designed, individual therapeutic approaches result in satisfactory healing.

- We have shown that the tibialis anterior turnover flap together with skin graft can be successfully used for the coverage of extended lesions in the anterior tibial region even if they affect the cortical layer of the bone.
- LTMF is a useful possibility for the reconstruction of deep lateral neck defects and can be used when other flaps fail.
- *Kazanjian*'s flap in combination with *Abbe*'s flap can be an excellent method to restore subtotal or total loss of lips.
- According to our results, capsule flaps are well-vascularized and have sufficient perfusion therefore they are appropriate for the salvage of exposed breast implants and for enhancement of implant cover in the case of thin and injured tissue.
- MLD leads to a significant cosmetologic improvement in case of trapdoor deformity.

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LIST OF PUBLICATIONS

List of full papers related to the subject of the dissertation

I. Szolnoky G, **Mohos G**, Dobozy A, Kemény L: Manual lymph drainage reduces trapdoor effect in subcutaneous island pedicle flaps. International Journal of Dermatology 2006; 45:1468-1470. **IF: 0.998**

II. **Mohos G**, Szabad G, Szolnoky G, Varga E, Kemény L: Lábszáron elhelyezkedő kiterjedt laphámrák kezelése izomlebeny és bőrtranszplantáció kombinációjával. Magyar Traumatológia, Ortopédia, Kézsebészet, Plasztikai Sebészet 2006; 49(4):378-381.

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*: Varga J and Mohos G contributed equally to the work

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I. Sera T, **Mohos G**, Papos M, Osvay M, Varga J, Lazar M, Kiss E, Kapitany K, Dobozy A, Csernay L, Pavics L: Sentinel node detection in malignant melanoma patients: radiation safety considerations. Dermatologic Surgery 2003; 29(2):141-145. **IF: 1.806**

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*: Mohos G and Kocsis Á contributed equally to the work

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