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What's new in plastic surgery?

Co nowego w chirurgii plastycznej?

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S u m m a r y

This article summarizes a number of the new trends and developments in plastic surgery. A number of which, such as face or upper extremity transplantation, can be considered new branches in plastic surgery, since organ transplantation was not previously associated with this discipline. Others, such as breast reconstruction, have evolved alongside plastic surgery and only recently have been exerting a strong influence on the progress of other medical disciplines like reconstructive medicine. This is a result of the methods developed by plastic surgeons in the field of fat processing and its efficient transplantation in face and breast surgery. Nerve-machine interfaces also serve as an example of completely new fields developed in plastic surgery which are currently shaping the future of bionic medicine. Other plastic surgery developments, such as migraine surgery, are the cause of controversial and creative ferment in science, because the results obtained from the surgical treatment of migraines have shed new light into headaches aetiology. The article also mentions transparent medical publishing as this belongs to those areas where plastic surgeons have been early-adopters of new trends derived from field leaders.

S t r e s z c z e n i e

Artykuł zarysowuje niektóre nowe osiągnięcia i trendy w chirurgii plastycznej. Wśród nich niektóre, jak alloprzeszczepy twarzy i kończyny górnej, mogą być uznawane za nowe gałęzie w chirurgii plastycznej, jako że przeszczepianie organów nie było dotychczas związane z rozwojem tej dyscypliny. Inne, jak rekonstrukcje piersi, rozwijały się wraz z chirurgią plastyczną, by dopiero ostatnio wywrzeć silny wpływ na rozwój innych gałęzi medycyny, jak medycyna regeneracyjna. Jest to wynikiem metod opracowanych przez chirurgów plastycznych dla przetwarzania tkanki tłuszczowej i jej skutecznego przeszczepiania w chirurgii twarzy i piersi. Innym przykładem całkowicie nowych dziedzin opracowanych w chirurgii plastycznej i obecnie kształtujących przyszłość medycyny bionicznej są połączenia typu maszyna-nerw obwodowy. Inne osiągnięcia chirurgii plastycznej jak chirurgiczne leczenie migren stały się przyczyną kontrowersji i twórczego fermentu w nauce, ponieważ wyniki uzyskiwane po operacjach wydają się rzucać nowe światło na etiologię tej choroby. Artykuł wymienia także nowe zasady w przejrzystości artykułów naukowych, ponieważ należą one do tych dziedzin, gdzie chirurdzy plastyczni stali się pionierami we wdrażaniu nowych zasad opracowanych w innych dziedzinach nauki.

INTRODUCTION

Plastic surgery encompasses a wide range of procedures which can be carried out over the surface of the human body. The intention of the surgery is, however, limited to two simple goals, that of the restoration of the body's form, and of the body's function. Restoration is therefore the key word that defines this discipline. Since restoration can be considered the act of bringing something back that existed before, or the act of bringing something into existence which should exist if all were natural and expected, then plastic surgery encompasses the entire body's form, as well as its beauty with all the pretence and vanity associated. Traditionally, plastic surgery has been divided into reconstructive and aesthetic surgery. Recently, however, plastic surgery has also been associated with regenerative medicine which focuses on research and the quest for replacement tissues and organs. While reconstructive surgery concentrates more on restoring those body parts that are perceived to be below the norm, aesthetic surgery operates on those body parts that are normal, but considered unsatisfactory to the patient.

Regenerative medicine is currently targeted at reconstructive surgery, but with future endeavours, will come to serve beauty too.

ALLOTRANSPLANTATION IN PLASTIC SURGERY

Traditionally organ transplantation was not linked to plastic surgery. This changed in 2002 when the general public became aware that face transplantation would soon be possible. After the first successful operation in 2005 the original social disapproval changed into gradual agreement (1). Today we no longer question the ethical justification, but have instead new concerns that address more practical and political issues such as costs, and patient allocation. New important questions include issues that were not previously perceived when this procedure was in its developmental stage. Should face transplantation be performed in developing countries where the social need for such treatment is higher than in rich societies where dramatic disfigurements are rare due to prevention? Will ethnical differences between donors and recipients still be important in such circumstances? The relative shortage of facial donors can impose elastic contraindications for candidate selection. Perhaps also gender matching should no longer be important? Recent data shows that it is possible that appearance is not critical, since the transfer of individual facial features is probably negligible (1). Interesting questions also concern the limits of secondary revisions after face transplantation. Recently, major skeletal revisions with Le Fort III osteotomy were performed for malocclusion. Blepharoplasty was also justified, because of the loose skin excess of both eyelids (2). It has been speculated that secondary procedures should also include various nerve transfers for sensory and motor neurotisation (3). The nerve transfers that are now considered a new paradigm shift in plastic surgery are briefly described below.

There is interesting new data concerning upper extremity transplantations. The modern era of forearm and arm transplantation started first with French and American operations in 1998 and 1999 respectively. Since that time more than 107 transplanted upper limbs have been reported. Currently, the main centres that have experience with these procedures exist in the USA, France, Germany, Poland, Austria, Spain, and China. The total loss rate is 22.4%, however the majority of losses occurred after combined procedures, where the patients received hand and leg, or hand and face transplants. Such patients were also more prone to fatal results (4). The most successful functional outcomes were reported for patients with distal forearm transplantations. These patients expect faster recovery, with limited sensory and motor reinnervation. More proximal defects are characterized by weaker hand grip and only minor discriminative sensation. However, even for transhumeral transplantations, protective sensation and some motor function is to be expected which should be regarded as a substantial improvement on the baseline (4). Although surgically complicated, upper limb transplantation is even more challenging from a medical point of view. The success rate of these procedures is strongly dependent on advanced immunosuppression, and the majority of complications are related to postoperative and lifelong medical therapy. It is therefore important that upper extremity transplantations be performed by multidisciplinary centres with professional experience in solid organ transplantations.

BREAST RECONSTRUCTION

There have recently been a number of very interesting changes taking place in breast reconstructive surgery. The two main reconstruction methods currently rely on the use of implants, or autologous tissue, or a combination of both. Reconstruction using implants is the simplest solution, especially in cases of one-stage treatment decisions. In such cases, the reconstruction is performed immediately after a skin sparing mastectomy. A sparing mastectomy preserves a well-perfused envelope, enabling the implant to be covered with skin and muscle. This method is particularly suitable for slim patients with small breasts. In larger and ptotic breast patients, two-stage reconstruction is usually selected (5). It consists of postponing the final reconstruction until the end of the oncological treatment. One of the main disadvantages of secondary reconstructions is the scarcity of tissues needed for a safe implant cover. Traditionally, this problem has been solved by preparing the skin with an expander, or using a tissue flap from the latissimus dorsi (LD) muscle, as an additional implant cover. Such a flap contains both muscle and skin, therefore it covers the implant with a thick layer of well perfused tissues. Recently, much attention has been paid to acellular dermal matrices (ADM) that allow for the safe covering of the implant and its fixation to the chest. However, the ADM has to be covered with well vascularized and elastic skin. Since this requires the preparation of the breast with an expander, the basic benefit of ADM is limited to muscle preservation (5).

Autologous tissue reconstructions without implants evolved from the initial use of pedicle flaps to free flaps which require microsurgical anastomoses. The reconstruction of a slightly ptotic, natural breast requires the harvesting of a large amount of skin and subcutaneous tissue. Such a large flap can only be achieved by using abdominal skin. In mature patients these tissues are generally loose and flaccid, thus removing their excess improves the shape of the abdomen. They can be transferred with one of the abdominal rectus muscles, supplied by the superior epigastric artery and vein. This flap is referred to as the transverse rectus abdominis myocutaneous (TRAM). Its disadvantage is, however, related to the need to harvest the muscle which causes a weakening of the abdominal wall. An alternative to a pedicled is a free TRAM, taken with a small fragment of the rectus muscle and its primary blood supply from inferior epigastric vessels. This removes the need to pull the muscle under the skin to its new position on the chest. The free TRAM is anastomosed with the internal mammary (IM), or thoracodorsal arteries (TD) (5).

It is currently believed that the best method for microsurgical reconstruction involves the deep inferior epigastric perforator (DIEP) flap, because its dissection preserves the rectus muscles. Over the past few years the use of this flap has enjoyed a growing popularity, despite its higher cost (6). It relies on perforating artery which runs between the epigastric inferior and the flap. When the perforator is dissected it can be pulled out from between the muscle fibres, together with its main inferior epigastric vessels. In its recipient area it is usually anastomosed with the internal mammary artery.

The choice of vessels that supply blood to the flap is the subject of much scientific debate. The IM artery has a constant course and a much greater flow than the TD artery. However, it is less accessible, i.e. it runs under the ribs (7). Furthermore the use of IM to breast reconstruction excludes its later application in the reconstruction of coronary arteries where it is considered to be the best material. The advantage of TD artery, in turn, is its easy access, especially after a previous biopsy of the sentinel node. Moreover, the TD microvascular anastomosis is located in the armpit, away from the reconstructed breast. In this situation the breast can be easily shaped and improved, without the fear of secondary damage and impaired flow (8). A drawback to the use of TD vessels for microvascular reconstruction is, in turn, the subsequent elimination of secondary reconstructions using the LD muscle which is supplied by this artery.

Modern breast oncology often uses breast conserving techniques (BCS) which, are considered the standard of excellence. Although growing trend in BCS was recently reversed (9), conserving techniques still have a significant influence on modern attitudes towards breast reconstructive surgery. Small losses after lumpectomies no longer require complex reconstructions. The role of reconstructive surgery is therefore substituted by oncoplastic techniques, i.e., local flaps on glandular tissue. Although such methods are adopted from breast reduction plastic surgery, oncoplastic techniques are, usually performed by oncological surgeons, simultaneously with a lumpectomy. If, despite local glandular flaps, the breast remains irregular or hollow, it can be additionally filled with autologous fat. Fat grafts are very much associated with the completely new trend in reconstructive surgery which could revolutionize breast surgery.

FAT GRAFTING AND BREAST SURGERY

The first attempts at fat grafting for breast reconstruction were performed in the nineteenth century. In the 1980s, the huge increase of popularity of fat transfers occurred as a result of the development of minimally invasive liposuction techniques, and tumescent anaesthesia. However, at this time an unsolvable problem led to the low efficiency of transplantation which resulted from fat absorption, and its calcification. Because of these two problems, as well as the concerns for the safety of patients exposed to unreliable mammographies after calcifications, the American Society of Plastic Surgeons (ASPS) banned fat transfers to the breast. This position was accepted by other national societies and was upheld until 2012 when new fat grafting techniques became available.

It is currently believed that two main factors determine the effectiveness of fat transplantation to the breast. These are the use of micrografting techniques, and the preoperative expansion of the breast with external expanders. Micrografting, which relies on the transfer of microlobules or microribbons of fat dispersed between well-vascularized tissues, prevents the creation of cysts. It has now been proved that fat inside even minor cysts cannot be vascularized before adypocytes breakdown (10). The use of micrografts, however, is effective only when the increase of the volume of the transplanted tissue does not cause a compression of the breast blood vessels, and does not restrict flow. The volume of fat can only safely be increased by increasing the preoperative volume of the breast. For this purpose, external expansion with sealed domes is applied to the breast, or to skin at the site of the mastectomy defect. The domes are a registered medical product known as the Brava system.

In a recent paper, the inventor of the Brava system, and his team, presented the results of operations of 488 patients whose breasts were reconstructed using fat transfers (11). The authors performed the reconstructions of partial defects after BCS, and of breasts after complete mastectomies. In some patients immediate reconstructions were also performed. Their results can be regarded as excellent. Although labour intensive, breast reconstruction with autogenous fat is minimally invasive, and requires only basic surgical skills. In this respect it significantly outperforms conventional reconstruction methods. It would therefore not be surprizing, if it soon displaces traditional techniques.

Fat transfer to the breast and the Brava system are also used in cosmetic breast augmentation (12). The quality of results obtained using fat grafting is not only extraordinary, but is also unattainable with implants. The breasts are firm, yet of a homogenous structure. Their shape depends on the surgeon, but excuses imperfections and minor mistakes. Patients have a completely natural perception of their breasts due to rich sensory innervation. If the proper operatory technique has been retained cysts are either avoidable, or small and temporary. The methods of this operation have recently been thoroughly described (13). The treatment, however, is time consuming and less cost effective than traditional implant augmentation. This is probably the reason why breast augmentation with fat is still unpopular.

SURGICAL TREATMENT OF MIGRAINE HEADACHES

The concept of the surgical treatment of migraines was developed after coincidental observation of headache amelioration with endoscopic forehead surgery (14). This observation was simultaneous with the first papers presenting the chemodenervation of migraine trigger sites with Botox. Although now the action of Botox in the medical treatment of migraines has proved to be more complicated (15). Originally it was linked to the decompression of the supraorbital (SON) and supratrochlear (STN) nerves, chronically irritated in their peripheral sites of passage through the corrugator supercilli and procerus muscles. The surgical theory of migraine aetiology explains that chronic SON/STN irritation is similar to that observed in carpal tunnel syndrome, and relies on the putative phenomenon of peripheral nerve sensitization. In contrast, according to neurological theories, migraine aetiology is a central phenomenon where the central sensitization in the brain stem and the trigeminovascular system has a primary role (16). The concept and flaws in manuscripts presenting studies on migraine surgery were criticized in neurological literature (17). However, the effectiveness of the surgical treatment of migraines was proved in 17 clinical studies with level I to IV evidence (18). Recently even new evidence on the peripheral trigger mechanism was presented. Nerves from patients with migraines were shown to have an axonal abnormality that may have resulted from peripheral myelin disruption, although primary axonal deficit was not excluded (19).

There are four trigger sites where surgical nerve decompression is effective. These include the occipital trigger, the temporal trigger, the frontal trigger, and the nasospetal trigger (18). In the occipital trigger site, the greater occipital nerve (GON), and sometimes the lesser occipital nerve, are decompressed, mainly at the intersection of the GON with the semispinalis capitis muscle. In the temporal trigger, the zygomaticotemporal nerve is reached and a segmental neurectomy is performed. This can be done at the same time as an endoscopic forehead lift and SON/STN decompression at the frontal trigger site. For patients with so-called sinus headaches, the septoplasty with a middle turbinectomy at the nasospetal trigger site is indicated.

NERVE TRANSFERS AND NERVE-MACHINE INTERFACES

Although complicated, nerve transfers are currently considered more valuable than nerve grafts in the treatment of brachial plexus and proximal peripheral nerve injuries. These procedures involve coapting a healthy nerve from the defect neighbourhood to the denervated distal recipient stump (20). As the transferred donor nerve is functional, the time required for reinnervation is much shorter than in the case of a nerve graft. This advantage of nerve transfers over nerve grafts exists at the expense of specific function impairment. A specific donor nerve of adequate size and function has to be sacrificed. Such nerve is usually located in reasonable proximity to the defect so as to enable coaptation with a recipient stump. In facial paralysis such disadvantages, which include the use of the masseter branch of a trigeminal nerve or a hypoglossal nerve, have long been accepted (21). However, in cases of upper extremity dysfunctions, nerve transfers are only now becoming more common (22).

Nerve grafts also require a certain degree of function impairment. However, in most cases it is limited to small sensory deficits of the foot because sural nerves are the preferred choice for grafts. The reinnervation of a nerve graft requires considerable time between the operation and the expected result. This is due to the long distances that the axons must regenerate in order to reach their end organs (23). In cases of transfers, this time is much shorter. This is important for motor function reconstruction because the motor endplates in the target muscles are prone to fast degeneration after nerve injury. Usually, the optimal time for a motor function restoration is less than six months. In distal injuries of the median and ulnar nerves, the six-month period is adequate for efficient axons regeneration, even in cases of nerve grafts. Proximal nerve injuries of the upper extremity may, however, require a nerve transfer in order to reach the endplates before target muscle degeneration.

Specific nerve transfers of the upper extremity have also been described. These include transfers for the restoration of shoulder stability, elbow flexion, radial neuropathy, and median and ulnar neuropathy (24). The results for shoulder and elbow transfers are promising. For radial and median neuropathy, however, traditional tendon transfers are probably the best choice. For ulnar neuropathy a terminal branch of the anterior interosseus nerve can be transferred to the deep ulnar motor branch in order to reinnervate intrinsic hand muscles (24).

Nerve transfers are also performed for the targeted reinnervation of muscles that generate signals for nerve-machine interfaces. Such electronic interfaces are used for the control of myoelectric prosthetic limbs. The first models of bionic upper extremity prostheses are now commercially available in the USA and Europe. These devices are equipped with their own power sources and are controlled by patients. They enable many every-day activities with a high degree of freedom. Myoelectric prostheses receive commands from implantable or surface electrodes located in proximity to the nerve-muscle endplates. The signals generated in the muscles are stronger than the signals traveling in the peripheral nerves. Today's electrodes are therefore produced to read signals from muscles rather than from singular nerve fascicles. However, prototype intrafascicular nerve electrodes do exist.

Signals from the residual muscles of the stump are properly translated into commands only when the electrodes are able to sense and discern the singular contractions of specific muscles. The more the signals can be discerned, the greater the degree of prosthesis freedom which can be controlled by the patient. The residual muscles are, however, present only in the stumps of distal amputation victims. Patients with amputations above the elbow have a limited number of innervated muscles that can be used for the control of prosthetic arms. Modern plastic surgery can offer them a new type of operation in the form of targeted muscle reinnervation; nerve transfers are performed for this purpose. The peripheral nerves that once innervated the amputated limb can now be transferred to selected muscles on the patient's arm or chest to provide the necessary amplification of nerve signals (25). It will also be possible to provide targeted innervation into units of free muscle. This new concept, called regenerative peripheral nerve interface, will be used in the form of separated muscle grafts. Such grafts will be implanted for each peripheral nerve fascicle of the available nerves of the stump, and will probably enable the perfect discrimination of signals travelling to the nerve ends in the residual limb (26).

Recently an interesting example of regenerative peripheral nerve interface was presented. In this experiment a free muscle graft was used to provide sensory feedback (27). For such a sensory regenerative nerve interface an extensor digitorum longus (EDL) muscle graft was transferred to the ipsilateral thigh. In the thigh this muscle graft was covered with an insulated electrode and implanted by a transected fascicle of the sensory sural nerve. This construct was then encircled by decellularized small intestinal submucosa and left in the thigh. After healing, the electrical stimulation of the muscle depolarized the afferent nerve within the muscle and provided sensory feedback.

However, according to the same authors, the next generation of targeted neural signalling depends on optogenetics (27). In this technology the nerves engineered to express blue light sensitive channelrhodopsin-2 ion channels and yellow light sensitive halorhodopsin chloride channels are stimulated by implanted optical fibres. The nerves are activated in response to the selected light colours, whereas the adjacent nerves not expressing opsins remain inactive. This technology is able to induce reproducible action potentials on a millisecond scale (27).

PLASTIC SURGERY POST BARIATRIC

The demand for corrective operations after bariatric surgery is a new, rapidly growing phenomenon, with a high impact on the costs of health care systems in EU countries and in the USA. Deformations after massive weight loss create serious problems for post bariatric patients, and decrease their quality of life. Although many insurance companies cover certain post bariatric reconstructive procedures, the costs of these have not been re-evaluated since before the bariatric surgery boom. There are also no internationally accepted standards in existence for the specific problems that should be covered. The most frequent insurance covered procedure is probably the panniculectomy. It includes an apronectomy with or without an additional abdominoplasty. The indications for this procedure include panniculus drop below the symphysis with chronic skin condition and an incisional or ventral hernia, or chronic dorsal or lumbar pain associated with abdominal wall incompetence (28). The average cost of a panniculectomy is twice as high as perceived by officially available data, and exceeds 6,000 Euro. This results from the fact that the majority of these operations are performed in combination with hernia repairs. Other common post bariatric procedures include breast and chest contouring, male chest contouring, arm contouring, and facial rejuvenation.

Post bariatric surgery patients differ from the general population and from the majority of aesthetic patients in the fact that there are unique features that have to be considered before plastic surgery. This group is often burdened with serious nutritional, and sometimes, psychiatric considerations, as well as running the risk of unusual complications (29). Malabsorption leading to abnormalities in proteins and vitamins is believed to be the major responsible factor. Also, the chronic anemia that often burden post bariatric patients and frequently require blood transfusions, additionally increase the complication rate. Such metabolic abnormalities should be addressed before plastic surgery (30). Because of the higher risk of surgical site infections, some new preventive techniques have been developed that include the use of negative pressure wound therapy for close surgical incisions. When widely applied over post bariatric surgical wounds, these dressings were shown to significantly reduce the incidence of exudate formation, as well as decreasing the length of hospitalization (31).

TRANSPARENT SCIENTIFIC PUBLISHING

New reporting guidelines were recently adopted by Plastic and Reconstructive Surgery, the world's leading plastic surgery scientific journal. These guidelines, usually presented as checklists, were created in order to help report the criteria required to give a clear account of a study's methods and results. This initiative is supported by a widely recognized provider of endorsed reporting guidelines, the Enhancing the QUAlity and Transparency Of health Research Network (EQUATOR) (32). Since many of the EQUATOR's checklists do not apply to plastic surgery's publishing characteristics, only specific lists were recommended. These include the CONSORT for randomized controlled trials, the PRISMA for meta-analyses, the STROBE for cohort, case-control and cross-sectional studies, and the SAMPL for basic statistical reporting. Especially important for plastic surgeons are case series reported using the STROBE guidelines. Case series, although low in the hierarchy of the evidence-based pyramid, constitutes the most common type of published research in plastic surgery literature. An excellent, new tutorial for newcomers describes recommendations for case series reporting in plastic surgery (33). It recommends that research questions be answered using a PICOST (population, intervention, control, outcome, setting, and time horizon description) approach. These steps, together with methods of data collection and analysis were presented; underlying that case series cannot endorse casual relationships between the treatment and the outcome. In their current introductory stage, the EQUATOR checklists are not obligatory when submitting a manuscript. It is, however, obvious that peer reviewers may find the checklists helpful, so should effectively increase the chances for a paper's acceptance (32).

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