New Concepts in Maxillofacial Bone Surgery

颌面骨外科的新~~进展~~见解

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Preface

The present volume is concerned with bone surgery in the area of the facial skeleton. We find this branch of maxillofacial surgery especially challenging because in our work within the Surgical Department of the University of Basle, we are constantly being confronted with the principles of internal fixation – in the care of polytraumatized patients, in organizing joint AO-ASIF courses[1] or during trauma conferences.

The problems of fracture disease and the unpleasant sequelae of unanatomical healing are by no means alien to maxillofacial surgery. Our main aim is to broaden our experience of the basic principles of stable anatomical fixation and early function in this branch of trauma and corrective surgery. It soon became apparent that primary healing of fractures and osteotomies, as well as undisturbed revascularization of bone transplants and long-term tolerance of inert implants and joint prostheses depend on the stability of fixation under preload.

Considering the complex biomechanics of the masticatory apparatus, special efforts had to be made to achieve stability in fractures, non-unions and implantations by adapting already existing instruments and implants to the specific requirements of the upper and lower jaws. New possibilities were added to time-honoured procedures. It was found that a new miniature dynamic compression plate proved very effective in stabilizing mandibular fractures. In sagittal split osteotomy of the ascending ramus – the most important operative intervention in the lower jaw – the lag screw principle was shown to be successful, the emphasis being placed on fixation of the fragments by interfragmentary pressure. In this case, stable fixation, standing up to immediate function, is no less important than the performance of the osteotomy itself.

The distinctive feature of this book is that it originates from a team whose members work closely together in everyday practice.

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[1] AO/ASIF = Arbeitsgemeinschaft für Osteosynthesefragen (Association for the Study of Internal Fixation).

They have endeavoured to apply the principle of stability uniformly to reconstructive and orthopaedic surgery of the face as well as to implantology.

We were painstaking in researching the literature on the subject, and are indebted to the authors cited in the index for the contribution they have made to our own knowledge.

I would like to express my sincere thanks to my secretary, Mrs. Helga Reichel, for preparing the manuscript and undertaking the arduous task of proof-reading.

I am further grateful to Mr. Dietmar Hund and his co-workers in the photographic department of the Kantonsspital Basel, University of Basel, who were responsible for nearly all the photographs.

Furthermore my thanks go to all who assisted in the making of this book – last not least to the Publishers with their excellent editorial staff.

B. SPIESSL

Preface

It was my privilege and delight to see our team of maxillo-facial surgeons under the dynamic leadership of Prof. Bernd Spiessl become progressively intrigued (and infected!) by the potentialities of precise and stable internal fixation. As there is hardly any other branch of surgery so much in need of precision, even down to the 10 μ-level, internal fixation in maxillo-facial surgery was by no means easy to achieve – especially so because precise fixation in this field has to stand up to immediate functional loads magnified by significant leverage effects. Mere application of the small fragment-set of instruments and implants did not work.

It was a great pleasure to see the basic ideas of the spherical gliding principles, underlying the development of the DC-plate by Perren, Russenberger and myself, to be taken up by the Spiessl-team in a most unconventional and ingenious way. They encountered the need to stabilize a bone from the bending side. This is a factor complex which we try to avoid in weight-bearing long bones at all costs. The brilliant idea of introducing a right angle geometry to the DC-hole, the outer holes providing a rotational force and thus compressing the opposite cortex, was one such development which I took pleasure in following with considerable admiration. That all the biomechanical data worked out by Perren and his collaborators concerning stabilization under preload came to fruition in a new related field was another source of joy. It therefore stands to reason that my very best wishes accompany this book, dedicated to a better rationale and therefore better understanding of improved patient care in the field of maxillo-facial surgery.

M. ALLGÖWER

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A

Transplantation of Autogenous Bone

1. Clinical Aspects of Free Autogenous Bone Transplantation

By H. M. Tschopp

The extent to which bone grafts survive after free transplantation depends entirely on the rapidity with which the blood supply to the graft is re-established. In the first place, therefore, it is the vascularization at the site of transplantation which plays an important rôle in the survival of the graft. On the other hand, the rate of vessel ingrowth is determined by the structure and intrinsic architecture of the transplant itself. In order to fully understand the events accompanying the transplantation of bone, it is essential to review some of the histophysiologic properties peculiar to all calcified structures.

1.1. Architecture of the Bone Graft

Bone should be regarded as an organized "soft tissue" of which part of the intercellular substance has been made rigid by depositions of calcium salts (HAM, 1952; TRUETA, 1963). This calcification of the organic intercellular substance explains the peculiar difficulties imposed on the nutrition and growth of a living bone cell. The osteoblasts which are derived from peri-vascular mesenchymal cells maintain a syncytium in contiguity with each other (VITALLI, 1970). Fine cytoplasmatic processes extend in all directions and also reach the adjacent vessels responsible for the nutrition of the cell. The organic intercellular substance which is deposited along these cytoplasmatic processes and around the cell-body is subsequently calcified by a complicated mechanism which is not fully understood. The bone cells are thus embedded in a rigid substance and more or less deprived of their natural means of nutrition and of the ability to rid themselves of waste products.

In order to survive a system of canaliculi and lacunae is created which is subsequently filled with tissue fluids and nutrition of the cell is accomplished by diffusion of food substances (HAM, 1952).

This mechanism of nutrition, however, is not very efficient and works only over very short distances. Therefore the majority of bone cells are separated not more than 0.1 mm from the supplying capillary either in the Haversian system of compact bone or in osteons of cancellous bone.

1.1.1. Compact Cortical Bone

In order to fulfill its static and dynamic function within the skeletal system, a dense structure of bone is formed as a cortex, which has good weight-bearing properties and also allows for muscular attachments. The main vessels responsible for the nutrition of compact bone are the blood vessels entering through Volkman's canals. These vessels divide and orient themselves perpendicularly to the weight-bearing forces (positive barotropism). Around the supplying vessels the calcified structures are laid down in layers as supporting columns (osteons). This compact calcified structure of cortical bone, however, limits the possibilities of nutrition.

1.1.2. Cancellous Bo

Cancellous bone is similar in structure to compact bone. Its main difference consists in the fact that trabeculae are formed which build a system of scaffoldings within the cortex. The orientation of these trabeculae is dependent on the direction of the outgrowing osteogenetic vessel (TRUETA, 1963). The trabeculae in cancellous bone are very small and their surface is completely covered with osteogenetic cells. By morphometric measurements it has been estimated that the overall surface of bone cells in a cube of 1000 cm^3 may cover an area of 200–350 m^2, which is approximately the size of a tennis court (VITALLI, 1970).

This relatively high proportion of surface cells to bone cells makes the conditions for nutrition of cancellous bone much more favorable.

1.2. Behavior of the Bone Graft After Free Transplantation

The question whether osteogenesis in autogenous bone grafts is due to the activity of surviving cells in the graft (theory of survival) or to metaplasia in host tissue cells (theory of induction) is still a classic issue of debate. While in small cancellous bone transplants both sources may be involved in supplying osteogenetic cells, most investigators would agree at the present time, that the majority of cells in a larger piece of bone, whether cancellous or cortical bone, will not survive free transplantation (BARTH, 1894; HAM, 1952; LERICHE, 1928; PHEMISTER, 1914).

The dead bony matrix, however, has an osteoinductive potency and serves as a scaffold which is eventually invaded by a network of new capillaries. This process of revascularization occurs mainly from elements in the host bone (periosteum, endosteum, intermediate bone) and/or surrounding host tissues. The osteogenetic cells which are derived from the capillaries subsequently act as foci of new bone formation, first by osteoclastic resorption of the dead bony matrix, and second by deposition of a reticular bone.

After this first phase of regeneration has been accomplished (its duration depending on the size of the graft) the reticular bone is slowly converted into a structural, lamellar bone with force-bearing properties. Thus the second phase of the healing process is commenced where the graft is able to respond adequately to functional stimuli by a process of remodelling and adaptation (Table 1).

Table 1. Healing process in bone grafts

1. Phase: Inductive Regeneration
2. Phase: Functional Adaptation

According to Roux's law of functional stimulation a bone graft has to be subjected to a continuous stress and strain in order to establish the functional reason for its existence.

1.3. Practical Application of Bone Transplantation

In the light of the foregoing one may postulate that three conditions have to be fulfilled in order to obtain a successful bone transplant:
1. Choice of the right bone transplant,
2. Good vascularization at the recipient site,
3. Absolute immobilization of the graft.

1.3.1. Choice of the Right Bone Transplant

The more trabeculae of the bone graft which are in contact with tissue fluids and the vascular system of the host, the higher will be the percentage of the bone cells that survive. Cancellous bone, whether taken from the iliac crest or the trochanter major, is superior to the compact cortical bone graft.

The current opinion on the transplantation of autogenous bone grafts versus homogenous and heterogenous bone grafts states that vascular penetration of the heterogenous implant is six or more times lower than in autogenous bone grafts (STRINGA, 1957). Moreover large areas of the homografts and heterografts are often totally excluded from the circulation and may subsequently act as a sequestrum and provoke infection.