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RECONSTRUCTION OF PROXIMAL HUMERUS BY MUSCLE-SLING PROSTHESIS

By

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In surgical reconstruction of the proximal humerus after extensive resection of bone, transplantation of autogenous fibula has long been the standard therapeutic measure (*Rovsing* 1910, *Borelius* 1914, *Skillern* 1920, *Albee* 1921, *Lexer* 1925, *Schauffler* 1926, *Hammond* 1926, *Behrend* 1930, *Clark* 1959, *Gilmer* 1963, *Goldberg* 1964, *Wilson & Lance* 1965).

Despite reports of satisfactory end-results even after long observation (*Clark* 1959, *Goldberg* 1964) the method has proved to have certain disadvantages such as a tendency of the graft to fracture (*Hammond* 1926, *Schauffler* 1926, *Gilmer* 1963, *Wilson & Lance* 1965) and unsatisfactory reconstruction of the shoulder joint and the anatomy of the upper arm.

In recent years various types of prostheses have been described to replace defects in the proximal humerus. Most of these prostheses are designed to replace only the humeral head or part of it (*Krueger* 1951, *Richard, Judet & René* 1952, *Neer* 1955). Other types of prostheses described in the literature and intended to replace a major part of the proximal humerus (*Ducci* 1963, *Lynn, Alexakis & Bechtol* 1965, *Casuccio* 1966) have one feature in common *viz.*, like the fibula graft they do not allow satisfactory reconstruction of the tendo-capsular apparatus of the humero-scapular joint or reliable reinsertion of the muscles attached to the proximal metaphysis and diaphysis of the humerus.

At the orthopaedic clinic, Härnösand, we were confronted with this problem (*Haraldsson* 1966) in the treatment of a 22-year old woman with a progressive, locally destructive tumour of the proximal part of the right humerus (Figure 1).

Histological examination of conventional biopsy specimens from the

Figure 1. Primary roentgenogram. Osteolytic process with osteogenetic cortical reaction.

interior of the cavity and affected part of the corticalis revealed no signs of malignant tumour. The pathologist's report was: "connective tissue islands in bone tissue and exotosis". In view of this favourable report and the fact that the results of all laboratory tests were normal the exostoses were removed and the cavity was curetted and filled with autogenous bone chips from the iliac crest. Two new biopsy specimens removed at this operation were likewise found to contain no signs of malignancy.

Later follow-up, however, revealed progressive destruction of the proximal humerus (Figure 2) and loss of function.

Biopsy specimens were then removed from altogether 3 parts of the tumour, but none of them showed evidence of malignancy.

Because of the progression of the tumour and the local destruction it was decided to resect the tumour with a broad safety margin of healthy tissue, which implied almost hemiresection of the humerus with removal of the proximal 14 cm of the bone, whose original total length was 31 cm. This required a prosthesis allowing reconstruction of the tendocapsular apparatus of the humeroscapular joint with reinsertion of all together 9 muscles attached to the proximal humerus.

Figure 2. Progression of tumour with destruction of proximal humerus.

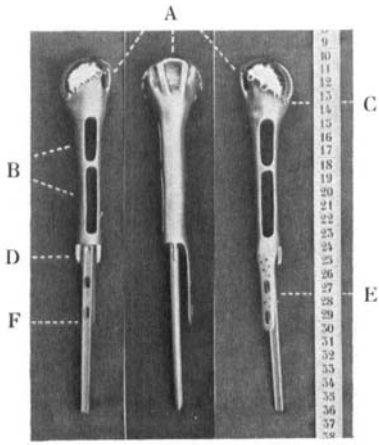

Figure 3. Muscle-sling prosthesis. A. Perforations for sling fixation of muscles of rotator-cuff to each other. B. Canals for sling fixation of muscles of metaphysis and diaphysis. C. Eyes for extra fixation. D. Flange preventing rotation. E. Plate for subperiosteal fixation. F. Self-locking intramedually shaft.

It was realised from the beginning that the effect of direct suturing of these muscles to a metal body would only last as long as the sutures held, which in view of the wear and tear would presumably be only for a limited period.

It was at last concluded that suturing of the muscles, preferably antagonists, to one another through specially made perforations in the prosthesis would provide a permanent muscle-sling fixation. The prosthesis was designed by the author on the basis of roentgenograms of the affected and contralateral side and was produced in vitallium by The Austenal Company, New York (Figure 3).

While waiting for the prosthesis the patient became pregnant. Since all together 7 biopsy specimens had shown no signs of malignancy it was decided to grant the patient's request to postpone the operation until after delivery. The patient was therefore operated upon 8 months

Figure 4. Preoperative roentgenogram.

later than originally intended. Preoperatively her general condition was good, the results of all laboratory tests were normal, and there were no signs of metastases. Her right shoulder joint was stiff, swollen, tender and aching. The preoperative roentgenogram taken 4 years after first examination is given in Figure 4.

SURGICAL TECHNIQUE

Exposure through Henry's approach (*Henry* 1959). The tumour was well defined against the surrounding soft parts. The subscapularis, supraspinatus, infraspinatus and teres minor muscles were divided together with the joint capsule and the long head of the biceps muscle. This enabled exarticulation. The axillary (circumflex) nerve and the posterior circumflex artery were partly embedded in tumour masses from which they were freed without injury. The pectoralis major, latissimus dorsi and teres major muscles were divided and the proximal part of the lateral and medial heads of the triceps muscle were loosened from

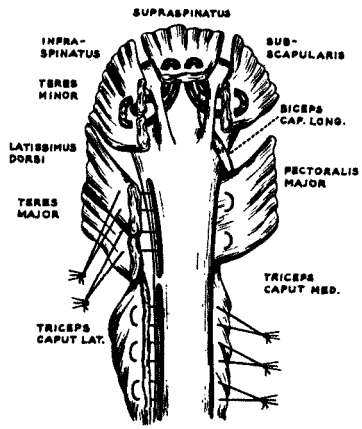

Figure 5. Diagrammatic representation of the technique of muscle-reinsertion on the muscle-sling prosthesis. The supraspinatus, infraspinatus, teres minor and subscapularis muscles are fixed to one another and the prosthesis by tendon transplants through perforations in the region of greater tuberosity of the prosthesis. The tendon transplants are taken from the long extensors of the 3rd and 4th toes. The latissimus dorsi and teres major are sutured to the pectoralis major muscle in the proximal diaphyseal canal of the prosthesis. The proximal part of the lateral head of the triceps is fixed to the corresponding part of the medial (deep) head of triceps in the distal diaphyseal perforation. The long head of the biceps muscle is divided, drawn through one of the holes in the prosthesis, resutured and fastened to the tendon graft.

bone. The proximal third of the insertion of the deltoid was also loosened. This muscle thus retained the major part of its insertion on the intact part of the humerus after division of the diaphysis with a broad margin of macroscopically healthy bone. The prosthesis was inserted in the remaining part of the humerus, after a slit had been sawn in the bone in the frontal plane for fixation of the flange of the prosthesis to prevent it from rotating. The reinsertion of the muscles on the prosthesis is illustrated in Figure 5.

Postoperative treatment consisted of 6 weeks' immobilisation of the limb in a thoraco-brachial splint followed by physiotherapy of the muscles and joints.

When last seen 9 months after the operation the shoulder no longer ached and even movement of the arm was practically painless. The muscles of the right shoulder were still somewhat weak and the range of movement of the joint was still reduced, but both sequelae were improving. The strength of the muscles of the right elbow, wrist and hand were satisfactory. The strength of the grip of the right hand, as measured dynamometrically, was thus 4 kg. The corresponding figure for the left hand was 5 kg. The patient's general condition was good. The E. S. R. was normal and there were no signs of metastases or of a local recurrence. The patient is right-handed and has no difficulty in using a knife and fork or in washing and dressing and does most of the work in a household of 3 persons. The range of movement of the operated shoulder at last follow-up is shown in Figure 6.

In the roentgenograms taken at the review, the prosthesis appeared to be firmly anchored in the residual part of the humerus. The congruence between the articular surface of the prosthesis and the glenoid

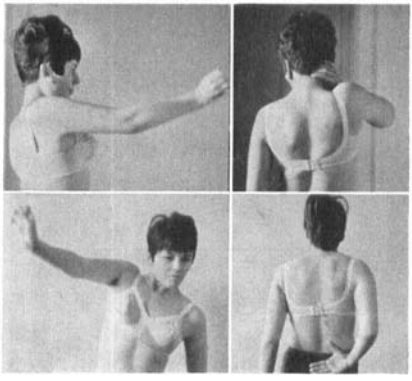

Figure 6. Range of motion at review. No neurological or vascular disturbances. No measurable atrophies except for 1 cm atrophy of right forearm.

Figure 7. Roentgenograms at review. Prosthesis anchored in distal humerus. Congruence in humero-scapular joint.

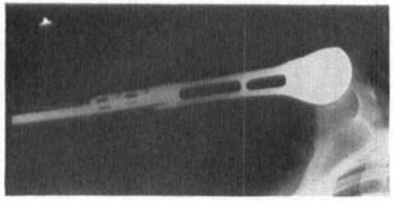

Figure 8. Abduction. No change in congruence in joint. No tendency to subluxation between prosthesis and glenoid cavity.

cavity appeared normal without any signs of subluxation during rest or movement (Figures 7 and 8).

Pathological examination of the excised tumour revealed that parts of the lesion had become malignant and now showed the histological picture of juxtacortical (parosteal) osteogenic sarcoma. The margin of resection showed no signs of tumour.

This rare neoplasm (less than 5 per cent of osteogenic sarcomas, *Dahlin* 1957, *Aakhus, Eide & Stokke* 1960) is distinctly less malignant than the ordinary osteogenic sarcoma (*Dwinnell, Dahlin & Ghormley* 1954, *Lichtenstein* 1965) and the question of treatment is still a matter of certain controversy.

Since the resection was believed to have been radical, further active measures were refrained from. The patient is being carefully followed up.[1]

[1] Since submitting this manuscript for publication several controls have been made.—2½ years post. op. the prosthesis showed no signs of loosening or breaking. Function was satisfactory. Radio-opaque spots had appeared in the sear. They were excised. Histological examinations showed no certain evidence of malignancy.

COMMENT

Though the patient has only been followed up for a relatively short time the preliminary results obtained with the prosthesis appear to warrant the conclusion that a muscle-sling prosthesis of this general design is worth a further trial. The method of reinsertion of the muscles to the prosthesis near their original site of insertion by slings through perforations in the prosthesis is supposed to provide permanent fixation of the muscles, that part of the perforations not occupied by the muscle slings presumably being filled with scar tissue. Because of the insertion of the muscles in the prosthesis itself the force of muscle pull is distributed in a more normal way over both the prosthesis and the parts distal thereto. This might mean that the risk of fracture or loosening of the prosthesis would be smaller than when the inserted material, graft or prosthesis functions only as a lever over which the muscles inserted distally to the prosthesis exert their pull. Moreover the prosthesis is suspended in muscles, which probably reduces the tendency to subluxation.

This prosthesis might be improved by deeper perforations extending further medially in the area of greater tuberosity of the prosthesis. This would facilitate reinsertion of the muscles of the rotator cuff as well as the passage of the head of the prosthesis under the acromion.

In cases where a still larger portion of the humerus must be sacrificed one might create a muscle sling between the deltoid and the coracobrachial muscles by means of a supplementary perforation situated more distally in the diaphysis of the prosthesis.

SUMMARY

A description is given of a muscle-sling prosthesis designed to replace large defects after extensive resection of the proximal half of the humerus. The muscles are reinserted by fixing them to one another through openings in the prosthesis, which is supposed to provide permanent fixation of muscles to prosthesis.

The preliminary clinical and roentgenological results are encouraging.

RESUME

Il est donné une description d'une prothèse de soutien des muscles, destinée à remédier à de larges manques à la suite d'une résection extensive de la moitié proximale de l'humérus. Les muscles ont été

réinsérés en les fixant les uns aux autres à travers les ouvertures pratiquées dans la prothèse afin d'assurer une fixation permanente des muscles à la prothèse.

Les résultats cliniques et radiologiques sont encourageants.

ZUSAMMENFASSUNG

Eine Beschreibung einer Muskelschlingeprothese wird gegeben, die konstruiert wurde um grosse Defekte nach ausgedehnter Resektion der proximalen Humerushälfte zu erstatten. Die Muskeln werden von neuem befestigt indem sie zueinander mittels Öffnungen in der Prothese fixiert werden und man will dadurch eine dauernde Fixierung der Muskeln an die Prothese schaffen.

Die voräufigen klinischen und röntgenologischen Ergebnisse sind ermutigend.

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