SILASTIC SPACERS IN TENDON GRAFTING

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WHEN an attempt to restore function by means of a tendon graft fails to give the desired results, the reason is practically always the formation of adhesions between the tendon and the surrounding tissue. Since this process is essential for the vascularisation of the graft, it must not be prevented but an attempt can be made to influence the nature of the adhesions in order to limit the functional restrictions caused by them.

Basically, the formation of collagenous adhesions may be modified in two ways : by the administration of drugs or by the induction of a tendon sheath.

Methods to control a natural healing process by administration of drugs are still in an experimental stage. The appropriate drugs (lathyrogens) are capable of changing the physical characteristics of collagen in a specific manner. Results of experiments with one of these drugs (beta-amino-proprio-nitril) are promising (Peacock, 1968).

In this paper we are mainly concerned with the second approach. The capacity of cell-poor tissue to form collagen is rather limited. Since the tendon sheath has a small number of cells, the grafting of a tendon in an intact sheath would seem to offer advantages in the form of a collagen-poor adhesion formation with little limitation of function.

Attempts to induce tendon sheath formation by the implantation of artificial material were first made three decades ago. Mayer and Ransohoff (1936) used celloidin tubes and replaced these tubes after the formation of the sheath by a tendon graft but this material proved to be insufficiently inert. Bassett and Carroll (1963) employed Silastic spacers which they attached to the distal phalanx. They obtained highly satisfactory results. Hunter (1965) utilised Silastic spacers reinforced with Mersilene. These spacers were attached not only to the distal phalanx but also to the proximal end of the tendon which made active movement possible. In a number of patients these prostheses were removed after a certain period of time and replaced by an autologous graft. Gaisford *et al.* (1966) used a technique similar to that of Bassett and Carroll and obtained satisfactory results in 73 tendon injuries. Nicolle (1969), like Hunter, used reinforced spacers which he sutured to the proximal and distal stumps of the profundus tendon. The spacers were replaced after two to three months by an autogenous tendon graft. His experiments clearly showed that only minimal adhesions are sufficient for the survival of a tendon graft and that maturation of these adhesions occurs more rapidly.

Geldmacher (1969) demonstrated that the amount of traction required to pull a tendon graft out of a sheath induced by a Silastic spacer, is 9 to 10 times lower than the amount required when such a spacer is not used. Geldmacher's conclusion that the indications for tendon repair in the hand by the use of Silastic spacers for the induction of a tendon sheath may be appreciably extended, is entirely in agreement with our experience.

When we decided some years ago to evaluate this method in a number of patients, we were motivated by the following considerations :

(*a*) The percentage of patients needing treatment and fulfilling the requirements for satisfactory results in tendon grafting, such as normal passive mobility, adequate vascularisation and sensibility, good skin cover, co-operation, etc., was small.

(*b*) The results of flexor tendon repairs were disappointing when the criteria mentioned above were not strictly adhered to.

(*c*) An attempt to restore function was nevertheless required in a number of patients. A surgical result—although poor when judged by objective criteria—can be of importance when evaluated by subjective criteria (Fig. 1).

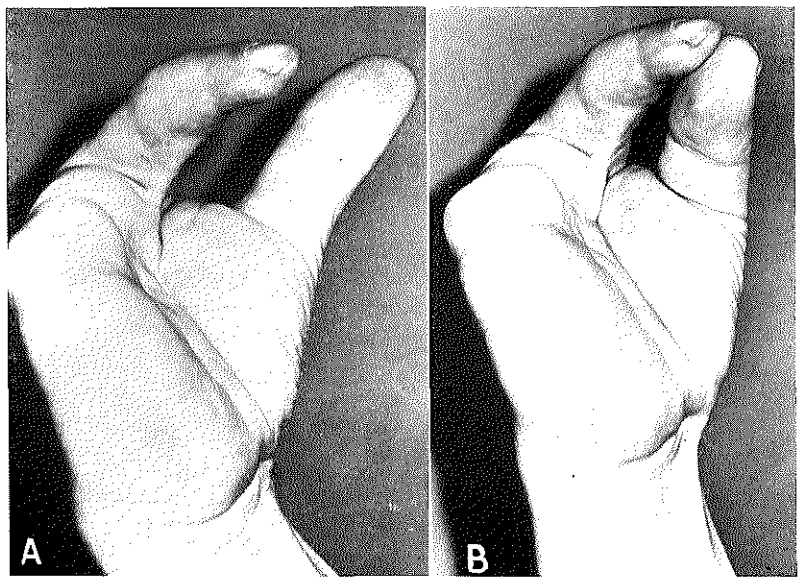

FIG. 1

Severely mutilated hand after tendon grafting of the index finger. A, Objectively : a poor result. B, Subjectively : a satisfactory result.

Indications.—*Restoration of flexion*.—Attempts to restore flexion were performed in a group of 25 patients. In 20 of these patients pre-operative examination showed neurovascular disturbances having a negative influence on the prognosis. Among these 20 patients were 7 in whom the passive mobility was less than normal, 4 in whom the tendon injury was complicated by an infection, 3 in whom previous attempts had been made to restore function and 2 in whom an improvement in skin cover was indicated.

In 2 of the 25 patients, the Silastic spacers was introduced immediately after the accident as a primary procedure. One of these patients also had a fracture of the proximal phalanx which was immobilised with a Kirschner wire (Fig. 2). The result of the subsequent tendon graft was highly satisfactory in both cases.

In 24 of the 25 cases the spacers were used for the repair of a tendon injury within no-man's-land. One of these 24 patients was treated for an injury of the index and middle fingers (Fig. 3). In one patient five spacers were implanted prior to the repair of severe tendon injuries at the level of the transverse carpal ligament (Fig. 4).

Technique.—*First stage*.—The skin incision is made in a Z-shaped fashion. Only so much of the tendon sheath is resected as is necessary to allow removal of the remnants of the sublimis and profundus tendons. When possible, the vincula at the level of the p.i.p. and d.i.p. joints are spared. A Silastic spacer with a diameter of 3 mm. is then implanted and fixed at the level of the insertion of the profundus tendon by means of

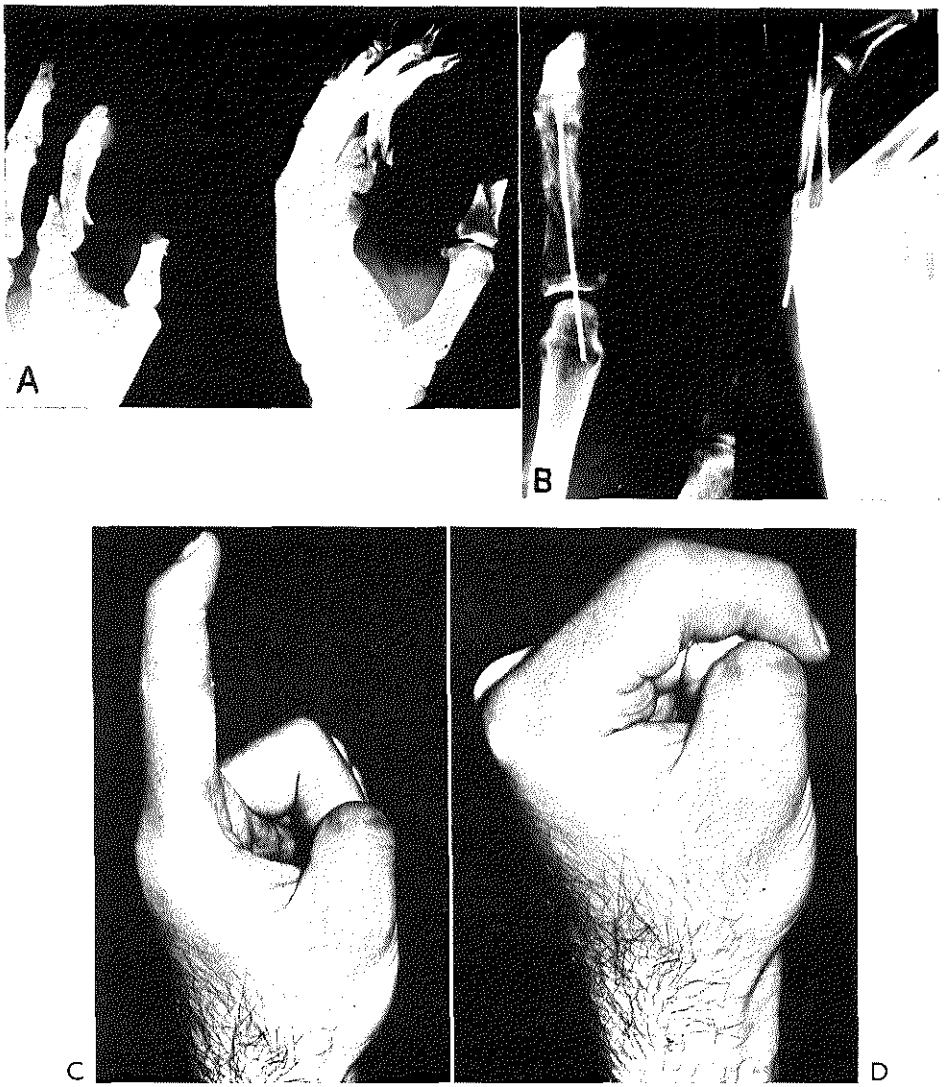

FIG. 2

Severe fracture and tendon lesion of index finger caused by circular saw. A and B, Primary immobilisation of fracture with Kirschner wire, and implantation of Silastic spacer. C and D, Result after replacement with tendon graft.

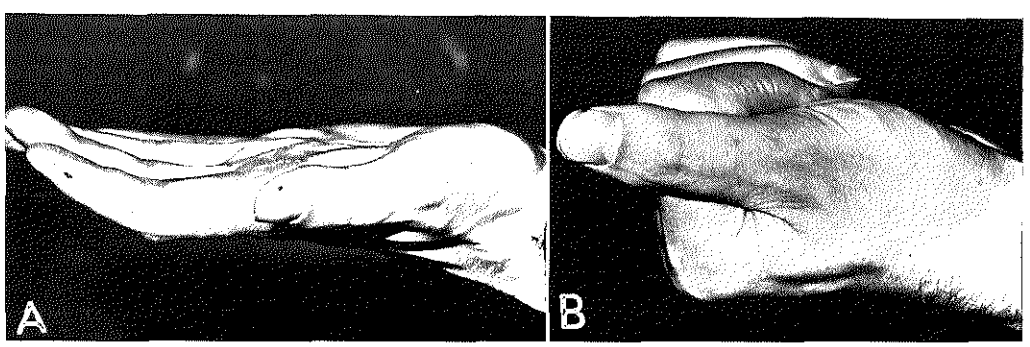

FIG. 3

A, Severe tendon lesions of index and middle fingers caused by a circular saw. B, Result after replacement with tendon graft.

one or two wire sutures. The proximal end of the spacer is slid along the proximal stump of the profundus tendon until it overlaps the latter for a distance of several

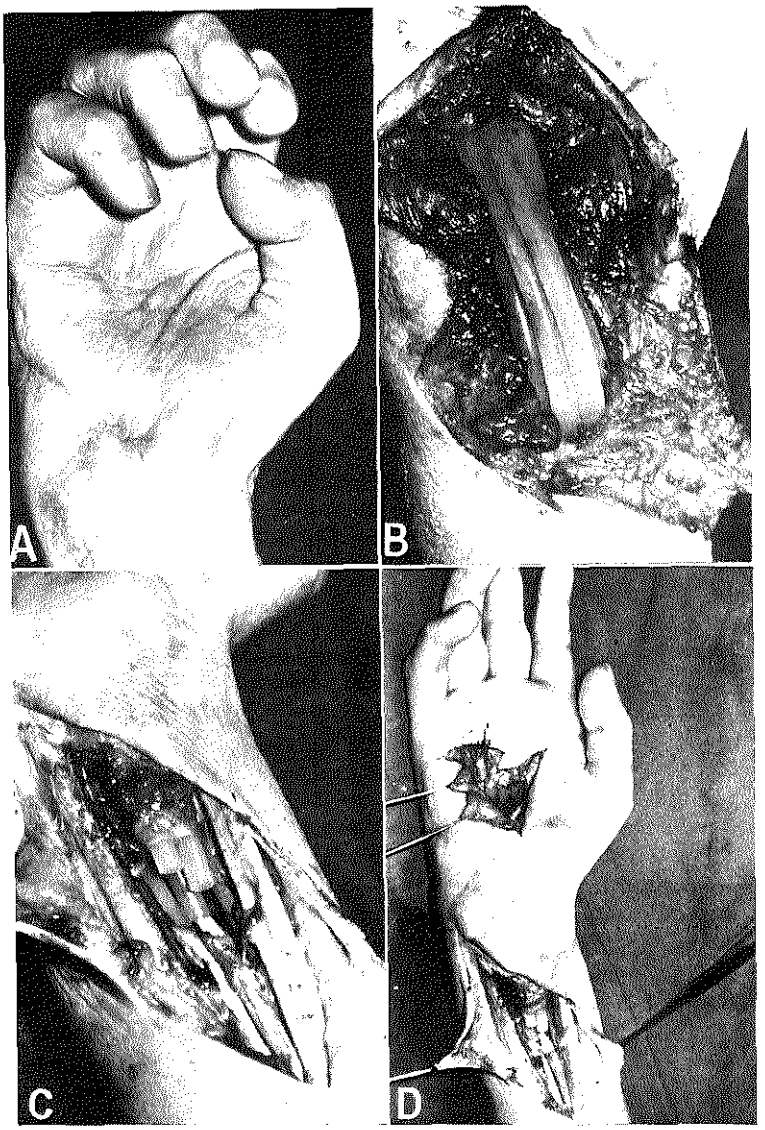

FIG. 4

A, Crippled hand after perforating injuries of the carpal tunnel resulting in massive destruction of all flexor tendons and median and ulnar nerves. B, Implantation of several Silastic spacers. C, Tunnel formation has taken place. D, Replacement of spacers by tendon grafts. Useful function returned.

centimetres. Before the hand is closed, the lumbrical is dissected out and cut proximal to the lumbrical canal. This last step has been performed routinely for some time because we believe that restoration of the delicate paradoxic extension mechanism of this muscle is not to be expected and malfunction of this muscle will have an adverse effect

on the restoration of the function of the flexor tendon. About a week after the operation, passive and active exercise is started.

Second stage.—Two or three months after implantation of the Silastic spacer, the new sheath is opened via the old scars in the palm of the hand and in the skin of the distal phalanx. The proximal end of the spacer is connected to the tendon graft, for which the palmaris longus tendon is used whenever feasible. The mesotenon of this graft is left intact (Fig. 5) because the blood supply occurs via this structure (Smith and Conway, 1966; Colville *et al.*, 1969). The tendon graft is drawn into the sheath by pulling out the spacer via the distal incision. Both anastomoses and the completion of the procedure are done conventionally.

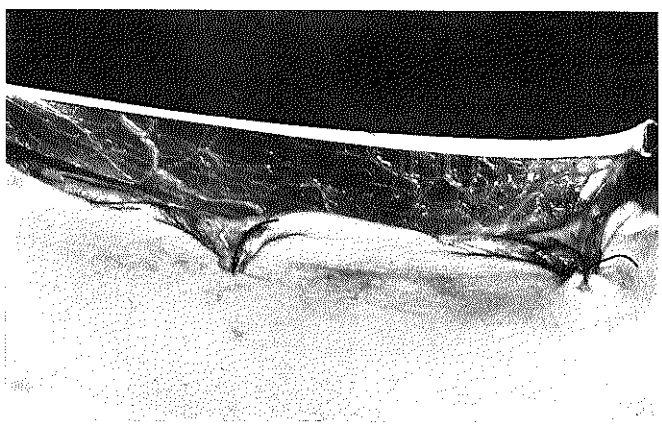

FIG. 5

Palmaris tendon with mesotenon.

Results.—Generally speaking, the results can be summarised as follows. Fifteen of the 25 patients could not reach the palm of the hand with the tip of the finger. Ten patients could do so, among them the five without neurovascular disturbances.[1]

A more detailed evaluation of the results based upon the functional restoration obtained in each patient seemed useless since the group of patients was chosen at random and the degree of restoration of function depends on many factors; the gliding capacity of the tendon is only one of them.

Furthermore, the question why we obtain good results cannot be answered before we know why we obtain bad results. One of the answers to the latter is without doubt the absence of gliding capacity. Without restoration of this capacity, function cannot be restored and the fact that this capacity was present in 24 of the 25 cases, seems to us to reveal more than a detailed discussion of the results.

That the recovery of function, when achieved, occurred much more rapidly than is normally the case, is not surprising since the inhibiting influence on function arising from the collagen-poor adhesions obtained with this method is much lower. However, recovery of the gliding capacity over the course of the preformed tendon sheath does

[1] Differentiation between disturbance of sensibility and circulation has been omitted deliberately. When there is an injury to the neurovascular bundle, very infrequently either the vessel or the nerve is not affected. It is generally accepted that a nerve lesion has an unfavourable influence on the results of a tendon graft, but the reason for this acceptance is obscure. We believe that more emphasis should be placed upon the vascular injury since revascularisation of a tendon graft depends on the local blood supply.

not guarantee recovery of function. There are situations in which the capacity of a tendon to bend a finger is of little value, for example :

Limitation of extension of the finger.—Postoperatively—for whatever reason—a strong flexion contracture may develop and abolish the potential range of motion (Fig. 6).

Hyperextension of the p.i.p. joint.—When loss of the stabilising function of the sublimis tendon is associated with a dislocation of the retinacular ligaments, a slight flexion of the distal phalanx will be accompanied by hyperextension of the p.i.p. joint and result in a " swan neck " deformity (Fig. 7).

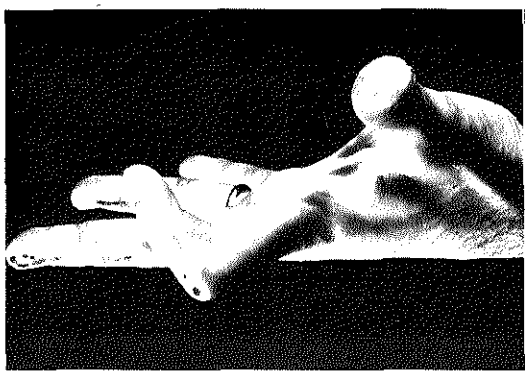

FIG. 6

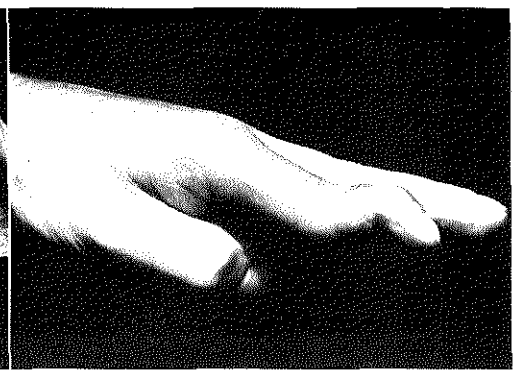

FIG. 7

Fig. 6.—A severe flexion contracture of the p.i.p. joint of the index finger occurring after the replacement of a Silastic spacer by a tendon graft made amputation necessary. Dissection of the amputated finger revealed that the tendon graft was surrounded by loose adhesions. The range of motion was however severely restricted because of massive fibrosis outside the newly formed tendon sheath.

Fig. 7.—Swan-neck deformity due to loss of the stabilising function of the sublimis tendon associated with dislocation of the retinacular ligaments.

The lumbrical-plus phenomenon.—When the power exerted by the flexor muscle is not transmitted to the flexor tendon but rather via the lumbrical to the extension apparatus of the finger, a short-circuit mechanism develops ; an attempt to flex the finger will result in extension. We believe that this phenomenon recently analysed by Parkes (1969) is rather common. For that reason we sever the lumbrical as a routine in flexor tendon grafting.

Blocking.—The potential range of motion of the flexor tendon via the reconstructed tendon sheath cannot be realised when the range of motion of the proximal anastomosis is limited by extensive scarring within the palm of the hand.

Complications.—Complications resulting from the implantation of a Silastic spacer can be summarised as follows :

Extrusion.—One of the five spacers implanted in a patient with a serious carpal lesion had to be removed because the wound in the scarred integument failed to heal.

Swelling.—In two patients implantation of the spacer was accompanied by severe œdema in the vicinity of the implant. This swelling completely disappeared in the course of a few weeks.

Contracture.—In some patients a certain degree of flexion contracture of the finger developed after the implant had been replaced by an autogenous tendon graft. These contractures were caused by polarisation of the scar tissue that had formed between the wall of the tendon sheath and the skeleton. This polarisation did not develop until active function had been recovered (Fig. 8).

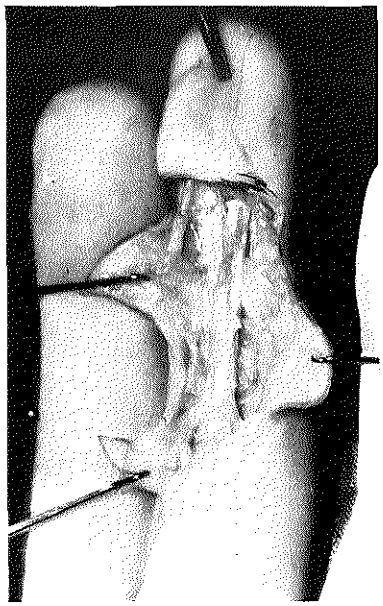

FIG. 8

Polarisation of scar tissue surrounding the newly formed sheath.

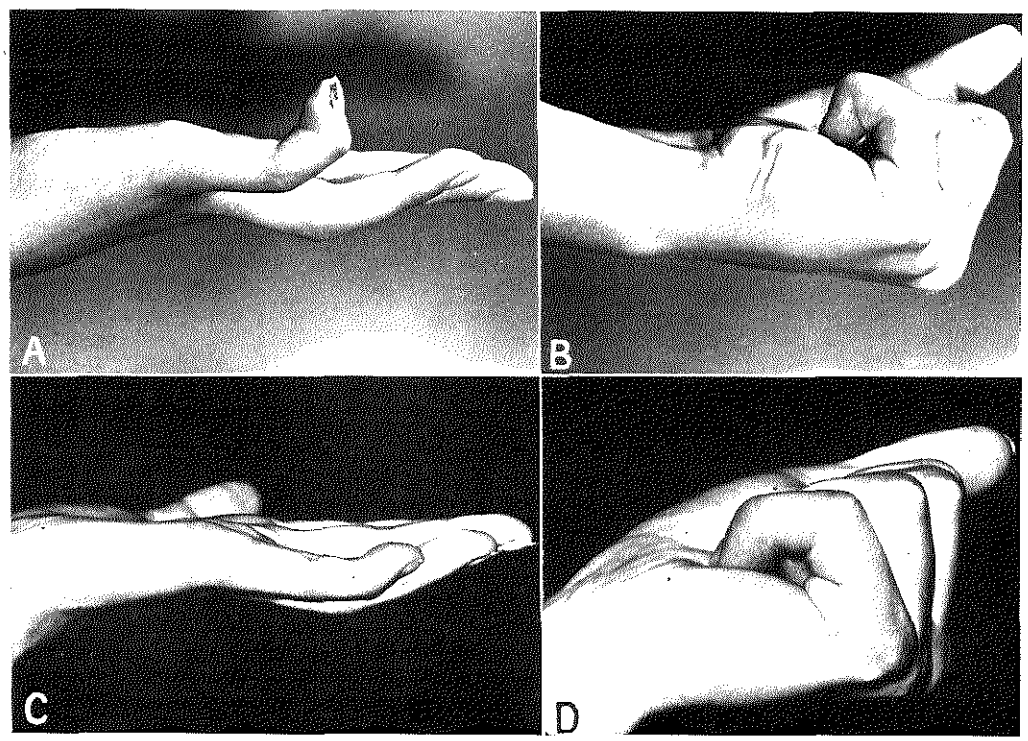

FIG. 9

Severe flexion contractures occurring in young girls (one blonde, the other red-haired). Exploration revealed that the range of motion inside the newly formed sheaths was quite satisfactory. The contractures were in both cases caused by peri-sheath polarisation of scar tissue. Satisfactory function was obtained by re-insertion of the distal end of the graft in the base of the middle phalanx after resection of the scar tissue at the level of the d.i.p. joint. A and B, Range of motion after tendon grafting of the little finger. C and D, Range of motion after re-insertion of the tendon in the base of the middle phalanx.

It is of course possible that in these patients the scar tissue had formed as a reaction to the implant however inert it may be. We are under the impression that individual factors are involved here and that the reaction of a patient to the implant may be dependent on such factors as age and sex (Fig. 9).

Further Uses of Tendon Spacers.—*Restoration of extension.*—As far as we know, the spacer has hardly ever been used for the reconstruction of the extension function of the finger although Hunter (1965) gives one example.

The reason for this is not entirely clear since in severe injuries to the dorsal side of the fingers, there may be intense scarring between the remnants of the extensor aponeurosis and the underlying bone or the integument. In such cases the use of a Silastic spacer is certainly to be recommended as an alternative to a more conventional attempt to restore function.

Restoration of thumb abduction.—Abduction of the thumb is indispensable for the restoration of opposition and can usually be achieved by transfer of a tendon. The procedure, however, offers little chance of success when the " opposition disturbance " is the result of a severe wrist injury and re-routing of a tendon would take it through a heavily scarred area. In such cases the use of Silastic spacers has been most successful.

Restoration of thumb adduction.—The loss of thumb adduction due to a lesion of the ulnar nerve may be accompanied by an appreciable loss of power. In such cases function can be restored by the transfer of a tendon via the second or third interdigital space. The restriction of function due to adhesion formation in this region can be considerable and the re-routing of a tendon via a prefabricated tunnel was very successful in one case.

SUMMARY

The results in tendon repair are to a large extent dependent on the quality of the adhesions which are formed between the tendon and surrounding tissues. When these adhesions contain little collagen, the gliding capacity of a tendon will be more easily restored. The capacity of cell-poor tissue to form collagen is limited and the reconstruction of a tendon sheath by implantation of a Silastic spacer is therefore advocated by some surgeons. A report is presented of the experiences which were obtained by the author in a series of 30 patients.

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