

"Internal Splints" for Tetraplegics

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SUMMARY

The "Internal Splint for Tetraplegic Patients" concept is being used at the Spinal Units of the H. F. Verwoerd Hospital and Kalafong Hospital in Pretoria. It consists of:-

1. An improved "bone-to-bone" posterior deltoid to triceps tendon transfer: for elbow extension.
2. Biceps tendon transfer: changing a supination deformity to a functional pronation.
3. Finger and thumb extension: using brachioradialis.
4. Finger flexion and thumb adduction against the fingers using extensor carpi radialis longus to motorise flexor digitorum profundus and rerouting the flexor pollicis longus tendon to the extensor carpi radialis brevis tendon. Promote metacarpophalangeal flexion by the Zancolli lasso operation and stabilizing the thumb by fusion of one of its joints.

These functional operations contribute greatly to a more independent management of daily activities. Certain prerequisites must be met, e.g. muscle power and endurance. Individual assessment done by the rehabilitation team is of utmost importance.

OPSOMMING

Die begrip van "Interne Spalke vir Tetrapleë" word by die Spinale Eenhede van die H. F. Verwoerd en Kalafong Hospitale in Pretoria gebruik. Dit bestaan uit:-

1. 'n Verbeterde "been-na-been" posterior deltoïed na triseps pees verplanting: vir elmboog ekstensie.
2. Biseps pees verplanting: om 'n supinasie deformiteit in 'n funksionale pronasie posisie te verander.
3. Vinger en duim ekstensie met gebruik van brachioradialis.
4. Vinger fleksie en duim adduksie teen die vingers met die gebruik van ekstensor carpi radialis longus om fleksor digitorum profundus te motoriseer en verlegging van die fleksor pollicis longus pees na die ekstensor carpi radialis brevis pees. Metakarpo-falangeale fleksie word bevorder deur middel van die Zancolli lasso en die duim word stabiliseer deur fusie van een van sy gewigte. Hierdie funksionele operasies dra grootliks by tot 'n meer onafhanklike bemeestering van daaglikse aktiwiteite. Sekere voorvereistes waaraan voldoen moet word is b.v. spierkrag en uithouvermoë. Individuele evaluasie wat deur die reabilitasiespan uitgevoer word, is van uiterste belang.

INTRODUCTION

Patients sustaining permanent cervical cord lesions after an accident are "made" more functional by highly

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specialised splints and aids.^{1,2} Muscles that are still functional are strengthened and trick movements are taught in order to gain further function.

Non-functioning muscles are generally either ignored or allowed to shorten so that permanent flexion contractures could add to function, e.g. a hook hand instead of a flat hand.

Well-known surgeons like Moberg from Sweden³ and Zancolli from Argentina⁴ designed operative procedures to replace external splintage if possible by active muscular or passive tenodesis methods. In South Africa, Boonzaier⁵ has done pioneering work in the field of surgical restoration of lost function in tetraplegics.

GENERAL APPROACH TO "INTERNAL SPLINT" PROCEDURES

From the outset the upper limbs are kept mobile

with regular physiotherapy movement sessions and are splinted in the functional position viz. the elbow in 90° flexion, the forearm in mid-pronated rotation, the wrist in 30° dorsiflexion, the metacarpophalangeal joints in 90° flexion, the interphalangeal joints straight (180°) and the thumb in 45° abduction-extension.

As soon as the patient is able to be in the upright position and sit with stability in a wheelchair, his needs concerning upper limb function are determined. The patient's own views on this subject are of cardinal importance.

The most common functional needs are:-

1. Elbow extension and flexion (the latter is usually present)
2. Pronation of the forearm
3. Wrist extension (this function is usually present)
4. Finger extension
5. Abduction and extension of the thumb
6. Flexion and adduction of the thumb
7. Flexion of the metacarpophalangeal joints
8. Flexion of the fingers — especially of the distal interphalangeal joints

The planning of the operation is discussed in detail with all those concerned, viz. the patient and often a member of his family, occupational therapists, physiotherapists, surgeon, nurses and social worker.

It should be remembered that the major concept of surgical repair remains the restoration of a balanced hand in the planning for a functional hand.

The following regimen is a basic scheme upon which the planning of the operations may be based, dependent on the level of the lesion and damage of the motor nuclei of the remaining functional muscles.

Stage 1

1. For extension of the elbow:

Posterior part of the deltoid muscle (at least 4 strength) is transplanted into the triceps tendon.⁶

The posterior deltoid insertion with a piece of cortex (2 x 4 cm) is loosened from the humerus. The middle 1 cm of the triceps tendon insertion on the olecranon is similarly loosened with a piece of olecranon cortex and flapped up proximally. The two pieces of bone are sutured together, using wire. The gap in the triceps is very carefully closed. The arm is placed in an extension splint for 1 week. After 1 week, controlled, careful and gradual active flexion and extension exercises are begun. 90° of flexion is allowed only after 5 weeks. Six weeks post-operatively full movement against resistance is allowed.

Stage 2.1

2.1.1 For finger and thumb extension:

The brachioradialis tendon is transferred into both the extensor digitorum communis and extensor pollicis longus tendons.

N.B. If more opposition of the thumb is desired, the extensor pollicis longus can be divided at the level of the thumb metacarpophalangeal joint.

The proximal part is then threaded through the interosseus membrane and round the palmaris longus tendon and then sutured back on to the distal section. This results in extension and abduction putting the thumb in a more opposed position.

2.1.2 For stabilisation of the thumb:

In the case of a high cervical lesion, a fusion of the first metacarpophalangeal joint is performed. In the lower lesions the carpometacarpal joint is fused (45° in the antero-posterior plane and 30° in the lateral plane).

2.1.3 For intrinsic metacarpophalangeal flexion with interphalangeal extension:

The Zancolli lasso procedure is performed for the index, middle, ring and little fingers.

The flexor digitorum superficialis is divided distally, pulled round the A1 flexor tendon sheath pulley and then re-attached to itself.

N.B. 1. Although the flexor digitorum superficialis is usually paralysed in tetraplegics, the above procedure is still carried out. It functions by means of a tenodesis effect.

2. A plaster-of-Paris splint is worn for 3 weeks after which active physiotherapy is allowed.

Stage 2.2

2.2.1 For flexion of the fingers:

The extensor carpi radialis longus is transferred into the flexor digitorum profundus.

N.B. If the extensor carpi radialis longus is not working, a tenodesis could be performed. This is done by attaching the flexor digitorum profundus to the forearm interosseus membrane. Dorsiflexion of the wrist will then result in finger flexion.

2.2.2 For flexion and adduction of the thumb:

Flexor pollicis longus is divided proximally and transposed dorsally by attaching it to the extensor carpi radialis brevis tendon by means of a "side-to-side" procedure.

N.B. A plaster-of-Paris splint is retained for 3 weeks followed by active physiotherapy.

Stage 3

For pronation of the forearm:

The forearm is usually held in an unfunctional supination position. In order to overcome this and restore the correct function to the deforming action of the biceps, the biceps tendon can be divided distally along its full length (Z-lengthening). The distal part is then brought dorsally around the radius to appear on the radial side and then re-attached to the proximal part of the tendon. The pronated position is held for 3 weeks by a thick Kirschner wire threaded through the radius and ulna.

N.B. 1. This procedure can precede the other stages⁷ or be performed simultaneously with stage 1.

2. An interesting observation is that after the posterior deltoid to triceps transplant, patients tend to spontaneously hold the forearm in pronation probably due to the slight abduction of the upper arm and the effect of gravity on the forearm. The above procedure is thus not always necessary.

DISCUSSION

The above procedures make it possible for the patient to carry out the following functions:-

1. Extension of the forearm — especially in an elevated position so that the patient can reach an object on a shelf (triceps action) or reach an overhead handle to lift himself for transfers.
2. If the patient has a functioning latissimus dorsi, it is sometimes even possible to use the triceps for transfers in and out of a wheelchair.
3. Opening the fingers and thumb preparatory to grasp (finger and thumb extension with wrist flexion).
4. Closing the fingers and thumb to grasp an object, e.g. a glass or a pencil (finger and thumb flexion with wrist extension).
5. Holding the forearm, hand and fingers in a functional position so that for example the patient could write or work a switchboard (forearm pronation, wrist extension, thumb flexion and adduction, finger metacarpophalangeal and interphalangeal flexion and index finger abduction against the thumb).

Many factors come into consideration when planning and deciding on these procedures. They must all be carefully weighed up, e.g.

1. The understanding by the patient. He must realise that he will never have a normal hand, but that certain functions will be greatly improved.
2. The relationship between sensation and rehabilitation. Motor rehabilitation is only successful if sensation is at least near normal.
3. The motivation of the patient.
4. Sometimes only stage 1 and/or 2 can be performed as a result of too little distal muscle power or a lack of muscle endurance.

CONCLUSION

These "internal splint" procedures are much more functional, practical and permanent than external splints. The balance of the hand is restored. Results are very encouraging. Patients are tremendously motivated to undergo these procedures having seen the progress and functional gains of those who have already undergone these operations.

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