IFSSH Scientific Committee Report - Cerebral Palsy

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Surgical Management of Thumb Deformity in Cerebral Palsy

Historical Perspective

Upper limb deformity in cerebral palsy is a consequence of imbalance between spastic and paretic muscles, often acting on unstable joints. Thumb deformity significantly impedes hand function. In extension, it limits the span and therefore the size of objects that may be grasped. In flexion, it acts as a block by occupying space in the palm and a lack of active thumb movement for pinch and grasp limits the usefulness of the hand.

Surgical reconstruction may be indicated to improve function or to facilitate hygiene, with the aim of creating a stable thumb able to function satisfactorily for grasp and release. Historically, the various surgical techniques are designed to decrease deformity and contracture, balance deforming muscle forces, increase strength and provide joint stability of the carpometacarpal, metacarpophalangeal and interphalangeal joints. Amongst others, Goldner (1990), House (1981, 1994), Manske (1985, 1990), Matev (1970), Swanson (1982), Tonkin (2001)and Zancolli (1983,

1987) have contributed to refinements in basic techniques of muscle releases, tendon lengthening, tendon transfers and joint stabilisations and fusions.

Indications/Contraindications

A decision to proceed to surgery should follow detailed and repeated examinations, both within the clinic and within the patient's usual environment. Two, if not three or more, separate 'surgical assessments' may be necessary before deciding on surgical or nonsurgical treatment alternatives.

The surgical assessment involves not only the surgeon and child but also parents or guardians, the coordinating physician, occupational and physical therapists, and a social counselor. It is useful to videotape the patient performing different tasks. Ideally, this is done in the presence of an occupational therapist, known and trusted by the child. Additional observers should be kept to a minimum. In some children, the performance of certain activities may be hindered by the increasing spasticity of effort and the emotional demand to perform. For these children, the level of spontaneous function may be higher in their natural environment. Alternatively, some can perform at the formal assessment, but find it easier not to do so in their natural environment, discarding the activities they find difficult for easier methods. Therefore, the ideal clinic involves multiple assessments both within the clinic and the child's natural environment, a keen appreciation of the parent's observations, and knowledge of the general medical condition and social circumstances of the child and family.

Zancolli and Zancolli (1987) have detailed seven principal considerations in selecting those suited to surgery.

General neurological condition

Impairment of speech, hearing and vision, convulsion, behavioural disorders, emotional instability and mental deficiency may have a significant impact on the results of surgery.

Types of neuromuscular disorder

Pyramidal (spastic) disorders or mixed disorders with a predominantly spastic component comprise over 60% of cases and lend themselves to soft-tissue surgery. Those with a predominant extrapyramidal disorder, athetosis, ataxia, tremor or rigidity are poor candidates for soft tissue surgery but may benefit from joint stabilisations, particularly fusions.

Extent and topography of upper limb involvement

The disorder may involve one or all four limbs. Patients most likely to benefit from reconstructive surgery are those with spastic hemiplegia or quadriplegia.

Age

From the ages of 5 and 6 years, the child is usually old enough to understand the reasons for surgery and to cooperate during postoperative rehabilitation. The adolescent patient has often adapted to the functional disability and is less likely to relearn new ways of functioning. In addition, joints may be less mobile. However, the cosmetic aspect may become a problem at adolescence, and is a reason for seeking advice at this age.

Hand sensibility impairment

Measuring hand sensibility involves testing joint position sense, two-point discrimination, touch and temperature senses and stereognosis, which is the most important of these. Poor hand sensibility becomes an overwhelming disability when it accompanies visual impairment. Although some believe that sensibility impairment does not affect surgical outcome, simply improving hand position by eliminating excessive wrist flexion, for instance, may improve sensory feedback.

Types of deformity

Deformity in all joints of the upper limb must be assessed. Typically there is internal rotation and adduction of the shoulder, flexion of the elbow, pronation of the forearm, flexion and ulnar deviation of the wrist, flexion of the fingers, though swan-neck deformities are also common, and thumb adduction and flexion. It is usually appropriate to attend to the proximal deformity first and work distally. However, the necessity for, and benefit from, shoulder and elbow surgery is usually less evident than that for forearm, wrist, finger and thumb deformities. Many advise surgery at multiple levels at the same surgical procedure.

Voluntary muscle group control

Those muscles that fire in phase with good control of contraction and relaxation are more effective when considering tendon transfers.

Classification of Thumb Deformity

The position of the thumb is dependent on the imbalance of extrinsic and intrinsic forces acting across the carpometacarpal, metacarpophalangeal and interphalangeal joints, any of which may be unstable.

A simple classification modifies that of House (1981). The classification type is assessed having asked the patient to make a fist, attempting to maintain the thumb in the lateral pinch position. In Type 1, intrinsic deformity, there is spasticity of the intrinsic thumb muscles causing adduction of the thumb metacarpal, flexion of the metacarpophalangeal joint and extension of the interphalangeal joint. The deforming forces are the adductor pollicis, the first dorsal interosseous and the flexor pollicis brevis muscles. The relative tightness of the adductor and short flexor will determine the position of the thumb, with one or the other occasionally dominant. The abductor pollicis longus, extensor pollicis brevis and the extensor pollicis longus are paretic.

In Type 2, extrinsic deformity, there is spasticity of the extrinsic thumb flexor (flexor pollicis longus) causing flexion of the metacarpophalangeal and interphalangeal joints. Metacarpal adduction is less marked. The extensor pollicis longus is paretic and wrist extension accentuates interphalangeal joint flexion. Isolated extrinsic spasticity is uncommon.

In Type 3, combined deformity, there is spasticity of both the intrinsic and extrinsic thumb muscles. The flexor pollicis longus, adductor pollicis, first dorsal interosseous and flexor pollicis brevis are all involved to some extent and the abductor pollicis longus, extensor pollicis brevis and extensor pollicis longus are relatively paretic. The metacarpal is adducted and the metacarpophalangeal and interphalangeal joints are flexed giving a true ‘thumb-in-palm’ posture.

Based on this classification, surgical techniques are designed to decrease the strength of deforming forces, augment weakened muscles and stabilise unstable joints. The classification does not give adequate indication of joint instability, nor of the position of the thumb in extension and abduction prior to grasp. The assessment needs to be supplemented by documentation of active and passive ranges of motion in each joint and the position of the thumb when attempting radial abduction with simultaneous wrist and finger extension. Dynamic contractures must be differentiated from static muscle and joint contractures.

A standard functional assessment includes videotaping of set tasks which include eating (ability to hold a knife and fork and to cut up food), dressing (pulling up trousers and doing up buttons), tying shoelaces, riding a bicycle (indicates ability to grasp and release) and playing sports. Patients are graded as independent, requiring assistance or totally dependent in their performance of each task.

Hand sensibility is assessed by testing joint position sense, two-point discrimination, touch and temperature sense and stereognosis. Shoulder and elbow positioning and patterns of hand use including grasp and release are documented. A decision to proceed to thumb surgery must take into account function and deformity in proximal joints, particularly the wrist joint. Alteration in wrist position may substantially alter thumb position and function. Many will combine thumb surgery with proximal joint surgery, preferring to perform all procedures at the same time. Some prefer to reassess thumb function following improvement in positioning of the upper limb and achievement of optimal wrist function. In this instance, thumb releases may be combined with proximal surgery but tendon transfers are delayed.

Contraindications to surgery include the non-functioning upper limb in which there is no muscle control, although joint stabilisations or fusions may be indicated for the purposes of hygiene, particularly when there is severe positional deformity. Soft tissue procedures are unsuccessful when pure athetosis is present. However, joint fusions may be effective in preventing extreme alternating joint positions. Lack of adequate control or significant weakness will preclude the use of any specific musculo-tendinous unit as a donor or muscle transfer. Effective transfer across an unstable joint may compromise function. Poor sensibility is not an absolute contraindication. However if the hand is ignored by the patient, improved thumb position is unlikely to result in improved function.

Nonoperative Treatment

Non-surgical treatment may achieve limited results. A rigid orthosis may maintain the thumb out of the palm but at the expense of thumb mobility. Softer splints can be used in mild deformities and assist in maintaining thumb abduction while permitting some movement, but hypertonicity does not diminish with orthoses or manipulation. Injection of botulinum toxin into the adductor may be helpful in both assessment and management.

Surgical Techniques

Surgical methods for correcting these deformities are outlined below. A complete list is provided in Table 1.

Releases

In both adductor and first dorsal interosseous release, the oblique and lateral heads of the adductor are released from their origins through a curved palmar incision along the thenar eminence crease (Matev, 1963). The flexor pollicis brevis can also be released when indicated. The first dorsal interosseous is released from its first metacarpal origin. A four flap or Z-plasty of the first web is appropriate to deal with secondary skin and fascial contractures. Complete adductor tenotomy distally overweakens the thumb. However, selective incision of tendinous fibers within the adductor muscle distally preserves some function and is an alternative to the origin release. These procedures are indicated for Type 1 and 3 deformities.

The flexor pollicis longus slide is an intramuscular tendon slide, performed through a longitudinal incision in the distal volar forearm. The tendon should be seen to slide 1 cm distally within its muscle fibers after the release. Alternatively, a Z-plasty lengthening is possible. This procedure is indicated for Type 2 deformities and in some Type 3 deformities. Care should be taken not to overweaken the flexor pollicis longus.

Transfers

In extensor/abductor augmentation, the preoperative assessment determines which, if any, of the extrinsic tendons require augmentation. The final decision may be made during surgery, when traction on each tendon unit will decide which tendon best draws the thumb out of the palm (without hyperextending the metacarpophalangeal joint). The aim is to obtain firm lateral pinch to the middle phalanx of the index finger during fist formation and radial abduction during finger and thumb extension prior to grasp. Tip and chuck pinch are only possible in mild cases with good central control.

The extensor pollicis longus to extensor pollicis brevis transfer supplements metacarpophalangeal joint extension, decreasing extensor activity of the interphalangeal joint (Manske, 1985). The intrinsic connection to the interphalangeal joint should be maintained. The extensor pollicis longus is sectioned proximal to the interphalangeal joint, rerouted through the first dorsal compartment, and reattached to extensor pollicis brevis at the metacarpophalangeal joint. The alteration in line also improves radial abduction. This may be combined with an active transfer to abductor pollicis longus or by dividing one slip of abductor pollicis longus proximally and tenodesing it around the insertion of the brachioradialis. Of the often multiple tendon slips of abductor pollicis longus, one is most effective in achieving radial abduction and should be isolated for transfer or tenodesis purposes. Transfer to extensor pollicis brevis may be more appropriate if the tendon is of substantial size and its action on the metacarpal and metacarpophalangeal joint achieves a superior position to that of the abductor pollicis longus.

No single motor for the tendon transfer is universally successful. Choice will depend on the individual muscle control as well as the usual principles applied to tendon transfers. Donor muscles are often spastic or weak, and the position obtained at surgery may not be maintained.

Brachioradialis needs extensive proximal dissection and may be weak or under poor control. Flexor carpi radialis is often spastic and should not be used when flexor carpi ulnaris has been transferred for wrist or finger extension, because a wrist extension deformity may develop. Flexor digitorum superficialis from the ring finger may be used to augment a re-routed extensor pollicis longus. This may be combined with plication of abductor pollicis longus. Possible motors must be assessed in each case. It may be that satisfactory volitional control is simply not possible, given the nature of the central deficiency. Joint stabilisation procedures then become the only means of controlling joint position.

Joint stabilisation

A carpometacarpal joint fusion is rarely indicated except when it is impossible to control metacarpal adduction. An intermetacarpal bone block results in a rigid abducted position. A carpometacarpal joint fusion is preferable as it allows some scaphotrapezial motion.

A metacarpophalangeal joint sesamoid capsulodesis is an effective means of overcoming metacarpophalangeal joint hyperextension (Tonkin et al., 1995; Zancolli, 1979). Without such a stabilisation, any tendon transfer crossing the metacarpophalangeal joint will be ineffective in abducting the metacarpal. The radial sesamoid is attached to the metacarpal at the head-neck junction via a suture through the metacarpal, tied dorsally, or with a bone anchor. The sesamoid lies within this palmar plate and, by securing it proximally, a capsulodesis (check rein) is effected across the metacarpophalangeal joint.

Metacarpophalangeal joint fusion is appropriate if control of hyperextension is not achieved by sesamoid capsulodesis or if tendon transfers fail to overcome a metacarpophalangeal joint flexion deformity (Goldner et al., 1990). Metacarpophalangeal joint fusion is required if a combined flexion /extension instability accompanies a radial/ulnar instability (Goldner et al., 1990). The cartilage of the epiphysis is removed, and a single K-wire is used to obtain fusion to the metacarpal head, maintaining the growth plate.

Interphalangeal joint fusion may be considered for recalcitrant flexion deformities of this joint or if flexor pollicis longus function is nonexistent and the joint is unstable. It may be wise to consider temporary K-wire fixation of any thumb joint prior to formal fusion. Function can then be assessed before an irreversible procedure is undertaken.

Postoperative rehabilitation

A short arm plaster cast maintains the thumb in full radial abduction and 20° of palmar abduction for 5 weeks. Removable splinting is continued during an exercise program in which the child is taught to abduct and extend the thumb actively and to maintain the thumb out of the palm during fist formation. The child is tutored in activities requiring lateral, pulp and chuck pinch. Occasionally, dynamic splinting to assist a tendon transfer is appropriate.

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Table 1: Surgical options for correcting thumb deformities

Releases

1. Adductor release in palm
2. Adductor tenotomy
3. 1st dorsal interosseous release
4. FPB release
5. FPL slide
6. 1st web-skin and fascia release

Transfers to augment APL, EPL, EPB using:

1. Brachioradialis
2. FDS
3. PL
4. EPL to EPB
5. FCR or FCU
6. ECRL

APL tenodesis:	through radius
	to brachioradialis, ECRL, FCR
	through 1st dorsal compartment

Joint stabilization

1. CMC joint fusion
2. MCP joint sesamoid capsulodesis

3. MCP joint fusion
4. IP joint fusion

Key: FPB, flexor pollicis brevis; FPL, flexor pollicis longus; APL, adductor pollicis longus; EPL, extensor pollicis longus; EPB, extensor pollicis brevis; FDS, flexor digitorum superficialis; PL, pollicis longus; FCR, flexor carpi radialis; FCU, flexor carpi ulnaris; ECRL, extensor carpi radialis longus; CMC, carpometacarpal; MCP, metacarpophalangeal; IP, interphalangeal