INTRODUCTION

Upper limb deformity in cerebral palsy is a consequence of imbalance between spastic and paretic muscles, often acting on unstable joints. 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.

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 the lack of active thumb movement for pinch and grasp limits the usefulness of the hand. Surgery may be indicated to improve function or to facilitate hygiene.

We use a classification system modified from that proposed by House et al. (1981) to describe the thumb deformity (Table 1). 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 (Fig 1). 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 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 (Fig 2). 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 (Fig 3).

The principle of surgery is to decrease the deforming forces and, where necessary, to augment the weakened muscles and to stabilize joints. The aim of this paper is to describe the assessment of the patients and to review the surgery performed in our department, applying the above principles.

PATIENTS AND METHODS

Thirty-two patients who had surgery for spastic thumb deformity between 1986 and 1993 were retrospectively reviewed. All patients were evaluated on several occasions preoperatively in the upper limb clinic run in conjunction with the Spastic Centre of New South Wales. A standard functional assessment was performed, including video-taping of set tasks. Five criteria were chosen to assess functional ability: eating (ability to hold knife and fork and cut up food), dressing (pulling up trousers and doing up buttons), tying shoe-laces, riding a bicycle (indicates ability to grasp and release) and playing sports. Patients were graded as independent, requiring assistance or totally dependent in their performance of each task.

Hand sensibility was 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 were documented. To assess the cause of the thumb deformity, the positions of the carpometacarpal, meta-
carpophalangeal and interphalangeal joints were recorded during active fist formation, which determines the classification type, and active radial abduction of the thumb with simultaneous wrist and finger extension. The passive range of motion of each joint was also documented. This detailed examination allowed the surgeon to determine the balance between spastic and paretic muscles and to identify underlying joint instability. A decision could then be made as to whether release procedures alone were indicated or whether transfers to supplement weak motors or joint stabilization procedures were also required (Goldner, 1988; House, 1994; Manske, 1990; Zancolli and Zancolli, 1987).

**Table 1—Classification of thumb deformity**

<table>
<thead>
<tr>
<th>Type of deformity</th>
<th>Deforming forces</th>
<th>Thumb position</th>
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<tbody>
<tr>
<td>Type 1, intrinsic</td>
<td>Adductor pollicis</td>
<td>Metacarpal adduction</td>
</tr>
<tr>
<td></td>
<td>First dorsal interosseous</td>
<td>MCP joint flexion</td>
</tr>
<tr>
<td></td>
<td>Flexor pollicis brevis</td>
<td>IP joint extension</td>
</tr>
<tr>
<td>Type 2, extrinsic</td>
<td>Flexor pollicis longus</td>
<td>MCP joint flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IP joint flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metacarpal adduction less marked</td>
</tr>
<tr>
<td>Type 3, combined</td>
<td>Adductor pollicis</td>
<td>Metacarpal adduction</td>
</tr>
<tr>
<td></td>
<td>First dorsal interosseous</td>
<td>MCP joint flexion</td>
</tr>
<tr>
<td></td>
<td>Flexor pollicis brevis</td>
<td>IP joint flexion</td>
</tr>
<tr>
<td></td>
<td>Flexor pollicis longus</td>
<td>(True ’thumb-in-palm’ deformity)</td>
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</table>

Abbreviations: MCP, metacarpophalangeal; IP, interphalangeal.

Fig 1  Type 1: intrinsic deformity.

Fig 2  Type 2: extrinsic deformity.
Surgical techniques

The following muscle releases, transfers and joint stabilization procedures were utilized to balance the deforming forces:

1. *Releases.* Adductor release was usually performed through a curved palmar incision along the thenar eminence crease (Matev, 1970) (Fig 4). The oblique and lateral heads were released from their origins. When indicated, the flexor pollicis brevis was also released and the first dorsal interosseous was detached from its first metacarpal origin through a dorsal incision. When a dorsal approach was used the adductor was released by selective incision of the tendinous fibres within the muscle distally. To release an extrinsic contracture of the flexor pollicis longus, an intramuscular tendon slide was performed through a longitudinal incision in the distal forearm. The tendon was released until it slid 1cm distally within the muscle so as not to over-weak the thumb flexor (Fig 5).

2. *Tendon transfers.* Extensor pollicis longus re-route–extensor pollicis brevis: the extensor pollicis longus was divided proximal to the interphalangeal joint and re-routed through the first dorsal compartment and reattached to the extensor pollicis brevis at the metacarpophalangeal joint (Manske, 1985). The intrinsic connection to the interphalangeal joint was maintained. Brachioradialis transfer: brachioradialis was mobilized by extensive proximal dissection and transferred as an active motor to abductor pollicis longus or the thumb extensors. Abductor pollicis longus tenodesis: a slip of abductor pollicis longus was tenodesed either around brachioradialis or the first dorsal compartment.

3. *Joint stabilization.* Metacarpophalangeal joint sesamoid capsulodesis: the radial sesamoid was attached to the metacarpal at the head–neck junction via a suture through the metacarpal, tied dorsally (Tonkin et al., 1995). Metacarpophalangeal or interphalangeal joint fusion was performed by resection of the epiphyseal cartilage, preserving the growth plate: stabilization was with an oblique K-wire (Goldner et al., 1990).
Postoperatively, a short arm plaster cast maintained the thumb in full radial abduction and 20° palmar abduction for 5 weeks. Removable splinting was then continued during an exercise programme in which the patient was taught to abduct and extend the thumb actively and to maintain the thumb out of the palm during fist formation. Patients were also tutored in activities requiring lateral, pulp and chuck pinch.

At follow-up, the standard functional assessment was repeated by the same clinical team. The position of the thumb joints during active and passive movements was recorded and the ability to perform lateral pinch was assessed.

RESULTS

There were 15 male and 17 female patients, of whom three men and eight women were aged over 16 years. The average age of the male patients under 16 years was nine years. The average age of the females under 16 years was 11 years. Eleven patients were quadriplegic (nine purely spastic, two with athetoid motion) and 21 were hemiplegic (17 with a primary diagnosis of cerebral palsy, one with a head injury, one hydrocephalus and two cerebrovascular accidents). The patients were reviewed at an average 32 (range 10–88) months after surgery.

In our series, 16 of the patients had a Type 3, combined deformity. Eleven patients had Type 1, intrinsic deformity and the remaining five had the relatively uncommon Type 2, extrinsic deformity.

The thumb was maintained out of the palm in 29 of the 32 patients (30 of the 33 thumbs). In 28 patients, this was achieved with one operation. Three patients underwent one further operation and one had a total of four operations. The majority of patients required three or four surgical techniques to correct the thumb deformity and these are outlined in Table 2. The number of release and augmentation procedures are listed in Tables 3 and 4 respectively.

Lateral pinch was established in 26 thumbs: to the middle phalanx of the index finger in 18 and to the middle phalanx of the middle finger in eight. In the latter group, the thumb was prevented from pinching against the index finger by IP joint flexion in three cases and by poor volitional control of index finger flexion which trapped the thumb in the remaining cases. In four thumbs, intermittent lateral pinch was possible but this was not of functional use. In three thumbs, lateral pinch was not established.

The number of patients who improved by one functional grade is recorded in Table 5. No patient improved from dependent to independent functioning. None of the patients was made worse by surgery.

The preoperative and postoperative active positions of the carpometacarpal, metacarpophalangeal and interphalangeal joints are listed in Table 6: measurements were available for 29 of the thumbs. Although the average improvement in metacarpal abduction was only 19°, this was functionally significant when it allowed the thumb ray to be brought out of the plane of the palm.

In the 18 patients who underwent a sesamoid capsulodesis, the position of the metacarpophalangeal joint was improved from an average of 30° hyperextension preoperatively to 15° flexion postoperatively. There were two patients in whom the sesamoid capsulodesis failed and the procedure was repeated. One of these patients subsequently required metacarpophalangeal joint arthrodesis.

Five patients with severe wrist, finger and thumb deformities had surgery primarily to improve cosmesis and hygiene. They had flexor releases and transfers to correct wrist and finger position and at the same time a flexor pollicis longus release. Appearance was improved in all five and lateral pinch established in two cases.

DISCUSSION

The decision to proceed to surgery should follow detailed and repeated examinations, both within the clinic and within the patient’s usual environment (House, 1994; Swanson, 1982; Zancolli et al., 1983). The assessment involves not only the surgeon and child, but also the parents or guardians, the co-ordinating physician, occupational and physical therapists and a social counsellor. It is useful to video-tape the patients performing different tasks. The selection of patients and the functional outcome depend on a number of factors including: the type and severity of the neuromuscular disorder; the nature and extent of the deformity; the quality of volitional muscle control; hand sensibility; and the age and intelligence of the patient (Zancolli and Zancolli, 1987).

Our classification of thumb deformity has evolved as our experience with the condition has grown. We have found that predictable results are dependent on an accurate assessment of the deforming forces and underlying joint instability. Specific surgical techniques are then directed to particular types of deformity as outlined in the following paragraphs.

Releases

In order to produce a functional balance of thumb motors, we prefer to weaken rather than defunction spastic muscles by tenotomy. This maintains some activity in the released muscle and reduces the possibility of inadvertently over-correcting the deformity.

Adductor release (types 1 and 3)

In younger patients, a more controlled release of the adductor is achieved through the palmar approach. This allows correction of the thumb deformity without loss of
active adduction. The dorsal approach is useful in older patients with a myostatic contracture and for easy access to the first dorsal interosseous. When a dorsal approach is used, the selective incision of tendinous fibres distally within the adductor muscle weakens but does not defunction the muscle.

_Flexor pollicis longus release (types 2 and 3)_

The release should be intramuscular, allowing the tendon to slide 1 cm distally, as it is important not to over-weaken the muscle.

**Extensor/abductor augmentation**

The decision as to which extensor/abductor requires augmentation is based on the preoperative evaluation and also an intraoperative assessment of the tendon-unit (recipient) which best draws the thumb out of the palm (Fig 6). The choice of transfer depends on the assessment of individual muscle control as well as the usual principles of tendon transfers. Many transfers are available (palmaris longus, flexor digitorum superficialis and even wrist extensors and flexors are possible alternatives to brachioradialis and extensor pollicis longus), but most are compromised by spasticity or paresis. Therefore, the position obtained immediately postoperatively is not always maintained. Accordingly, function postoperatively relates to the quality of control present preoperatively.

Our preferred techniques for extensor and abductor augmentation are extensor pollicis longus to extensor pollicis brevis transfer (especially in type 1) and brachioradialis to abductor pollicis longus or extensor pollicis brevis. The former procedure supplements metacarpophalangeal joint extension but decreases extensor activity to the interphalangeal joint. The latter procedure provides an active motor to abductor pollicis longus or extensor pollicis brevis and results in more predictable function than an abductor pollicis longus tenodesis. However, brachioradialis requires extensive proximal dissection and is sometimes weak and under poor volitional control. We now commonly employ the extensor pollicis longus to extensor pollicis brevis transfer in combination with brachioradialis to abductor pollicis longus for type 1 and 3 deformities.

**Joint stabilization procedures**

These are required when underlying joint instability compromises efforts to rebalance the forces or when, owing to lack of volitional control; it is the only means of controlling joint position. This is particularly important for the metacarpophalangeal joint, where hyperextension instability is exacerbated by augmentation of motors acting distal to the joint (extensor pollicis longus, extensor pollicis brevis). This in turn leads to an adduction moment acting on the thumb metacarpal rather than the desired abduction moment.

Metacarpophalangeal joint capsulodesis is an effective way of overcoming hyperextension of this joint (Tonkin et al., 1995). Metacarpophalangeal joint fusion (Goldner et al., 1990), preserving the physis in immature bone, is
used when capsulodesis cannot control hyperextension or when tendon transfers fail to overcome a metacarpophalangeal joint flexion deformity. Carpometacarpal joint fusion is rarely indicated except when it is impossible to control metacarpal abduction: there is then some preservation of movement from the scaphotrapezial joint. This is preferable to complete loss of thumb metacarpal motion which results from an interposition bone graft between the first and second metacarpals. Interphalangeal joint fusion may be considered for persistent flexion deformities or if the joint is unstable.

Quantifying the functional outcome in this group of patients is difficult. We have used a simple evaluation system based on five daily tasks. We accept that the estimation of thumb position is also imprecise, relying as it does on the co-operation of the patient and the eye of the examiner (albeit the same one in every case). Furthermore, the final functional outcome is dependent on the success or failure of other surgical procedures on the limb (Gschwind and Tonkin, 1992; Tonkin and Gschwind, 1992). We tend not to combine thumb surgery with wrist and finger procedures, other than to consider an flexor pollicis longus lengthening or adductor release, if indicated, at the time of forearm surgery. The correction of a wrist flexion deformity may alter the attitude of the thumb significantly and we therefore prefer to wait for 6–12 months after the former procedure before considering a more sophisticated correction of the thumb deformity.

The aim of surgery 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. The key to achieving consistent release of the spastic thumb-in-palm deformity and to establishing functional lateral pinch is the accurate determination of the deforming forces and the identification of joint instability. This paper presents the results of our early surgery applying these principles. It is not designed to do anything other than describe our results, our failures and to develop a philosophy which, we hope, provides a logical approach to the choice of release, augmentation and stabilization procedures.

References


