Normal hand function is essential to carry out all the activities of daily living independently. The child using his hands in play prepares himself for this independence.

Soon after birth the infant sucks his fingers lustily but at this stage his grasp is purely reflex and purposeless. Eye hand control develops early, so that by five months the hands meeting together in the midline begin to grasp with purpose. This grasp is palmar and ulnar but as reaching becomes more co-ordinated the infant grasps between the palm and base of the thumb. By eight months the inferior pincer grasp develops and small objects are held between the side of the index finger and thumb. At the end of the first year the normal adult pincer grasp is present.

Release develops later than grasp and is not well adjusted to the size of the object until the end of the first year. The child continues to develop power and dexterity of the hand learning by touch and manipulation throughout his growth period.

To develop normal hand function he needs both normal bone and soft tissues and must develop normal synergic action between the various muscle groups of the hand. Normal sensation is also necessary for the development of normal hand use.

**ABNORMAL HAND FUNCTION**

Any abnormality of hand function is a disturbing factor in the normal growth process. The child may not develop a normal power grip or the ability to handle objects delicately using the thumb and finger tips. When sensation is abnormal hand function is disturbed or even absent.

Common Causes of Abnormal Function

1. Congenital defects.
   (a) Arthrogryposis where severe and disabling deformities are present at birth, with limitation of joint ranges and weak fibrotic muscles. The wrists and fingers are usually flexed with little movement present.
   (b) Absent radius or ulnar usually associated with a small deformed club hand laterally flexed to the side of the missing bone. Finger movements are often poor due to abnormal muscle and bone formation.
   (c) Other defects which include the many hand deformities of a mixed nature. These are very variable with no two alike.

2. Paralytic causes.
   Here muscle weakness and consequent imbalance results in inability to use the hand normally. Contractures and deformity occur with growth and constant abnormal use. Poliomyelitis, peripheral neuritis and cerebral damage may all cause varying degrees of paralysis.

   In rheumatoid arthritis the inflammatory condition of the connective tissue causes inability to use the hand in the early stages because of pain and muscle spasm. Later structural changes occur due to progressive fibrosis and joint damage causing disabling deformities.

4. Traumatic causes.
   Many accidents occurring in childhood result in damage to the hand.

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Burns which affect the skin and soft tissue develop contractures during the granulating phase. Even after skin grafting, shrinkage occurs and in the child's hand, severe deformity can result.

Tendon injuries, fractures and nerve lesions are all common mishaps. Often following satisfactory repair fibrosis may result in tendon adherence, contractures and stiff joints.

In all these conditions contracture of the soft tissues of the hand is a common factor contributing to abnormal hand function. Any contracture can cause disabling deformities which prevent the development of normal hand function. Growth during childhood causes deformities to increase unless they are treated with effective and continuous therapy.

Frequently contractures can be avoided with careful management and many deformities can be corrected without surgical interference. This necessitates the use of effective splinting over a long period of time.

The Role of Splints in Treating the Hand

Treatment of the hand aims to restore function and particularly the grip in all its various forms. A useful grip needs sufficient wrist extension to give power to the finger flexors, and flexible opposable digits. Because of the initial deformity this is not always possible but surprisingly useful function can be obtained with treatment.

Many therapeutic measures will be involved but are often ineffective unless used in conjunction with suitable splinting.

The use of splints depends on the cause of the malfunction and varies accordingly.

1. Resting Splints.

These allow recovery of paralysed muscles to take place in a physiological resting position, i.e. near the mid-position of the normal movement range of the joint. They are also used to reduce pain from muscle spasm and inflamed tissues as occurs in the rheumatoid hand.

2. Splints to stretch tissues.

These are used where contracted tissues are present as in congenital defects or if this has occurred for any other reason. They are also used to prevent contractures occurring. Serial fixed or removable splints are most effective.

3. Functional splints.

Active or lively splints help function as recovery is occurring and have a place in paediatric work. However, as much of the splinting used during childhood is concerned with prevention or correction of deformity, splinting is often more passive and rigid. It must be used in conjunction with other active physiotherapeutic measures.

Materials used and their method of application

It is essential that all hand splints be light and comfortable. Heavy cumbersome splints are not well tolerated by the child. They will not remain in position or be as effective.


This is probably the cheapest material available and is easily and quickly applied. Specially prepared low plaster loss bandages are used when making these splints, and the most common methods of splinting with this are:

(a) Serial fixed plasters. A light fixed plaster is applied initially with as much correction as possible without causing circulatory changes. This is changed at first at frequent intervals (every three or four days) and later at weekly or fortnightly intervals according to the correction gained, and is generally used over a six week period.

To apply the plaster, the forearm and hand are covered with stockinette and a thin layer of sheet wool evenly applied. Half a plaster bandage (of 2", 3" or 4" width according to limb size) is soaked in the usual way and bandaged firmly and smoothly. Only enough bandage is applied to hold the position...
while correction is obtained. It is then completed but kept as light as possible as a heavy plaster will slip on a small malformed arm.

The elbow may be included to prevent the plaster slipping, e.g., correcting a small club hand with no thumb. In this instance the arm is plastered from the axilla to just above the wrist with the elbow in 90° flexion. When this part is set the plaster is completed while the wrist is held in a corrected position. Care must be taken not to cause pressure from plaster edges.

If the plaster is moulded into a slightly elliptical rather than cylindrical shape over the soft tissues of the forearm it is less likely to slip (Fig. 1).

![Fixed plaster for club hand showing elliptical shaped moulding of the forearm.](image)

It is not usually necessary to reinforce the plaster but a collar and cuff sling will prevent damage during the drying period.

(b) Removable plaster splints. These are made from plaster slabs of 4" or 6" width according to the size of the hand. For light effective splints only four thicknesses of plaster are used in their making. These can be reinforced with rolled plaster strips, moulded duralium, the plastic centres of plaster bandages softened in hot water and then moulded, celastic or glassona. A light but durable splint can be made from an intelligent combination of these materials.

The slab extends from just beyond the middle finger to 1" below the elbow crease in a full hand splint and to the finger webs in a cock up splint. A thumb hole is marked at the base of the first metacarpal and at the fold of its web as the hand rests in place on the slab. An oval hole is cut shaped to clear the thenar eminence and allow correct positioning of the thumb. If the thumb is to be included, a three thickness slab wide enough almost to encircle the thumb and extending from the tip of the thumb along the web and as far as the tip of the index finger is measured. A narrow two thickness slab is made to mould over the web area (Fig. 2).

Where there is hair growth, the limb is lightly greased. The wet slab from which excess water is carefully removed is applied to the forearm and hand moulding it to the appropriate position.

The use of a thumb hole gives a good fit to the splint and helps hold the slab in place during making. The thumb slab is applied over the palmar and medial surface, across the web and along the side of the index finger. This ensures good moulding into the web. The narrow slab placed across the web holds the thumb slab in place (Fig. 3). Unless the area of the thumb web is well moulded the thumb will not fit satisfactorily into the splint and hyperextension of the metacarpophalangeal joint occurs.

The slab is bandaged, using one layer of plaster, only if the child is very restless or the position hard to maintain, e.g. a spastic hand.

The splint is finished in the usual way. When dry, velcro straps are applied using glassona to hold them in place and the splint is reinforced as necessary. The wrist straps may be more effective if crossed with straps over the dorsum of the hand. In the posterior hand splint an encircling strap passing over the web of the thumb across the lower palm and then around the splint and the wrist to attach posteriorly at the thumb web area prevents the splint from slipping (Fig. 4). Straps holding the fingers in place avoids the palmar crease in a spastic hand. All straps are more effective if felt pads are used over skin areas to ensure a firm grip.

Figure 2
Plaster slabs—note thumb hole in arm slab.

The making of a palmar or dorsal splint is essentially the same with the thumb inserted appropriately through the hole. Strips of plaster may also be added to separate the fingers.

When the splint is set the edges are marked for cutting down. Unless the plaster is cut low at the wrist joint and along the sides of the fingers it will slip off. It must allow comfortable elbow flexion. The strap positions are marked to hold the fingers, thumb, wrist and forearm in position.

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Although these materials are light and often easily moulded directly to the skin it is not always possible to get an effective correction with a small deformed hand. Some materials are both light and semirigid and make more comfortable splints especially where spasm is present. They also allow a little movement which may assist hand function in the congenitally deformed limb.

They are easily cleaned, withstand play in cold water and tolerate an amazing amount of abuse.

Some can be remoulded for further correction or to accommodate growth and will not need renewing over a long period of time.

(a) Prenyl. This semirigid plastic is available in varying weights and makes a light comfortable splint. It is fairly easy to cut with scissors and is pliable when put into hot water. It is directly applied to the skin and can be stretched and moulded to the part. It must be held in position until set which takes several minutes and this is a disadvantage in a young child.

It can however be easily remoulded and adjusted as necessary. It may cause skin irritation and discomfort from sweating and punch holes will help prevent this but slightly lessen its rigidity. Lining with a fine lemon hide helps reduce these discomforts.

Application: A slab is measured by outlining the hand and forearm allowing \( \frac{1}{2} \) extra. A thumb hole is cut for a cock up splint which only extends to just beyond the metacarpophalangeal joints. In the full hand splint the thumb is separated from the finger piece by a slit cut to the thumb web.

Immersion in very hot water for a few seconds makes the material very easy to use, but it must be cooled to a comfortable temperature before applying to the skin. It is moulded into the position and held in place with a crepe bandage, which must be bandaged lightly.

In the posterior hand splint the thumb piece is swung around to fit over the web of the thumb and thenar eminence. A thumb slab moulded in the same way as the plaster splint is joined to the posterior slab with Prenyl cement.

As soon as the splint is set sufficiently to hold its shape it is removed and immersed in cold water to increase its rigidity quickly. It may be reinforced using moulded strips of prenyl or prenyl ribbing cemented in place.

Velcro straps hold the splint in place and are attached by rivets or sewn on through small punch holes.

Isoprene, a more recently available plastic can be used in a similar manner and has the advantage of being more malleable and becomes rigid more quickly.

(b) Polythene. This plastic material needs heating to 300-400° in an oven. It can be applied directly to the limb over felt padding but is better moulded onto a plaster cast in paediatric work.

The splint is both light and durable and well tolerated although a little
more cumbersome and fits less snugly on a small hand. Being a more rigid splint it stands up to hard wear. It cannot be altered satisfactorily to allow for growth or improvement of the hand.

The positive cast is made from the negative, in the usual way, by the physiotherapist, and the splintmaker uses this for the moulding of the splint. The splint is then fitted and suitably trimmed. Leather or velcro straps are riveted in place. Punch holes help prevent excessive sweating and adhesive felt, pressure on any bony areas (Fig. 5).

3. Metal Splints.

Plastic materials, especially prenyl and isoprene are largely replacing the use of metal in splint making. They are, however, useful in strapping some contracted fingers and can be serially adjusted. Varying gauge duralium is used according to the size of the limb. The splintmaker cuts the splint from an accurate paper pattern made by the physiotherapist.

When used for serial correction it is applied with an adhesive felt cover and strapped directly to the hand. Felt is used to increase the corrective force without traumatic pressure to the skin.

Types of Splints Used

Any of these materials can be used in making a splint. The choice depends on the condition being treated, the child's age, the length of time the splint is to be used or when it is used. Each patient is carefully considered and often a variety of splinting material is used during the course of treatment.

1. The Cock up Splint. (See case history Lisa.)

This may be used on the palmar surface (Fig. 7) or dorsal surface (Fig. 14).

2. The Resting Splint. (See case history Ronnie.)

This is usually worn on the palmar surface of the arm and is made in the physiological resting position of semi-grasp with the thumb directly below the index finger.

In the rheumatoid hand this position of rest will vary if deformity is occurring. The fingers may be more extended but it is important to maintain the functional cupping of the hand.

3. The Posterior Hand Splint. (See case history Cathie.)

This extends from just beyond the finger tips to 1 1/2" below the flexed elbow. The thumb is held in the reflex inhibitory position of extension and abduction with the splint well moulded over the web and thenar eminence (Fig. 4). A hand shake grasp used in making the splint induces reflex relaxation of the hand and accurate moulding over the thumb web.

An overextended wrist position causes uncomfortable pressure on the back of the wrist and the splint will not be tolerated. It may be necessary to use a felt strip along the first metacarpal when making the plaster splint.

4. The Thumb Splint. (See case history Cathie.)

This also aims to induce reflex relaxation of the hand and an elongation of
hand splinting in children

the contracted web. It fits over the web of the thumb and extends partway along the first phalanx of the thumb and index finger and is usually padded with felt. It is moulded over the posterior and anterior aspects of the first interosseous space and held in place by a velcro strap around the wrist. It is a useful splint in the hemiplegic infant and may help function in the older child (Fig. 17).

5. Various modifications of these splints can be devised to improve hand function.

Case Histories

Lisa, aged 6 weeks was referred for treatment of arthrogrypic type flexion deformities of her hands. The right hand could be passively extended fully at the wrist and fingers, the left only to neutral. The left elbow was fully extended at rest but could be passively flexed to 75° (Fig. 6). Both shoulders were limited in external rotation and elevation. Some grasp reflex was present in both hands.

Splinting

Cock up splints were used including the fingers but leaving the thumbs free, these being abducted with felt (Fig. 7). In a month with increasing correction of the deformity these were remade and the thumbs included in the splints. The splints were of plaster reinforced with glassona. A left prenyl arm splint including the hand held the elbow in maximal flexion and was used alternatively with the hand splint (Fig. 8).

Progress

Active dorsiflexion of the right wrist and fingers improved to almost normal over a three month period and this splint was then used at night only. The left elbow gained an increasing amount of passive and a small range of active flexion. The left wrist still lacked sufficient extension to give an effective grip and as tactile grasp was developing a small prenyl cock up splint was made. At 15 months her active control of the arms is good (Fig. 9).

Problems

The cock up splints which included the thumbs tended to slip and needed crossed straps to hold them in place. Remoulding of the elbow splint to increase elbow flexion was not well tolerated and needed readjusting. This splint soon needed reinforcing to counteract the overacting triceps. With increasing hand awareness the splint actively encouraged some elbow flexor exercise as the baby sucked her thumb protruding through its hole.

Figure 6
Lisa showing deformities of arms at 6 weeks.

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Splinting

Serial pterygoid splints gave the most comfortable early correction of these small grossly deformed hands. Later serial plaster splints were used to splint the thumb and fingers more adequately. The fingers were separated by narrow plaster ridges to correct curving and ulnar deviation (Fig. 11).

Problems

These hands have been difficult to splint and in the initial stage only felt and Z.O. strapping could be used. The severe almost spastic like flexion deformity of the metacarpophalangeal joint has been difficult to correct and hold in the splint and caused some hyperextension of the interphalangeal joints. The splints eventually were kept satisfactorily in place by using a long strap which crossed over the back of the hand and encircled the splint and wrist.

Progress

This child has gained considerable functional use of his hands although their appearance is not normal (Fig. 12). He can crawl on all fours and is now pulling up to standing in an attempt to walk.

*Barbara, aged 8 years was born with severe flexion deformities of both hands. The thumbs lacked a metacarpal and were small and useless. Muscle development to the hands was abnormal. The second metacarpal was widely spaced from the third. The rest of the arms were normal.*

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Splinting and Progress

The hands were treated with serial plaster splints that were changed frequently and initially reinforced with Z.O. adhesive tape. This also held the splints in place using gauze or felt over skin areas.

When the flexion deformities were sufficiently corrected and hand use improving, the first finger was splinted into an opposable position with a plaster splint at night and a light duralium one for day use.

The rudimentary thumbs were removed at 4 years. Night splints were continued until 7 years. The left hand then had good function and was left free.

The right wrist lacked dorsiflexion beyond neutral. This hand was stretched in serial fixed plasters for 8 weeks. These included the wrist but left the fingers free so as to not interfere with the flexion of the metacarpophalangeal joints. After removal of the plaster an anterior prenyl cock up splint was made for day use and a dorsal cock up splint for functional use. In this latter splint the three lateral fingers were inserted through a slit in the prenyl and this palmar piece controlled dorsiflexion, fitting just below the metacarpophalangeal joint. The plasticity of prenyl gives considerable latitude in moulding.

The splints needed a lemon hide lining to prevent skin irritation. The child needed persuasion to persevere with the hand splint which does increase function and has maintained a stronger and better range of dorsiflexion (Figs. 13 and 14).

Kelvin was referred at 3 weeks for serial plaster splinting for deformities of both hands. These lacked thumbs and normal muscle and joint function and were initially flexed at the wrist and fingers. Both removable plaster and duralium splints were used.

At 3 years the child had no further treatment until re-referred, aged 6 years, because of flexion and ulnar deviation of the left wrist. Because of very poor active finger flexion and no opposable digits, objects were held between the palm and forearm.

Serial fixed plasters on this hand increased range and were followed by plaster night splints and a light prenyl day splint.

Problerms

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Progress

Lack of finger flexion and opposable digits is a serious disability but the young congenitally deformed child develops surprisingly functional hand use. This child has increased function of the hand when using the splint (Fig. 15).

Progress

He quickly regained full extension became pain free and has gained increasing finger flexion with regular physiotherapy and suitable medication.

Ellen aged 10 years suffered full thickness burns to both hands and forearms. Anterior metal cock up splints were used over dressings in the initial stage. Despite early skin grafting she developed gross hyperextension deformities of the metacarpophalangeal joints.

Splinting and Progress

Sansplint dorsal splints were made to hold the fingers in flexion and remoulded with improvement of range. The left hand was more

Ronnie aged 8 years was ordered resting splints during the early acute stages of rheumatoid arthritis. These were made with extended fingers but slight cupping of the palm as the finger flexors were painful and contracting with spasm. Plaster reinforced with glassona was used.

Problems

With continued use the child developed some skin irritation and was given cotton stockinette to wear under the splints.
difficult to control and serial fixed plasters were used for three weeks in an attempt to flex the metacarpophalangeal joints. The left hand was regrafted across the metacarpophalangeal joints dorsally and the thumb freed and the web grafted. The right hand was manipulated at the same time. Both had further serial plasters with frequent changes although the left was not changed except for dressing until the grafts were satisfactorily healed.

Eventually the hands were left free to encourage function but dorsal splints which now had thumb pieces were used part time in the day and at night. The right hand was left completely free one year after injury. The splint on the left was changed to a prenyl anterior one with the fingers as flexed as possible and the thumb web stretched.

Problems

The serial splinting in fixed plaster was difficult because of poor skin and lack of normal sensation. Adhesive felt was used in attempt to protect vulnerable areas and also to stretch the finger webs. In between changes of plasters it was at times necessary to leave the hands free of plaster for 24 hours using saline baths and the plastic splints to control the position.

The left hand was strapped to a curved duralium splint which was serially remoulded to gain further correction of the 4th and 5th fingers and allow function of the others at a stage when skin areas were particularly vulnerible. Strapping over tulle grass was used and healing occurred satisfactorily.

Tony aged 11½ years suffered a severe injury to his right hand with degloving but no tendon or nerve injury. He was referred for serial splinting because of the flexion deformity of the 4th finger, until healing of the hand was complete.

Splints

Serial removable plaster splints which included the wrist and splinted the fourth finger only were used. These needed reinforcing with glassona and later a duralium strut to maintain finger extension without hyperextension of the metacarpophalangeal joint (Fig. 16).
Progress

A full range of passive movement of the fourth finger was gained and good function of the rest of the hand. The fourth finger lacked flexion at the interphalangeal joints probably because of adherence of the flexor tendons, and is to be surgically investigated.

Kathie was born by Caesarian section and found to have a right hemiplegia at 8 months. She has an athetoid type lesion and has some use of the right arm but co-ordination is poor and associated with movements of this limb are a problem.

Splinting

She was unable to tolerate a plaster night splint but finds the prenyl one very comfortable. She has had this for one year and it was recently completely remodelled to accommodate growth (Fig. 4).

A sansplint thumb splint was made two years ago in an attempt to improve the use of her hand (Fig. 17).

Conclusion

Although splinting may give much improved hand function it is not always well tolerated by an active child who prefers his own trick movements which are quicker and easier. The physiotherapist needs much patience in helping both the parents and the child to appreciate the value of splinting which must always be as light, comfortable and effective as possible. However, the gratifying results that can be gained, as illustrated by the above case histories, more than adequately compensate for the demands placed upon the children, parents and physiotherapists.

Summary

The development of normal hand function and its importance in attaining independence has been discussed. Abnormalities of hand function and the various causes have been mentioned. The various splints, the materials used and their construction have also been described, and illustrated in the case histories.

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Case histories and photographs have illustrated the use of the splints, their effectiveness and the gratifying results that can be gained.

Bibliography


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