PROCEEDINGS OF
THE NORDISK ORTOPEDISK FÖRENINGS
28TH ASSEMBLY IN HELSINGFORS

JUNE 1956

The meeting of the Scandinavian Orthopedic Association was held in Helsinki under the presidency of K. E. Kallio.

MUSCLE AND TENDON TRANSPOSITION IN POLIOMYELITIS

Speakers: *H. Nissen-Lie,* Oslo, *L. Hagelstam,* Helsingfors.

H. S. Nissen-Lie (Oslo):

The treatment of pareses following poliomyelitis has long been one of the main tasks of orthopedic surgery.

The great epidemics of recent years have increased the number of invalids who claim our aid, at the same time as we have put patients under observation at an earlier stage.

Today our treatment is first and foremost prophylaxis and reconstruction. Besides exercises and splints we have a number of operations which can prevent deformity and to a certain extent restore lost function. Deformity and lack of stability is best prevented by arthrodesis; in transposition of the tendons the intention is to make use of the residual musculature for the most necessary movements.

A number of conditions must be fulfilled in order to carry out a successful tendon transposition.

1. Free passive mobility must be present, a transposed muscle cannot work against a fixed contracture.

2. The muscle to be transposed must have sufficient strength. One must take into consideration that the muscle loses much strength by being transposed, and if it is too weak for its new task, then it will be tired out and the result be a failure.

In treating the poliomyelitic pareses, precisely this condition often loses its force since the strength of the muscles available is difficult to judge.

3. The muscle must attain a standard of mobility which is sufficient for its new function.

4. The transposed tendon must go through loose subcutaneous fat with a straight course as far as possible.

5. It is of advantage to employ a muscle which normally co-operates in the movement it is sought to obtain.

6. The intervention must be performed aseptically and atraumatically; the vessels and nerves of the muscle must not be damaged.

7. Finally it must be stated that the result is dependent on a thorough physiotherapeutic treatment. The patient must be trained to use the transposed muscle, and the muscle must be exercised to attain the greatest possible strength.

The indications for operative intervention are particularly difficult with respect to poliomyelitic pareses. The functioning of the patient, taken as a whole, is decisive. Even if the local findings are in agreement, an intervention which is of great value to one patient may harm another. A wrist arthrodesis is an excellent procedure, but a wheelchair patient can lose his sole opportunity of mobility in this intervention. Opposition of the thumb is very valuable; but where adduction of the thumb is the patient's only form of grip a successful opposition operation can rob him of the ability to hold writing material and food utensils. It helps little if we can show good results from our interventions if the patient loses other functions, more important to him. One must be especially careful when operating on elderly people and on patients who have practised substitute movements over a long period. What can be achieved by the operation will also depend to a large extent on the patient's intelligence and on the energy which it can be anticipated he will devote to the necessary aftertreatment.

An operative intervention must never be performed without detailed observation, preferably over a fairly long period. The possibilities which may arise must be discussed with the patient or his relatives, and the discomforts which follow the intervention must never be glossed over. Great advantage can be obtained from explaining the plans of operation to the physiotherapist and social workers so as to estimate the potential of the patient together with these colleagues.

When ought the interventions to be performed? how long after the acute stage? and at which age?

In my opinion the patient should be operated on as early as possible, preferably as a direct link with the primary physiotherapy. The most fundamental part of the spontaneous improvement occurs in the course of the first 3–6 months. Slight pareses will recover sufficient strength, total pareses will very seldom achieve any utilisable function. On the basis of a large and carefully investigated series W. J. W. Sharrard 1) says that if there is paralysis after 6 months it is "unfair to the patient to hold out false hope of recovery". The physiotherapy is continued as long as there is obvious progress, but if a muscle or muscle group is paralytic after 6 months there is little point in postponing an advantageous operation a further 1–2 years.

The patient's age is however decisive in many operations. Arthrodesis must normally be postponed until the child is grown. In tendon transplantations one has more of a free hand, but individual authors (2, 3) declare that one ought not to carry out these operations until after 8 years of age. The delay means however not only lost time and unnecessary treatment; there is a great risk of fixed deformities and often after some time the patient will have acquired substitute movements which it can be dangerous to abandon.

Pareses in the upper and lower extremities demand different operations. In the lower extremities stability is most important, in the upper extremities it is free, active mobility which is essential. The lower extremities must stand constant weight-bearing, in the upper extremities one can utilise all active mobility even if the strength is moderate. On the lower extremity great benefit can be gained from

permanent splints, on the upper extremity splints as a rule hinder function. To a large extent the operative indication for the upper extremity will depend on the patient's other pareses. If the lower extremities are weak and the patient is dependent on crutches or wheelchair, the operative demands are considerably different from those when the pareses are limited to the upper extremity alone. Patients with bilateral pareses may require different operations from those who have *one* good arm.

The deciding factor in the capacity of the upper extremity is the function of the hand; from a favourable initial position the fingers must be afforded active mobility and the thumb must be made capable of opposition. In order to take advantage of the finger movements the wrist joint must be stabilised, if necessary by arthrodesis. Moreover it must be possible to move the hand forward to that point and position where it is to be used; it must be possible therefore to move the elbow joint actively. By arthrodesis the movements of the scapula can be transferred to the upper arm, and thus replace to a certain extent the movements of the shoulder joint.

The polio patients possess *one* great advantage over invalids with paresis of another type,—their sensibility always remains intact. Good sensibility in the fingers is so decisive that even the most paralysed arm will be better than a prosthesis. Even in widespread pareses the parts of the muscles which have recovered can be utilised to afford the patient an extremity which can be used. It often occurs that certain of the strongly paretic muscles regain considerable strength after functional possibilities have been created by surgical interventions.

In what follows I will survey the most common tendon transpositions in the upper extremities. The other introductory speaker, Dr. L. Hagelstam, is presenting a large series from the Invalid Institute in Helsingfors, important interventions on the lower extremities. From Norway Dr. Møllerud will present the series from the Invalid Clinic of Sophies Minde.

A number of tendon transpositions and other operations have been suggested and performed on every single joint in the upper extremity.

The attempt has been made to stabilise the scapula by transpositions of several muscle attachments (teres major, pect. major, pect. minor) (4), or to fix the scapula to the ribs or to use a transverse fascioplasty (5). For defective abduction in the shoulder joint with complete or partial paralysis of the m. deltoideus a number of tendon transpositions are suggested but all authors (6, 7, 8) emphasise that the indications must be strong and that the intervention can be only performed on isolated or partial paresis of the m. deltoideus. In widespread pareses with loose joints only an arthrodesis can be possible.

For fail elbows Steindler's method is the most frequent. The medial epicondyle with the origin of certain forearm muscles is moved higher on the upper arm, and those muscles which normally take part in the flexion of the elbow obtain a better point of attack. The intervention requires strong forearm muscles and a firmly stabilised wrist joint. The operation cannot counteract the pronation contracture which normally follows biceps paresis, and the mobility is less than normal. The method is recognised as the best in suitable cases, and several articles have been published which show good results (9, 10). One can, however, also make use of other muscles for active flexion of the elbow.

Clarke (11) employs the m. pectoralis whose thoracal origin is passed down to the front of the upper arm and is attached to the biceps tendon.

Bunell (12) has utilised the m. sterno-cleido and moves the lower attachment of the muscle to the shoulder region and with the aid of a fascia transplant transfers this attachment to the biceps tendon.

Pro- and supination of the forearm are very important functions which it is difficult to restore. Attempts have been made to compensate for defective supination with the aid of the flexor carpi ulnaris the tendon of which is brought round the ulna to the extension aspect of the radius. A supinated wrist with defective pronation can be utilised even less and the attempt to create pronation has been made by moving the biceps attachment over to the outer aspect of the radius.

In pareses of the wrist musculature it is sought, by sharing the residual flexors and extensors, to obtain sufficient stability and at the same time to retain mobility. With isolated radialis pareses several articles have been published which show good results (13, 14).

Firm stability is however so decisive in the functioning of the hand that arthrodesis will often be preferred. This is especially often necessary in polio pareses where there is little musculature at one's disposal and everything must be used for finger function. As stated before, however, care must be taken as patients with pareses in the lower extremities as well are often completely dependent on a mobile wrist joint.

In flexing and extending the fingers the wrist joint musculature can be used, even if the mobility result is somewhat less.

It is of advantage to make use of the wrist flexors as finger extensors and vice versa, since these muscles work synergically under normal conditions.

More difficult to replace are the intricius muscles, m. lumbricales and interossei with their influence on the movements of the individual finger joints. Bunell employs the m. sublimis; the divided sublimis tendons are brought together with the m. interossei and attached to the extension mechanism so that the claw position of the fingers is counteracted.

The same effect can be achieved by dividing the tendon sheet beyond the base phalanx so that the flexor profundus also flexes the base joint. In some cases arthrodesis of the interphalangeal joints in semiflexion may be necessary. A flexion contracture of the base joints with free mobility in the middle and outer joints can also result in a utilisable grip.

For the thumb free active mobility in the carpo-metacarpal joint is the deciding factor. It must be possible to stabilise the metacarpo phalangeal and the interphalangeal joints in a slight flexion, but mobility here is not so important.

Defective opposition is a very frequent consequence of poliomyelitis. While the other muscles improve and achieve adequate strength, more often permanent paralysis of the small muscles in the thenar occurs. Sherrard (1) found that 30 out of 75 opponens pareses remained permanently paralytic while only 3 out of 81 triceps pareses and 9 out of 108 pectoralis pareses were permanently paralysed.

A number of tendon transpositions have been proposed to obtain active opposition of the thumb (15, 16, 17), and of recent years there have been several follow-ups (18, 19).

In principle the majority are agreed about the requirements which Bunell in particular has stressed, that the active tendon must pass from the ulnar aspect of the wrist joint to the radial aspect of the first phalanx of the thumb, and that the simplest method is to employ the m. sublimis from the long and ring fingers. C. E.

Irwin (20) has shown that excellent results can be achieved with isolated paresis of the m. opponens and the flexor brevis, but that the poliomyelitic pareses are often more widespread and need supplementary interventions.

Finally I shall review a small series operated on personally. In the course of the years, 1952–1955, 73 operations in all were performed on 43 patients with Polio pareses of the upper extremities. 18 of the 43 patients were between 5–14 years, 17 were 15–24 years and 8 were more than 25 years old. The operation was performed 4 times within a year after the acute stage of the disease, 14 times during the 2nd year, 8 times in the third year, and 17 times more than 3 years after the onset of the disease.

I have not found any case where tenoplasty might possibly achieve active abduction of the upper arm, but in 6 cases with total pareses and subluxated joints carried out shoulder arthrodesis. In paralysis of the wrist I have preferred arthrodesis, since I believe that reliable stability in a good position is most important for a good result and that discomfort from a stiff wrist joint is relatively slight.

In all cases the residual wrist muscles are utilised in finger movements. In all, 8 unilateral wrist arthrodeses were performed.

Where no utilisable musculature is available, the thumb and fingers also may show in individual cases indications for fixation interventions. 6 arthrodeses of the 1st carpometacarpal joint and 2 tenodeses were performed.

Tendon transpositions were carried out to obtain active mobility of the elbow, thumb and fingers, and once for supination of the forearm.

In paralysis of all the elbow flexors widespread pareses have as a rule been present in addition, and I have only twice performed Steindler's operation.

The result was fairly good with active mobility around the right angle (60 to 110°).

The other patients had no forearm musculature nor any function in the M. pectoralis. In two cases I made use of the sternocleidomastoid muscle and in this way obtained a good result with active flexion from 20° to 120°. The strength is sufficient for light work and the cosmetic result is not dismaying.

For supination I once tried transposition of the m. flexor carpi ulnaris, but without result.

For active flexion and extension of the fingers 10 tendon transpositions were performed 8 of which had satisfactory results. The extensor carpi radialis gave in 3 cases good flexion of the fingers, and in 3 other cases good flexion of the thumb. Twice the m. palmaris longus was the sole available muscle for finger extension, but on both occasions obtained adequate opening of the finger grip.

For opponens paresis following poliomyelitis I performed 36 tendon transplantations, 33 of which were followed-up for more than 1 year. 27 showed satisfactory results while 6 were unsuccessful. In one case which was operated on more than 10 years after the acute stage of the disease, the thumb was atrophic with adduction contracture and subluxation in the carpometacarpal joint. The other unsuccessful cases had very widespread pareses and probably the transferred m. sublimis was too weak.

15 of the 27 with satisfactory results were excellent with normal opposition, abduction, flexion and extension. The patients had a good grip, and a normal grip

between thumb and index finger. The remaining 12 gained good effect from the transplanted tendon, but the stability and mobility of the thumb was not normal. In the majority of cases defective or reduced flexion of the carpo-phalangeal joint of the thumb was discovered, combined with hyperflexion of the outer joint; in other cases defective stability of the carpometacarpal joint was the cause of the less successful result. In these 12 cases supplementary interventions as suggested by Irwin would possibly have improved the results.

For paralysis of the m. interossei and m. lumbricales I have not performed any intervention on poliomyelitis patients, but I have availed myself of Bunell's sublimis transplantation for ulnar and median damage and one case of syringomelitis.

Finally I shall discuss briefly 2 patients with unilateral, almost completely paralysed arms; these were given utilisable function by a series of operations. In both there was paralysis of the deltoid, the pectoralis and all the upper arm musculature, and moreover considerable pareses of the forearm, hand and fingers. Both believed that the arm was useless and desired amputation.

Arthrodesis were performed in the shoulder, wrist and 1st metacarpo-carpal joint. Later transplantation of the sternocleidomastoid was carried out to flex the elbow. In the one patient the m. palmaris longus was employed to extend the fingers; utilisable finger flexion was given to the other by transferring the m. carpi radialis.

Summary.

The transposition of tendon attachments is employed to prevent deformities but also to restore active mobility. The tendon transposition is used both as an independent intervention and together with arthrodesis.

In the treatment of patients with pareses following poliomyelitis the indications for operative intervention must be always very strong and can only be determined after careful and long observation. One must strive for an improvement in the whole functioning of the patient, not treat merely the local paresis.

Consideration must be given to the patient's age, his intelligence and the energy he can be expected to devote to the aftertreatment.

The operative procedure ought to be performed if possible in connexion with the primary physiotherapy, as soon as retrogression of the pareses can no longer be shown, but before contractures have developed. Where total paralysis exists 6 months after the acute stage of the disease no utilisable function can be expected; if some activity can be demonstrated one ought to wait as a rule at least one year. Children under 5 years of age should of necessity be operated on however.

In order to obtain active mobility after tendon transposition free, passive mobility must previously exist. Similarly the muscle to be transferred must have adequate strength and mobility; the tendon must go through loose subcutaneous fat and the intervention must be performed aseptically and atraumatically. The muscle used should work synergically with the paralysed one and a thorough physiotherapeutic treatment must be pursued after the operation.

For the lower extremities good stability is the most important factor, for the upper extremities free active mobility.

The function of the hand is decisive:—it must be possible to give active mobility to the fingers from a favourable initial position. It must also be possible to bring forward the hand to that point at which it can be utilised and active mobility ought

to be given to the elbow joint. The wrist joint and shoulder can be fixed, if necessary, in a favourable position.

The most common operations on the upper extremities were reviewed and finally a personal series was reported, 73 investigations on 43 patients with poliomyelitic pareses in the upper extremities.

18 of the patients were 5–14 years, 17 between 15–24, and 8 more than 25 years. The operation was performed 4 times within a year of the acute stage, 14 times in the 2nd year, 8 times in the third year and 17 times more than 3 years after the onset of the disease. 6 shoulder arthrodeses were carried out, 8 wrist arthrodeses and also 6 arthrodeses and 2 tenodeses on the 1st carpometacarpal joint.

Tendon transpositions were performed to obtain active mobility in the elbow, forearm, thumb and fingers.

Steindler's operation was performed twice and produced an active flexion in the elbow from 60° to 110°. A transposition of the sternocleidomastoid gave to a totally paralysed arm in 2 other cases an active flexion from 20° to 120°.

For active flexion and extension of the fingers a total of 10 tendon transpositions were carried out, 8 of which gave satisfactory results. For opponens pareses 36 tendon transplantations were performed, 33 of which were followed-up for more than 1 year. The results were satisfactory on 27 occasions. 15 of these were excellent with normal opposition, abduction, flexion and extension. The remaining 12 obtained benefit from the transplanted tendon but the stability and mobility were otherwise not normal. In the majority of cases the tendon to m. sublimis IV was passed under the attachment of m. fl. carpi ulnaris and then subcutaneously to the base of the thumb's first phalanx.

Finally 2 patients were demonstrated with unilateral, almost completely paralysed arms on which a series of operations brought about utilisable function.

Lars Hagelstam (Helsingfors):

The aim of tendon transposition and the results of muscle or tendon transference in the lower limb for poliomyelitis are reviewed on the basis of 534 operations carried out on 500 patients. A great number of patients had severe chronic deformities. The first aim of tendon transposition was to prevent deformity or to maintain satisfactory preliminary reduction in case a chronic deformity had developed. On the other hand, tendon transfer aimed at restoration of active movement.

For correction of flexion contracture of the hip joint the tensor fasciae femoris muscle was transferred dorsally to the great trochanter and fixed to the sacrum. In respect of posture and walking ability the results of the operation were good. Paralysis of the quadriceps femoris muscle with flexion deformity of the knee joint indicated transfer of the ilio-femoral band or of the tendons of the medial or lateral hamstrings, or of both, to the patella. Recurrence of contracture was prevented and stability improved in most cases.

For securing stability of the foot, triple arthrodesis was performed simultaneously with tendon transposition on the foot in most adult patients. One hundred and one patients were operated upon for calcaneus deformity by transference of the peroneal tendons, toe flexors, posterior tibial or anterior tibial tendons in different combinations. The operation in most cases considerably improved the power

of the plantar flexion movement. The results of tendon transference for varus deformity were poor because the deformity was difficult to correct even with an arthrodesis and showed a great tendency to recur. Transposition of the peroneal tendons for valgus deformity, on the contrary, was successful in respect of deformity as well as dynamic action in most cases. Metatarsus primus flexus or medial cavus deformity could not be corrected by transference of the extensor hallucis longus tendon, whereas transposition of peroneus longus to the dorsum of the first metatarsal bone resulted in correction of the deformity. For equinus deformity the extensor hallucis longus, the posterior tibial or the peroneal tendons were transferred to the dorsum of the foot with many good results. A difficult problem arises when triceps surae is the only functioning muscle. The attempts at active tenodesis resulted in failures because of post-operative adhesions, but correction of the deformity was maintained after tenodesis.

The paper will be published in this journal.

TENDON TRANSPOSITIONS IN THE POLIO-PARALYSED HAND

by *K. Bang Rasmussen* (Copenhagen)

Summary

The material comprises 113 operations on 98 hands with polio-pareses mainly localized to the intrinsic muscles of the hand. The patients were operated in the Orthopaedic Hospital, Copenhagen, in the years 1953 to 1955.

In poliomyelitis we have all degrees of pareses from the grade of 5 to the grade of 0, this circumstance complicating the indication for operation and the planning of treatment.

The indication for tendon transpositions were an uneven spread of pareses compromising the balance of hand and fingers.

Most often we have used synergetic muscles of grade 5 to 4.

The 133 operations may be grouped as follows:

1) *Paralysis of lumbrical and interosseous muscles* (8 cases).

Treatment: a) Transposition of the sublimis tendons in 4 cases (good 2—fair 1—bad 1)

b) Transposition of extensor indicis propr. and extensor digiti quinti propr. in 4 cases (good 2—fair 2).

In poliomyelitis a transposition of the extensor tendons should be preferred. This operation stabilizes the metacarpo-phalangeal joints without reducing the flexion-power in the interphalangeal joints, where often are found partial pareses.

2) *Paresis of lumbrical and interosseous muscles without contracture* (12 cases).

Treatment: Activation of the 1st dorsal interosseous (good 6—fair 4—bad 2).

Another 7 patients ought to have been treated in the same way.

3) *Paralysis of the intrinsic and extrinsic muscles of the thumb* (7 cases).
Treatment: Stabilisation with a bone-graft between the 1st and 2nd metacarpal and activation of the long flexor and extensor (good 5—fair 2).

4) *Paralysis of the intrinsic muscles of the thumb* (6 cases).
Treatment: Opponens-plasty and tenodesis on the interphalangeal joint with both flexor and extensor tendons (good 6).
By tenodesing the interphalangeal joint this joint is stabilized, and the muscle power is transferred to the metacarpo-phalangeal joint.

5) *Paralysis of opposition of the thumb* (80 cases).
Treatment: Opponens-plasty after varying methods (good 44—fair 21—bad 15).

In poliomyelitis with varying paralysis of the intrinsic muscles of the thumb a standard operation cannot be used. The comparatively great number of unsatisfactory results are due to

a) a too weak sublimis
b) wrong insertion in the 1st phalanx
c) wrong placement of the tendon in relation to the metacarpo-phalangeal joint resulting in flexion or extension contracture in the metacarpo-phalangeal joint or maybe in a valgus contracture in the same joint. The hand cannot be opened.

Inspired by Joseph Boyes we have consequently modified the opponens-plasty. Most often the sublimis tendon is fixed in the short abductor tendon thus eliminating the risk of wrong placement of the tendon in relation to the metacarpo-phalangeal joint with following extension or flexion contracture. A reliable function of the short abductor is ensured in this way, and the hand may be opened. The very last rotating movement of the thumb, but the least important, is sacrificed.
27 opponens-paralyses have been operated on according to these principles (good 18—fair 6—bad 3). Out of the 27 cases 10 were reoperations as a consequence of a former bad result.

TREATMENT OF PARESES OF THE ELBOW FLEXORS AFTER POLIO

by *Knud Jansen* (Copenhagen)

The treatment of pareses of the elbow flexors must, as stated by Nissen-Lie, be considered as an integral part of complete reconstruction of arm function. The treatment is preceded or followed by the reconstructive treatment of the hand, where this is indicated, since only one who has a functionally effective hand will fully benefit from active elbow flexion.

It is clear here, as in other reconstructions, that the treatment must be planned with regard to the patient's functional capacity as a whole and on the basis of careful testing of the strength of the individual muscles. We often see the biceps-brachialis paralysis combined with severe pareses in other muscle groups, particularly the shoulder muscles and hand muscles, and this is often seen amongst the patients usually most severely affected, and often bilaterally.

We have at our disposal *operative* treatment and *splinting.*

The possible operations today are as follows:

Arthrodesis of the elbow joint

Steindler's transposition of the lower arm flexors

Transposition of the triceps brachii

Pectoralis-myoplasty

Myo-fascioplasty of the sternomastoideus.

Arthrodesis of the elbow is one of the most difficult arthrodeses and the result is not functionally satisfactory. In certain cases on the other hand an arthrodesis of the wrist joint or shoulder joint may be an advantageous supplement to activated flexion of the elbow.

Steindler's transposition of the lower arm flexors up onto the humerus by moving the medial epicondyle is rightly considered as the most physiologically correct muscle transplantation that is known. Since *Steindler* in *1918* announced the first results of his technique both he himself and others have announced an overwhelming number of good results. The fairly good and poor results are attributed both to overestimation of the transposed muscles and to the limitation of supination which accompanies the strengthening of the pronator teres.

In concluding the presentation of my own series I shall touch a little on the technical considerations arising from the operation.

The transposition of the triceps brachii is recommended by Caroll, and the method is also used by *Seddon* in certain cases. It is however a severe sacrifice to abandon active extension of the elbow.

It is in any case contra-indicated in patients with pareses of the trunk or lower-extremities, since these patients must be able to support themselves on a stick.

The most effective solution since Steindler's report is that of *Clark* in *1946,* a pectoralis myoplasty. The lateral part of the pectoral major is phylogenetically united with the independent nerve and blood vessel supply which enters proximally. *Clark* dissects this approx. 6 cm wide muscle belly from the costae and brings it down to the upper arm, where it is fixed to the muscle-tendon transition. *Seddon* announced in 1949 and 1951 good results from more than 20 patients.

Finally *Bunnell* became the advocate of a utilisation of the sternocleidomastoid muscle whereby this is attached to the biceps tendon by a long strip of fascia lata. He has himself attained good results with this, but judging from our general experience of the slackening characteristics of long fascia transplants, and since the operation produces a not insignificant cosmetic defect, this operation must certainly be reserved for quite special cases.

Personal series.

In the Orthopedic Hospital in Copenhagen, Dept. 2., we have employed *Steindler*'s operation for 12 polio-patients, one of which was operated on bilaterally.

The operation was undertaken 2–22 years after the polio attack. 2 years must certainly be considered as the minimal effective period, particularly out of regard for the strength of the muscles which are to be transposed. The patients were then 5–29 years old, 6 were under 10 years, 5 between 10 and 20.

All the patients had a severe shoulder paresis. Previously 1 patient had undergone a shoulder arthrodesis, 1 patient a humero-scapular tenodesis and another patient

a scapular suspension according to *Henry*. A reconstruction of the hand function had been performed on 3 of the patients. I intend to discuss later and in more detail one of the patients previously operated on according to *Clark*.

Operative technique.

We commence the operation with a curved incision on the ulnar aspect of the elbow. The flexor head is isolated from the lateral aspect. After securing the ulnar nerve a part of the ulnar epicondyle is chiselled away, as suggested by *Campbell*, and the muscle group is afterwards dissected free from the joint capsule. Finally the flexor carpi ulnaris is detached at the farthest possible point from its origin on the ulna so that the nerve branches are spared. The intervention is simplified if one omits to tranpose the flexor carpi ulnaris, but it is often precisely this muscle which has best preserved its function. The epicondyle is afterwards fixed with a silk suture through a hole drilled about 4 cm more proximally of the medial epicondyloid line and to the intermuscular septum.

Post-operatively the flexed arm is treated with a plaster bandage for 6 weeks, while during the last three the lower arm is released for flexion and physiotherapeutic exercises with myotensor.

The post-operative course has been uncomplicated and easy. Muscular strength allowed quite quickly the active flexion of the elbow, and only in one case was the strength too slight; the explanation of this was that the transplant was too weak, using muscles from 2 to 4. In a satisfactory result we must stipulate that the hand can reach the mouth, that the strength is of practical importance and that there is no significant extension defect. There was 45° extension defect in the above-mentioned case only. Otherwise this was not a dominating complication in our series.

An evident weakness in *Steindler*'s technique is the limitation concerning supination. In all our patients there was reduced supination postoperatively, and in 3 patients to a considerable extent. As stated this difficulty can be met in different

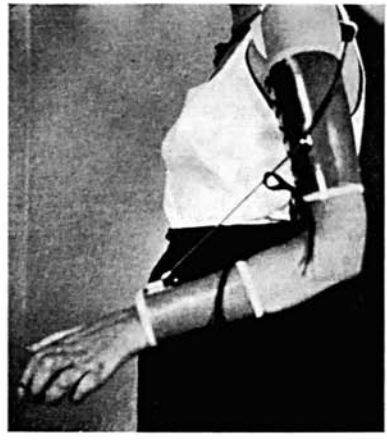


Fig. 1.

ways. *Bunnell* prefers to lengthen the transplant with a strip of fascia. Thus the pull becomes less hindering to rotation, while *Caroll* simply inserts the epicondyle more laterally into the humerus.

Encouraged by *Seddon*'s fine results we employed *Clark*'s pectoralis myoplasty for 3 patients.

The lateral 6–8 cm of the pectoralis major are exposed by a long incision in the anterior axillary line. As recommended by *Seddon* we have also taken a few cm of the rectus fascia. The nerve supply to this portion of the muscle is found, as stated, proximally below the coracoid process, where it is tested with Faradic current. It is brought down subcutaneously to the biceps tendon, where through a special skin incision it is inserted with suitable tension. The after-treatment is much the same as in *Steindler*'s operation.

The requirements for a successful result are obviously a strong pectoralis major —and also good outward rotators in the shoulder for stabilisation during the flexion movement.

These conditions were present in our first patient, a 33 year old man, 16 years after the polio attack. The biceps were 0, the pectoralis 4–5, the other shoulder muscles good. The flexing power was 3–4 after the treatment was finished.

Our next patient, a woman aged 24, had previously undergone shoulder arthrodesis before the muscle plastics. In this case too, an excellent power of flexion was obtained.

Our next patient, a 21 year old woman from Greenland, offers particular interest. The pectoralis major was found to be strength 3, the shoulder muscles 1–2, biceps 0 and the lower arm flexors weak. After the pectoralis plasty she could flex the arm but without strength. Therefore 7 months later *Steindler*'s operation was performed. 1 year later strength in flexing the elbow is considerably better, and she can now see to her personal needs and care for her boy.

In those cases where we do not find the required basis for one of the operations discussed we can help the patient with a splint. Of recent years we have changed to an arm capsule with shoulder pull according to the prosthesis principle. (Fig. 1).

In conclusion I wish to stress that in *Steindler*'s operation and *Clark*'s operation it is possible to help the majority of patients with flexor pareses in the elbow. In certain cases a combined operation can produce the necessary power of flexion, and finally the most difficult cases can be helped to some extent by functional splints.

TRANSPOSITION OF THE PECTORALIS MUSCLE TO THE BICEPS MUSCLE (FILM)

by *O. Farnes* (Oslo)

RESULTS AFTER TENDON TRANSPLANTATIONS IN POLIOMYELITIS

by *Adolf Møllerud* (Oslo)

There has been much discussion about the value of tendon transplantations in children. In our clinic we mostly do these operations on children and as a consequence of this we have relatively few arthrodeses (on the foot) in combination with tendon transplantations. To get an impression of our results, I have made a "follow up" study of the patients operated upon during the 10 year period 1945–54,

in this clinic. In all 120 patients had tendon transplantations performed in this period, 112 of which have been followed up by personal interviews (93.3 %). These 112 patients represent 185 tendon transplantations on 138 extremities. The average follow up period was 2.6 years, with a minimum of one year. Average age at operation 11.9 years (youngest patient 2.5 years at operation). 51 females and 61 males. Arthrodesis at the time of or after the tendon transpl. was performed 12 times, 10 of which were in the age group 16 years or more. Postoperative complications: 3 times delayed wound healing. Late complications: 5 times drop of the first toe after transference of Ext. hal. long. to the 1st metat. 18 times the tendon failed to maintain its new attachment. In 31 cases the transpl. muscle lost some power after the operation.

In evaluating the results we have compared the postoperative with the preoperative situation in each case, to see to which degree the desired result had been accomplished. The result termed excellent is as good as or better than hoped for preoperatively. The result classified as good is nearly as good as we desired, while the terms fair and bad are used to classify the cases who have had only little or no benefit of the operation.

According to this the result in the whole series is 30.27 % excellent, 27.56 % good, 19.45 % fair and 22.72 % bad.

However the result differs a lot from one category of transplantation to another, thus the transpl. of the sublimis tendon of the 4th finger to restore opposition to the thumb gave a rating of good + excellent of 84.6 % (13 cases) while the transference of Tib. post to the achilles showed a relatively poor result (45.5 % good + excellent, 11 cases).

Most of the transplantations were on the foot (167 cases of the 185). The transpl. of the E.H.L. to the 1st metatarsal gave the best result (72 cases). T. Ant. transpl. laterally to the dorsum showed 59.1 % good + excellent results (22 cases). Peronei to dorsum gave excellent + good results in 66.6 % and the peronei to Achilles 55 % good + excellent.

We have mostly operated on children and we have 26 transpl. in the age group 1–5 years, 72 in the age group 6–10 years, 55 in the age group 11–15 years and only 32 in the age group 16 years or more. There is no significant difference in the results in these groups, excellent + good ratings lying between 50 and 60 %. The bad results are very constant in all the groups, varying from 22 to 25 %.

We believe that tendon transplantation in selected cases of poliomyelitis is a useful means of treatment. We have no age limit and we consider these operations to be specially suited for children, where braces or splints are the only alternative without soft tissue operations. In many cases the tendon transference can avoid a stabilizing bone operation later.

SOME EXPERIENCES OF TRANSPOSITION OF THE HAMSTRINGS IN PARALYSIS AFTER ANTERIOR POLIOMYELITIS

by *H. Støren* (Stavern)

The transposing of the hamstrings has, in the cases at our disposal, been undertaken on two indications:

1) Peripheral paralysis: Poliomyelitis.

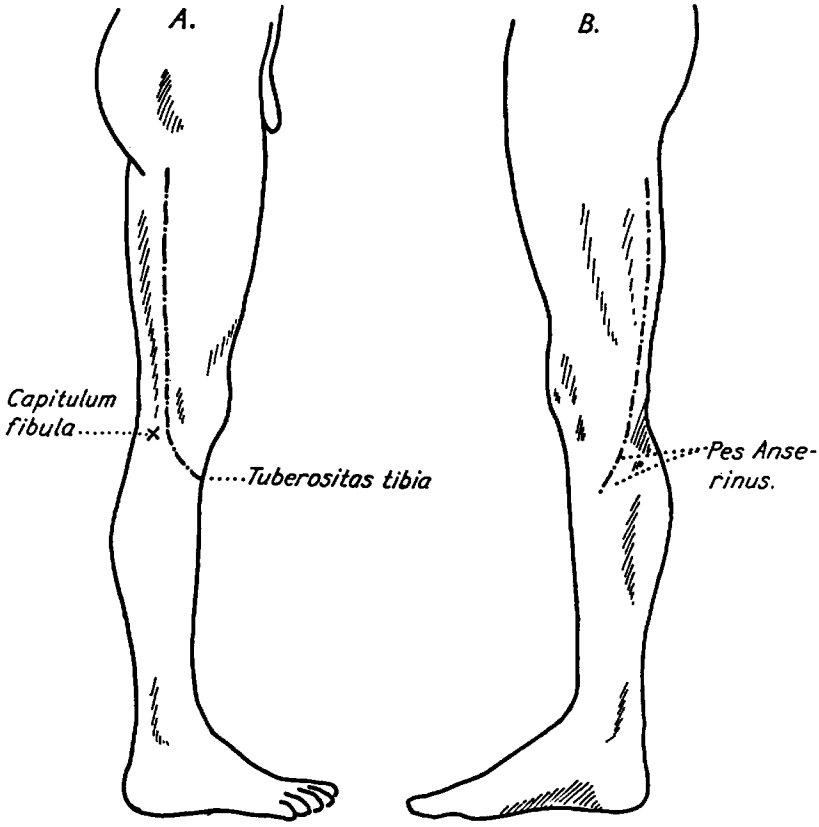


Fig. 1.

A. Through a lateral incision the anterior surface of the patella is exposed and the biceps and tractus iliotibialis are transposed.

B. Through a medial incision, the medial hamstrings are transposed.

2) Central paralysis: Little's disease and conditions related to it. (Conditions in the latter are quite different and must be treated in a special way.)

The results are dependent upon:

1) The vitality and strength of the muscles to be moved. We seldom have found fully competent hamstrings in anterior poliomyelitis.
2) Good operative technique.

In those textbooks I have seen, e.g. Campbell and Erlacher, the technique mentioned is, in my opinion, not of the best. I recommend the following two incisions:

On the outer aspect of the thigh the incision employed by Bylow-Hansen is used, from the upper part of the thigh down to the head of the fibula, and curving forward to the tibial tuberosity. The skin and subcutaneous tissue is stripped off to the necessary extent forward, including the front of the patella and the infrapatellar ligament. Fig. 1 a.

This incision is for the biceps and the ilio-tibial tract. The latter is used with

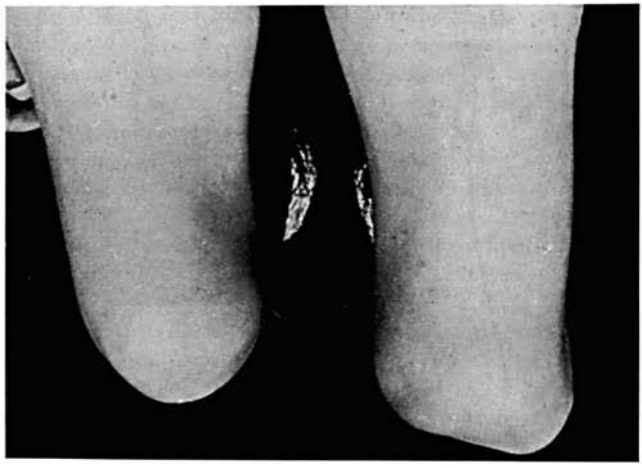


Fig. 2.
The left knee shows a lateral dislocation of the patella following transposition of the biceps muscle only.

TABLE 1

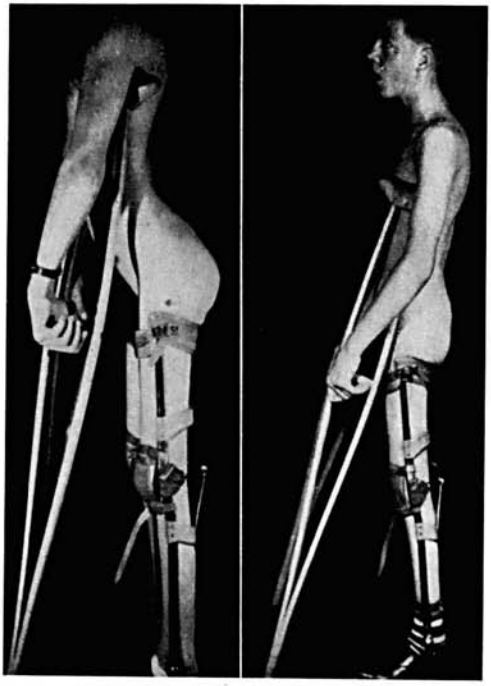
Survey of results in 11 poliomyelitic paralyses of quadriceps treated by transposition of hamstrings, partly combined with transposition of the iliotibial tract.

Group	Quadriceps function	State of hamstring muscles	No. of operated patients	Result
1	0	relatively good	3	Can stretch the knee with hanging down leg completely or almost completely.
2	0	less good	5	Stretches with hanging leg 35°–60°. Walk without bandage.
3	0	bad	3	Stretches only when lying on his side. Walk without bandage.
4	0	very bad	1	Has to wear a bandage, but walks much better than before operation.

One patient of group 3 complains of pain in the knee—but all of them think that the operation has helped them.

advantage as a supporting measure, if the tensor fasciæ latæ functions. The biceps reaches only to the middle part of the patella. The ileo-tibial tract is rotated 180° on its axis and is fastened to the patella in such a way that it covers the transposed hamstrings.

Medially the incision is made from the upper part of the thigh backwards and



A *Fig. 3.* B

A. Before the operation.

Abduction and flexion-contracture of the hip joint accompanied by a lordosis. Flexion-contracture of both knee joints, which can only be held corrected with considerable pressure against patella in a brace.

B. After the operation.

Despite almost complete paralysis, the hamstrings have been transposed to the anterior surface of the patella. At the same time, the tractus ilio-tibialis was transposed to the arcus costae and the iliopsoas muscle to the rectus femoris. The lumbar lordosis has been eliminated. It is necessary that he still wears braces, but pressure is no longer required against the front of the patella. Subjectively there is great improvement.

downward towards the pes anserinus. Fig. 1 b. Here the medial muscles are freed. They are moved subcutaneously in the usual straight direction down to the patella and through this channel further downwards to the tibial tuberosity. This is important as the infrapatellar ligament is slack and atrophied in paralysis caused by anterior poliomyelitis. In spastic cases this combats the frequently found proximal displacement of the patella.

All fixation of the transferred muscles to the bone must be done intraosseally. Fixation only to the periosteum is quite insufficient.

We have seldom employed transposition of the biceps only and have thus not experienced lateral dislocation of the patella, but a patient who was operated upon in another orthopedic clinic came to us with the above mentioned condition. Fig. 2.

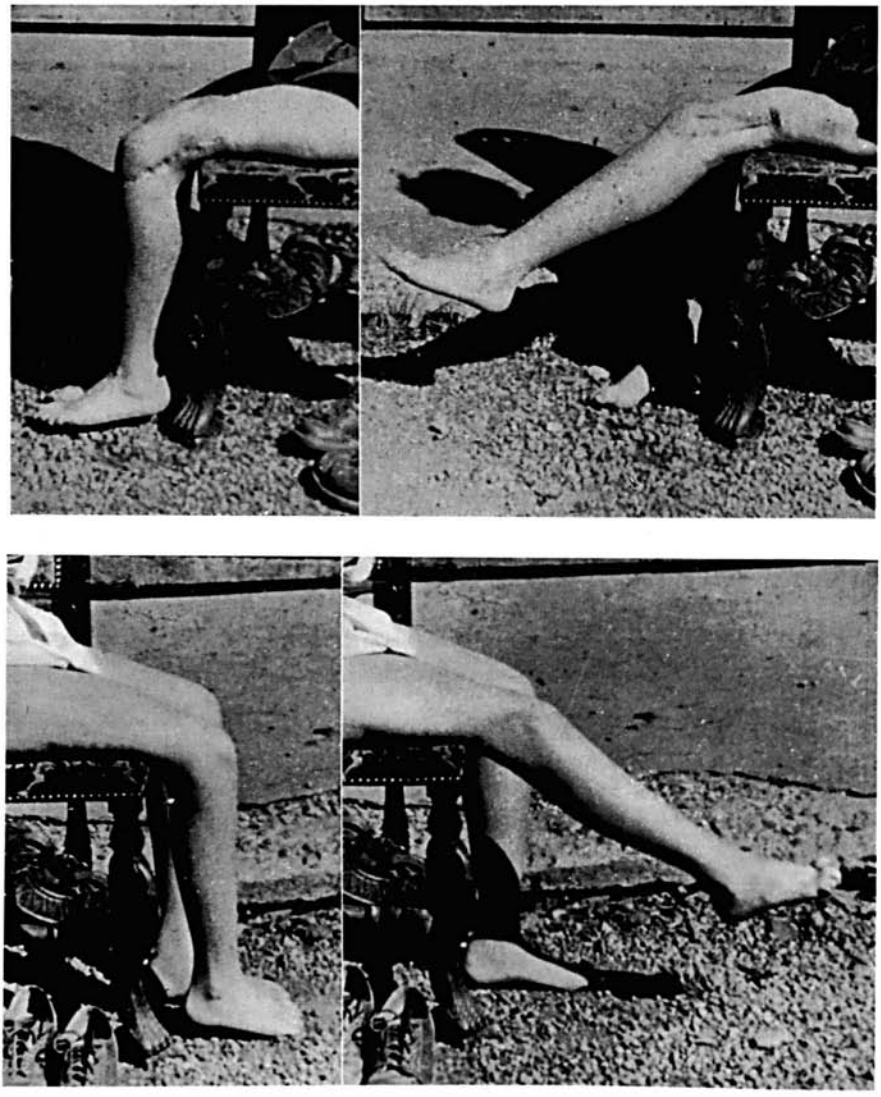


Fig. 4.

Quadriceps-function was 0, both extremities before operation.

A. On the left extremity, transposition of biceps and tensor fascia lata has been performed.

B. On the right, only the medial hamstrings have been transposed. These show, as you see, just as good function.

At reoperation, where transposing of the medial flexors was also performed, even although they were paralysed the condition was corrected and the result permanently good.

We have not undertaken the transposing of the biceps from the medial side to counteract the lateral patellar dislocation, which is mentioned by the Americans.

When the gastrocnemius has shown good function, we have not been afraid to use all the functioning hamstrings.

A survey of the results in cases of paralysis after anterior poliomyelitis, is seen in table form. Table 1.

Quadriceps function is in all cases 0 or practically 0.

As one can expect in advance, the results are dependent upon the condition of the hamstring muscles. In group two there were two cases where only the medial thigh flexors were used, since the biceps was completely paralytic. In these two cases the extension of the hanging leg is only 35–40°.

In group two one patient has pain in the knee. X-ray pictures show a fairly advanced arthrosis. The only patient in group four with very bad function of the hamstrings, had in addition flexor contraction of ten degrees in both kneejoints, and abduction and flexion contractures in the right hip joint. For the last mentioned, Thomasen's operation was performed: Transposition of the ilio-tibial tract to the costal arch on the opposite side. The patient is not free of his bandages, but there is a very considerable improvement in his condition after the contractures have been abolished both in the kneejoints and the hips, which is evident in the picture. Fig. 4, before and after operation.

The good result in group one, where the condition of the hamstringmuscles is good, can be seen in this film.

TENDON TRANSPLANTATION IN THE FOOT AFTER POLIOMYELITIS IN CHILDREN

by *Johs. Mortens* (in collaboration with *P. Gregersen* and *L. Zachariae*)

Material: At the three departments of the Orthopaedic Hospital in Copenhagen 102 feet in children from the great epidemic of poliomyelitis in 1952–53 have been treated with early tendon transplantation in order to prevent or minimise deformity and improve function.

The established two principles have been applied:

1) Reinforcement of weak antagonists.

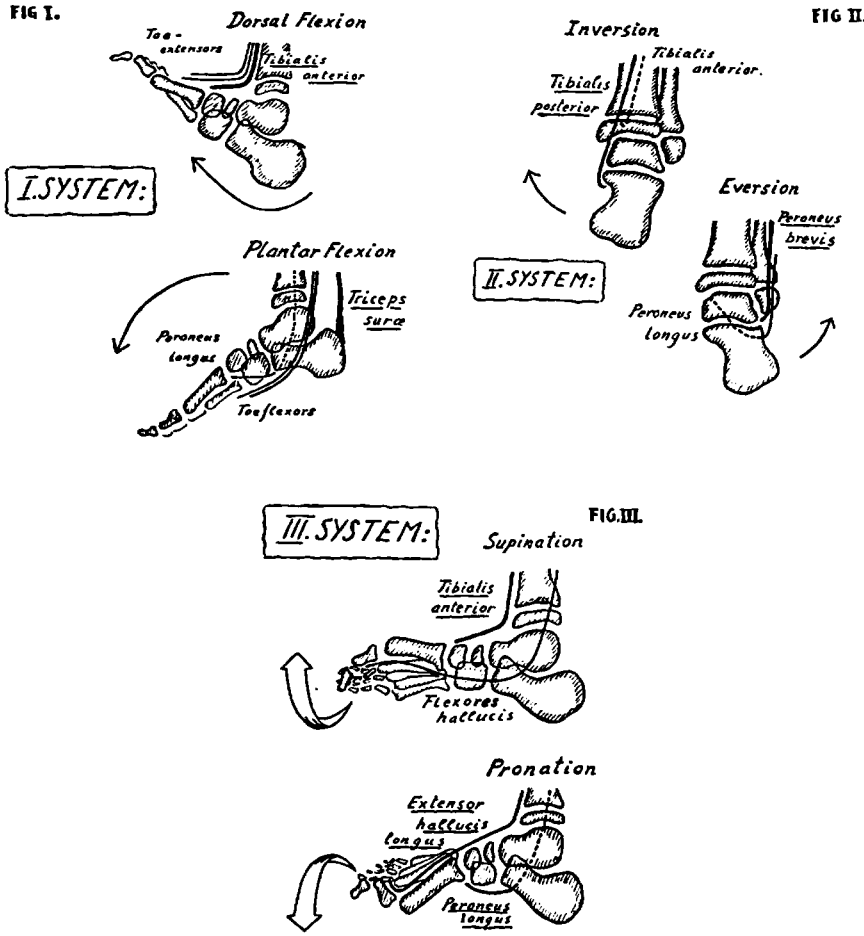
2) Transplantation of the main deforming muscle.

Where possible the two principles have been combined.

The age at operation has been between 2½ and 12 years (on average 6 years). Only few have been operated before the age of 4 to 5 years. On an average they have been operated two years after the onset, and the postoperative observation has been little over one year.

Results: Results are presented in Table I. Classified as "Good" are only cases where deformity has been reduced or abolished and function improved. "Doubtful" are cases where deformity and function is unaltered, but where it is possible that the tendon transplantation done has prevented development of further deformity. Rated as "Bad" results are some cases of unaltered deformity and function where

THE THREE SYSTEMS OF MUSCLE BALANCE IN THE FOOT



it is unlikely that the operation done has had any preventive effect. Most cases, however, in this group are cases where deformity has progressed or instability, overcorrection or a secondary deformity has resulted from the tendon transplantation.

The combined results show that in half the cases the operation has been successful. In the smaller groups of "Medical cavus" and "Equino-varus" the operation has been almost uniformly successful, but not so in the two larger groups with the more severe deformities: In the groups of calcaneo-deformities less than half the cases have improved by the operation and in the group of "Plano-valgus" less than one quarter.

TABLE I
Results.

Deformity	Paralysis	Good		Doubtful		Bad		Total	
Calcaneo -cavus	Triceps	7		5		3		15	
Calcaneo -cavo -valgus	Triceps + Invertors	10	20	5	10	7	13	22	43
Calcaneo -cavo -varus	Triceps + Evertors	3				3		5	
Medial cavus	Tibialis anterior	12		1		2		15	
Plano-valgus	Tibialis ant. + post.	7		4		19		30	
Equino-varus	Peronei ± Dorsiflexors	12				2		14	
Total		51		15		36		102	

TABLE II
Analysis of doubtful and bad results.

Cause of failure	Number	Comment
Technical fault		
Bad planning of operation	1	
Neglect of preliminar correction	2	5 avoidable
of fixed deformity	2	
Overcorrection	5	risks inherent
Instability	4	12 in the method
Secondary deformity	3	partly avoidable
Insufficiency. Deformity unaltered or progressed in spite of well planned and executed operation	34 of which 20 plano-valgus	the limitation of the method
Total of 102 tendon transplants	51 = 15 doubtful and 36 bad	

Analysis: In Table II the doubtful and bad results are analysed. Technical faults, badly planned operations and failure to correct fixed deformities before transplantation result in failures which are *avoidable.* However, overcorrection, instability and a secondary deformity are *risks inherent in the method.* These risks can only

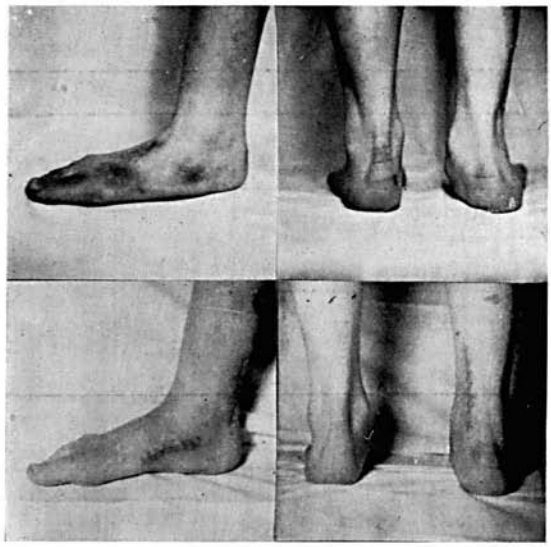


Fig. IV.
PARALYTIC PLANO-VALGUS FOOT
Above: Result of tendon transplantation alone. No improvement.
Below: After *Grice*'s extraarticular, subtaloid arthrodesis with a tibial graft in the sinus tarsi and additional tendon transplantation. Deformity abolished.

be reduced by careful planning of the operation in selected cases and *by not employing the method too ambitiously.* The last group, the largest, indicates the *limitation of the method.* In 34 of 102 cases no improvement, or progression of the deformity resulted in spite of well planned and executed operations. In 20 of these cases the deformity was a plano-valgus; the remaining 14 cases belong to the calcaneus group.

Slides were shown indicating the three systems of muscle balance in the foot (fig. 1, 2 and 3). Very briefly owing to the time permitted the *limitations* and *risks* and the *possibilities* of tendon transplantation as a method to restore muscle balance were discussed in relation to these three figures. More detailed information can be found in Proceedings of the Nordisk Ort. För.s 27th assembly, Copenhagen June 1954, Acta Orth. Scand. Vol. XXIV, Fasc. 4, 1955, in Mortens and Pilcher: Tendon transplantation ..., J.B.J.S., Vol. 38B, No. 3, Aug. 1956 and in an article by Mortens, Gregersen and Zachariae to be published in this journal.

The *conclusions* were:

"Tendon transplantation is a useful method in restoring muscle balance and reducing deformity in *selected* cases of partly paralysed feet in children. The method has its limitations, and inherent risks which, however, to a large extent can be prevented by careful planning and execution of the operation with adequate preliminary measures against fixed deformities. Its limitation is mainly in relation to the plano-valgus deformity where other stabilizing procedures are called for."

In the following discussion slides of a paralytic plano-valgus foot were demon-

strated (fig. 4). Tendon transplantation of the peronei to the inner side of the dorsum had not been able to hold the foot and a *Grice* extraarticular subtaloid arthrodesis with a bone graft in the sinus tarsi was later performed additionally transplanting flexor hallucis longus to tibialis posterior.—It is now the speaker's practice in a paralytic plano-valgus foot to perform this bony stabilization in combination with adequate tendon transplantation. The operation could be done down to the age of 4 and up to about the age of 8 years.

He also pointed out that the discrepancy—mainly concerning the equino-varus deformity—in *Hagelstam*'s material and his probably was due to the fact that in the material from O.H.K. uniformly *yearly* tendon transplantation was performed and almost no fixed deformity had occurred whereas in the Finnish material due to circumstances probably many old cases had been operated upon. Tendon transplantation as a method to reduce deformity and improve function could only be expected to be of any help when the foot was supple and fixed deformity not present.

(The study will be published in complete form in the acta orthop. scand).

DISCUSSION:

K. Kallio, Helsinki.

I. Alvik (Oslo). The fixation of the medial epicondyle with its musculature in Steindler's operation to restore the flexor strength of the elbow is based on a little technical finesse. On the anterior aspect of the humerus at the prospective site of the fixation a hole is made in the corticalis, of the same size as the epicondyle which has been chiselled away. The hole is lengthened downward like a slot. The epicondyle is inserted into the hole and pushed down so that only the muscle attachments emerge through the slot. The epicondyle is thus locked fast, cannot come out, and physiotherapy can already be begun a few days post-operatively.

One of the causes of less successful results following opponens plastics is the contracture of the musculature in interstice l., especially dorsal interosseus l. Therefore it should always be thoroughly stretched before opponens plastics.

The result of the quadricepsplasty demonstrates as a rule the greater or lesser extent to which the patient, sitting on a table edge with legs hanging down, can stretch the knee. In walking the part played is less important, however, since both the lateral and medial flexor groups of the thigh act as extensors of the knee joint at the beginning of the standing phase in walking. It is these muscles which at the beginning of the standing phase lock the knee in slight hyperextension, not the quadriceps, which only checks body weight when the stride is initiated. On the other hand the extension of the knee in the swinging phase is a quadriceps function and the flexing of the knee in the beginning of the swinging phase in order to unwind the foot is a function of the hamstrings. For both these reasons it is therefore a serious step to move the flexors to the extensor mechanism. A large part of the apparently good results in quadriceps-plasties is due to the abolishment of an earlier flexion contracture and the quadricepsplasty probably also prevents the reappearance of the flexion contracture.

E. Moberg, Gotenburg.

P. Lütken (Aalborg). As a final note to Moberg's suggestions concerning an improved nomenclature,—transplantation, transfer and transposition,—it may be pointed out that we often employ the term Activatio for what Moberg wishes to call transfer, supplemented by the function which is activated. For example, Activatio pronationis—Act. supinationis—Act. flectionis plantaris and so forth.

In the papers read it was made clear that the results of isolated tendon transposition were often inadequate. This does not matter when tendon transposition is undertaken to avoid fixed deformity of the foot skeleton in children, provided that the purpose of the intervention and its expected importance are explained to the parents. It is much easier and less harmful to undertake the latter perhaps necessary stabilising operation on a foot without—or with slight skeletal deformation, than to correct e.g. the severe calcaneus feet.

Short report of two patients with polio, the latter of whom also proved to have progressive muscular dystrophy. These cases have been published in The Danish Orthopedic Association.

C. Hirsch, Upsala.

G. Wiberg (Lund). In a number of cases of tendon transfer with quadriceps weakness, luxation of the patella occurred laterally. If possible this should be avoided since it leads to arthritis deformans. The cause of the luxation may lie in a dysplasia of the lateral femoral condyle. Therefore an X-ray with an axial picture of the femoro-patellar joint should be taken before the operation, so that especial care may be adopted in these cases.

Johs. Mortens, Copenhagen.

H. Støren (Stavern).—To *Wiberg:*

There was only one case of lateral luxation in my series and this was not operated on by us; a technical error seemed to be present,—the biceps was fixed to the upper lateral border of the patella. We always fix the biceps to the middle part of the patella and simultaneously to the rectus tendon so that we obtain a pull in the same direction as the vastus.

With this method we have not yet experienced any lateral luxations of the patella. In USA it has been suggested that the biceps be transposed from the medial side to counteract the lateral luxation. We have not attempted this since we have serious objections to this method.

To *Alvik:*

In 2 of my cases where the biceps were completely paralytic transposition of the medial thigh flexors only was performed.

Before the operation the patients lacked all extension ability. *Afterwards* they could in every case extend 30–40 degrees of the hanging leg. And from once being dependent on splints for walking they could now walk without aid.

As Hirsch pointed out these transpositions also give such good extension ability that it is possible to extend the knee actively while the extremity is brought forward in walking. It is not only a passive swinging movement. Moreover it is not,

as Alvik stated, merely a movement of the flexor tendons "a little forward". As I mentioned they are transposed completely across to the tendons of the extension mechanism—and I have stressed the importance of a correct technique.

S. v. Rosen (Malmö). I have recently operated one case of opponens paralysis local anæsthesia. This procedure made it possible to control the movements of the thumb during the operation.

L. Hagelstam (Helsingfors). The difference between the results presented by myself and by John Mortens can be explained as follows: the patients in the Danish series were operated on before the deformities became fixed, while my series largely consists of patients with rigid, fixed scolioses.

F. Langenskiöld (Helsingfors). I should like to direct attention to paralytic contractures in the hip joint, which cannot be prevented through splints or significantly improved by physiotherapy but must almost always be operated on. Two main types may be distinguished: the one occurs on paralysis of the glutaeus maximus and is characterised by flexion and outward rotation, the other arises on paralysis of the adductors and is purely an abduction contracture. In both instances strong tension is present in the iliotibial band which is first of all conditioned by the contracture. Whether the tension in this non-muscular organ depends on a true or relative shortening cannot for the present be determined. The fact that the tension may already arise some months after the onset of illness, argues in favour of true shortening. The flexion contracture has been discussed previously in this congress. Here I shall only touch upon the abduction contracture. To combat this it is necessary to cut through the iliotibial band and often the lateral elements of the joint capsule as well. Moreover it seemed necessary to me to create an obstacle to recurrence. Since no suitable muscle was available I cut out a strip from the upper part of the tractus which I conducted subcutaneously to the symphysis pubis and fastened it there to the periosteum with the leg in adduction and inward rotation. The legs were then crossed and bound together. No plaster. Through this intervention the abduction contracture, the wrongly aligned pelvis and the scoliosis entailed by it could be counteracted. The idea is not new (Leo Mayer) but almost totally neglected.

Discussion of Ivar Alvik's paper: Treatment of paralytic scoliosis.

The correction of scolioses by using large plaster bandages and turnbuckles is generally attributed to Risser. As early as 1929 I saw in New York however a number treated in this way by Hibbs. At the Invalid Institute we employed this method earlier and sometimes obtained passable results but two years ago we changed to the Milwaukee corset (Bount & Schmidt) which has given us much more satisfaction.

Erik Severin (Gotenburg):

This is an account of a series comprising 30 hands operated on by transferring the sublimis tendon of the ring finger to the thumb. The operative method has been principally that described by *Bunnell*. Twelve of the cases were included in an earlier review by *Söderberg* (Acta Orth. Scand, 1952). On the occasion of the operation the age of the patients varied between 10 and 46 years. The period between

the onset of illness and the operation amounted to a minimum of 1 year and a maximum of 12 years. A bare half of the cases were operated on during the period 2–3 years after falling ill. Besides the lack of opposition ability absolute conditions of operation were both good function in the two long flexors of the ring finger and good passive mobility in the thumb without contracture. The duration of observation was from 6 months up to 8 years.

The results of operating were grouped in this way:

Group I	*Excellent* Opposition achieved, turning the top of the thumb into a good grip with the index finger and long finger or further ...	22 (21)*
Group II	*Good* Good grip, thumb—index finger—long finger, but without complete rotation of the thumb	3 (4)*
Group III	*Bad* Remainder	5
	Total of hands operated on	30

One of the cases in group II had other pareses in the thumb with the result that the tendon transfer performed, although technically successful, could not be fully taken advantage of. In the three other cases the tendon transferred was attached too far out on the first phalanx. Therefore it exerted too great flexion on the metacarpophalangeal joints by comparison with the strength of the extensors. In one of these cases the operation was repeated later, inserting the tendon more proximally into the base of the thumb's first phalanx. The result of this other operation was very good and the case could therefore be passed to group I. This is marked in the table by ( )*. The poor results (group III) were due in one of the cases to suture insufficiency and in the four remaining cases to other pareses in the thumb operated on. Before an attempt is made to reconstruct active opposition of the thumb, it is necessary to analyse the remaining active functions of the thumb: its adduction-abduction and its flexion-extension. Defects in this respect may destroy the result of an otherwise technically successful activation of the thumb's power of opposition.

From the technical point of view the following should be noticed. On opposition the pulling power on the thumb must owe its direction to the region of the pisiform. On transfer, when the sublimis tendon has been passed round the tendon of the m. flexor carpi ulnaris, it may happen that on stretching it will ride up proximally and thus acquire an undesirable direction of pull. *Bunnell*'s method of forming a block to the sublimis tendon by means of a little strip from the tendon of the m. flexor carpi ulnaris is simple and reliable. The method recommended by Kivilaakso following F. Langenskiöld where in order to make the position secure the sublimis tendon is drawn instead up through a slot in the palmar aponeurosis has not been tried by myself.

The new attachment of the sublimis tendon on the thumb's first phalanx must be moved dorsally over the finger and just distal to the metacarpophalangeal joints. If the attachment comes further along distally it results in an unfavourable flexion effect on the first phalanx. On the other hand, judging from my experience with

this series it is of no importance if the insertion occurs dorso-ulnarly or dorso-radially. Provided that one has fully reached the dorsal aspect of the thumb the tendon also obtains the desired rotatory effect from the dorso-radial insertion.

Bunnell recommended that the distal stump of the sublimis tendon be employed for tenodesis to counteract overstretching in the first interphalangeal joints. Through fear of overstretching this detail of the operation mut not be exaggerated however. When the tenodesis is completed the surgeon must be able to stretch the joints fully, otherwise an unnecessary flexion contracture is incurred. In suitable cases and when carried out with the correct technique transfer of the ring finger's sublimis tendon offers an excellent method by which to activate the opponens ability of the thumb.

ON NEUROMUSCULAR FATIGUE IN POLIOMYELITIS

by *C. Lindquist* (Helsingfors)

TREATMENT OF PARALYTIC SCOLIOSIS

by *I. Alvik* (Oslo)

DISCUSSION:

C. Hirsch, Upsala, *F. Langenskiöld*, Helsingfors.

K. Jansen (Copenhagen). Our approach to the treatment of scoliosis should not be generalized, as the problem is different in idiopatic and in paralytic cases.

In idiopatic scoliosis it may be true that the gain by fusion is poor in most cases, and that conservative treatment with excercises and braces is unable to control the deformity.

The problem in paralytic cases is similar to what has been discussed in the papers on polio feet and polio hips. The flexible, paralytic scoliosis caused by muscular imbalance must be fought by physiotherapy, braces and fusion. The scoliotic contracture is definitely a serious problem, and our efforts should be applied toward avoiding this condition, and whenever it has developed, we must try to correct the contracture by casts or braces and to stabilize the spine by a fusion.

Contrary to the idiopatic scoliosis, the polio scoliosis is frequently followed by disabling complaints due to fatigue and pain—and these complaints in themselves may justify surgery.

EXPERIMENTAL SCOLIOSES (ADVANCE REPORT)

by *O. Gottlieb* (Copenhagen) (in collaboration with *J. Balslev Jørgensen* and *R. Movin*, Copenhagen)

The study is an attempt to confirm Somerville's theory concerning *Rotational Scoliosis* (1951–52).

The tests were performed on young rabbits, fixing the spinal processes with wire.

The animals were X-rayed 6–8 weeks and 12–16 weeks postoperatively. The first X-ray photographs of 46 rabbits showed:

Scoliosis	3
Blocking	16
No effect	27

The 19 animals with blocking or scoliosis showed at the 2nd X-ray examination:

Cessation of scoliosis	7
Unchanged scoliosis	6
Not controlled	6

The 7 animals where the scoliosis made no progress showed in 6 cases that the wire had slipped or was broken.

From our tests we drew the conclusion that we had been able to reproduce to a certain extent Somerville's results although the blocking of the column's mobility was only moderate. The scolioses were provoked on animals where as far as is known to us spontaneous scolioses are never found and on animals without the upright gait of man. We believe therefore that even these moderately pronounced scolioses encourage further attempts, since *if* the theory provides the explanation of a certain category of special polio-scolioses, an effective operative intervention can also be perceived as the treatment, namely, ligamentotomy of the supra- and interspinal ligaments.

INHIBITION AND STIMULATION OF GROWTH

Speakers: *K. Jansen*, Copenhagen, *A. Langenskiöld*, Helsingfors.

K. Jansen (Copenhagen):

Discrepancy of the legs is a very frequent and often a very severe disability. Patients suffering from a major disparity are often regarded as true cripples by other people. As the term "orthopedia" in itself indicates a direct obligation for us to correct the child, and as the serious polio epidemics during the last years have highly actualized the problem of growth, it appears fitting that our Society has resolved to bring this important subject up to a discussion.

Polio is by far the most frequent cause of discrepancy. In the various materials polio rates as the cause from 57 % to 90 % in accordance with *White* and *Stubbins* depending on whether the materials have been collected from the big areas of epidemics or from other regions. The cause of inhibition following polio has not been clarified. *Grice* has found that the growth during the first year after the acute phase is normal and perhaps even slightly increased, but hereafter the inhibition starts, most often following a linear curve of varying inclination. A decreased blood circulation cannot be the explanation, as it has been shown that the minute volume of the paralytic extremity is not reduced. This was demonstrated by Dohn at the meeting in Oslo in 1952. Undoubtedly a certain relation to the extent of the paralysis exists, but we do not have any definite answer.

Several congenital and acquisital diseases are followed by inhibition to a higher or lower degree. From these diseases I shall briefly mention the more frequent ones, because the recognition of these diagnoses in this connection makes the control of growth a natural part of the treatment scheme.

Essential hypoplasia of one single extremity apparently with no further abnormality is the most frequent of the congenital anomalies.

Chondrodysplasia Ollier nearly always produces a shortening often combined with assymetrical growth and angulation.

The congenital aplasia of one or both epiphyses is a defect often found in the proximal segment of the femur, this defect causing the most severe shortenings.

Congenital pseudarthrosis and the related diaphyseal deformities also result in shortening of the extremity.

Finally *cystic dysplasia, multiple exostoses* and *multiple chondromas* are sometimes followed by disturbances of growth, and in most cases by inhibition.

Neurofibromatosis von Recklinghausen is followed by hypertrophy whereas *spina bifida* and the inherent spinal dysplasias cause reduced growth of the inherent involved.

Arteriovenous hæmangiomas often cause hypertrophy of the affected leg, and based upon experimental and clinical experiences it is ascertained that this overgrowth is due to the abnormal blood circulation.

Diseases of the hip, congenital hip dislocation as well as diseases which do not manifest themselves until the adolescence, e.g. Perthe's disease and slipped epiphysis may lead to a disparity of the legs although the actual growth is normal.

Pyogenic osteomyelitis and *osseous tuberculosis* cause a shortening in the cases where the epiphysis is destroyed, but in several cases these diseases produce an overgrowth of the afflicted region, apparently due to the altered vascularity around the epiphyses.

The unknown factor regulating the growth may cause a part equalisation by a secondary compensating growth of the sound extremity.

While fractures in adults heal with a shortening which is determined by the result of the treatment, the diaphyseal fractures in children are deceptive. Frequently an overgrowth compensating the shortening is seen, and in cases with no shortening after the fracture the leg grows too much. The more manipulating with fractures like this in children and the more callus produced, the more increase in growth may be expected.

In a material of 75 children fractures *David* has concluded that a shortening up to 5 cm., measured 8 weeks after the injury had already been compensated 2 to 10 months later. When the lesion destroys the epiphysis the growth will stop. In cases of partial lesion of the epiphysis the consequence will be an oblique growth of the limb.

Treatment of discrepancy

For correcting an inequality the following 3 different principles are at our disposal:

1: Bandaging;

2: Corrective osteotomy;

3: Intervention on the rate of growth.

It is evident that growth control can be used only in children, while adults with untreated growth deformity or with acquired disparity must be treated with bandages or osteotomy.

In adults with a shortening less than 3 cm. equalisation can be obtained by

raising the heel of a manufactured shoe, supplemented by a tilt of the pelvis. Greater degrees demand orthopedic shoes, and differences of more than 5–6 cm. require boots or prosthetic type bandages. In the most severe cases only an amputation will permit a satisfactory functional and cosmetic result.

The group in between these extremes are the cases which today are subject to our interest.

Corrective osteotomy is almost a classical operation now. *Rizzoli* (1871) of Bologna was the very first to perform this operation, later followed by *Codivilla* and *Putti*.

Seen from a theoretical point of view the lengthening osteotomy is the most adequate operation, and excellent materials have been published by *Abott* and *Saunders*.

Bost and *Larsen* (1956) have recently published their results of lengthening osteotomies in 23 children.

The principle of the operation is an oblique osteotomy, fixation with medullary nail and traction. In spite of this material coming from one of the outstanding centres, it is still followed by severe complications.

Thus the lengthening operation performed even by the most skilful hands is very difficult and risky and may give complications, primarily difficulties in healing besides lesion of muscles which often are weak beforehand (*Phemister*).

The shortening operation offers more security as emphasized by *Taylor* and by *Shands* (1916 and 1917). By the shortening operation a shortening of up to 6 cm. can be maintained by a combined femur and crus osteotomy without compromising the muscle function. Here also the procedure of healing may give complications.

White who in 1935 published a large material demonstrates that 25–50 % gained by shortening operation was lost again during the following 1–2 years (1945). Later on he changed to epiphyseodesis as the standard operation. *Jonsätter* and others also prefer epiphyseodesis when possible.

Control of growth

The two theoretical possibilities at hand for influencing the growth are partly an inhibition or arrest of the growth of the epiphysis of the long leg, partly a stimulation of the growth of the epiphysis of the short leg.

Already in 1888 *Ollier* corrected a varus deformity by excision of the epiphyseal plate, but not until *Premister*'s report in 1933 was this principle applied on a large scale. His method is to insert a bonegraft across the lateral and the medial side of the epiphysis distally on the femur and proximally on the tibia simultaneously curetting the epiphyseal plate. This technique was modified by *White* and *Stubbins* reducing the risk of an asymmetrical growth.

By this method *White* had good results in 148 patients. He is counting on obtaining a correction of 0.9 cm. in one year in the distal femoral epiphysis, and 0.6 cm. in the proximal tibial epiphysis.

In 1945 *Straub, Thompson* and *Wilson* have reported a similar result in 80 patients. This was checked by clinical measuring alone.

Green and *Anderson* have shown that in 147 patients the correction obtained in 85 % of the patients was less than 1½ cm. within the predicted outcome. In 20.7 % the result was excellent and in 23.1 % it was poor. Clinically 50 % were good.

Oblique deformities in a high degree occurred in 20 %. *Phemister*, too, has cases of asymmetrical inhibition.

Temporary arrest of the epiphyseal growth became a new stage in the development. In 1945 *Haas* by circling the epiphyseal plate with wire loops demonstrated that the growth was arrested. If the wire loop broke or was removed, growth resumed again. However, the growth rate was slower than before, and possibly the definite closure of the epiphysis occurred sooner than normally. The experiments were first carried out in animals, later the operation was performed on children. *Haas* warns against arrest of the epiphysis until the age of 8, when the epiphysis is sufficiently ossified.

Based on this material *Blount* et al. developed a simplified method for epiphyseal arrest which is now used to a great extent. Staples of vitallium are inserted across the epiphyseal line distally on the femur and proximally on the tibia. The fibular epiphysis can be blocked by a staple or closed by an osseous epiphyseodesis. *Blount*'s results, like *Haas*', are very poor before the age of 8. He ascribes the complications to the staples being of insufficient dimensions, so far as the older group is concerned.

Results with the epiphyseal stapling was first reported in Scandinavia by *Thrap-Meyer*.

The pressure of growth is considerable in the epiphyseal plates (*Strabino* and *Colonna*). Blount's staples which when inserted were bent or broken could when tested in models resist a pressure of several hundred kg.s. After removal of the staples the growth continues at a nearly normal rate. Blount even finds the growth to be accelerated during the first months and he recommends awaiting some overcorrection before the staples are removed.

Epiphyseal arrest by roentgen irradiation has been attempted in animal experients and in children (*Barr et al., Judy*). The effect is not dependable and the risk of roentgen injury is considerably greater than that by surgical procedures.

Stimulation of growth

An acceleration of growth of the epiphysis of the short leg must be the ideal solution to the problem. All methods in use aim at the establishment of hyperæmi in the epiphyseal region. Lumbar sympathectomy has been advocated by *Harris*. Hereby a correction of 1 cm. can be obtained.

Supported by 350 sympathectomies *McDonald* emphasizes the favourable effect on the growth in polio patients by this operation. Others regard the effect more sceptically (*Fitzgerald, Wilson et al.*). As mentioned it has been demonstrated that in polio the deep blood circulation is intact, and mainly the skin is seat of the stases. On the other hand a sympathectomy is an excellent procedure on polio patients with "a cold leg", a supplementing effect on the growth being an additional advantage, but at any rate it is not sufficient in itself. The fact that arteriovenous hæmangiomas and fistulas are followed by hypertrophy has inspired experiments on artificial fistulas.

A local irritation of the epiphysis similar to the condition observed in osteomyelitis was experimentally applied with some effect in 1869 by *von Langenbeck*. Later on several publications with varying results have been published.

By experiments on animals *Chapchal* and *Zeldenrust* found uncertain and varying

stimulation of growth by implantation of ivory into the metaphyses, and no effect at all from metallic bodies.

Hendon and *Spencer* found no effect by implantation of copper wire in rabbits.

Barr and *Ober* observed some effect from ivory.

Especially *N. C. Pease's* report in 1952 about growth stimulating effect of ivory screws in children has brought this method into new life. *Pease*'s report, however, does not yield too much hope for an effective method as his results do not reveal a direct correction but a reduction of the calculated disparity. *Pease* has had no complications in his procedures. *Blount* has also discovered some stimulation of the epiphyseal growth after insertion of ivory, but his results are so moderate that he only considers the operation justified when the child has to be anesthetized and operated on from other reasons. *Blount* has made the interesting observation that inserted vitalliumtracers will not only stimulate the growth in the metaphysis operated on, but also in the other end of the bone.

Trueta has reported some interesting experiments on animals interrupting the diaphyseal blood circulation. A significant stimulation of the rate of growth has been obtained. His clinical results have not yet been published.

Methods for measuring and planning of treatment

When working on the methods for treatment which here have been outlined, and especially on one of the growth arresting operations (epiphyseodesis or epiphyseal stapling), a very careful measuring is necessary together with a dependable basis for prediction of the future growth.

Even though clinical measuring (anatomical or functional leg length) is preferred by some, roentgenological measuring must be regarded as the most exact way, and it is at any rate necessary in cases where a method has to be tested.

Green, Wyatt and *Anderson* have developed a technique of orthoroentgenography on long films.

Goldstein's and *Dreisinger*'s spot orthography is a further development of this method which we have preferred.

Sandaa and *Sevastikoglu* have reported less costly methods with the same efficiency.

Based on a considerable normal material *Green* and *Anderson* have worked out extremely valuable patterns of growth for children from the age of 8 to the end of the growth period.

Based on these patterns the result of an epiphyseodesis can be estimated. In order to obtain sufficient safety, it is important also to judge the maturity of skeletal structure (*Green*). Furthermore it is valuable to measure clinically the child's parents and older brothers and sisters. Finally our judgement will be supported by drawing a growth curve for the child some years prior to the expected time of operation.

In spite of all these precautions we may be disappointed. Therefore, it is safest, provided that it can be regarded as justified by viewing the curves, to perform the epiphyseodesis in two stages. First the femur is arrested, and in the event of the development or the degree of maturity changing unexpectedly, secondarily the tibia.

By using *Blount*'s technique we are guarded against the danger of considerable overcorrection.

Own material

At the Orthopedic Hospital in Copenhagen we have during the last five years endeavoured to give the control of growth a proper place in the treatment. Particular interest has been paid to the epiphyseal arrest by *Blount*'s method and to the stimulation of growth by *Pease*'s method. Dr. *Guldhammer* in Copenhagen is working on the problem of growth on a wider basis. I shall give you a survey of our preliminary results. As statistical material they do not account for much, but to us they have meant so much that gradually we have been able to handle the problem.

We have performed *Blount*'s method of epiphyseal arrest close to his own technique. During the first years we used rather thin staples of which a few gave in to the pressure of growth; later on thicker staples of vitallium proved to be fully sufficient. We have tried to arrest the fibular epihysis by means of a staple. This, however, is difficult, and we now perform a veritable epiphyseodesis as recommended by *Blount*.

For controlling the discrepancy we have since 1952 been using spot-orthoroentgenography with regular measurements. We have based our calculations on *Green* and *Anderson*'s patterns of growth at the same time considering the total height of the child, its brothers and sisters, and parents, and the maturity as well. The renewed interest in the stimulation of growth, which followed *Pease*'s report has induced us to test this method on a rather large scale. The operation is quite simple as we insert one or two long screws made of ivory in the distal femoral and the

Etiology of discrepancy

Polio	25	
Hypoplasia	9	
aplasia fibulae	1	
Myelitis	2	
Myelocele	1	
Neurofibromatosis	1	
Coxitidis seq.	1	
fract. femur seq.	1	
fract. crur. seq.	1	
Chondrodysplasia Ollier	1	unilateral
part. epiphys. injury	1	stapling
art. ven. hemangioma	2	(long leg)

Fig. 1.

Etiology of discrepancy in 46 cases treated by epiphyseal arrest.

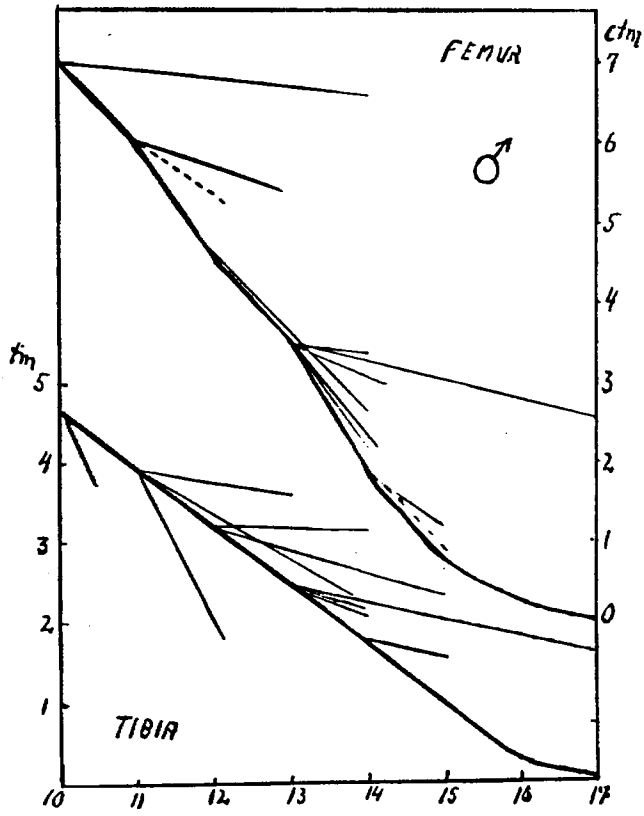


Fig. 2 a.

Fig. 2 a and b.

The curves mean to demonstrate the effect of epiphyseal arrest compared with the curves of Green and Anderson. The thick, long curves are the Green and Anderson curves. The short lines diverging from these curves represent the correction of discrepancy in the observation period. (The dotted lines indicate the Phemister operations, whereas the full lines indicate the Blount cases). If the total growth was eliminated, the discrepancy should be reduced parallel to the growth curves. Apart from 5 cases the gain was less than expected, i.e. the curve is more horizontal.

proximal tibial metaphysis. The amount of inserted ivory is apparently of no particular importance either to the course of the operation—which is always uneventful—or to the effect.

In all we have treated 103 children, 52 out of these were girls, and 51 were boys. In 78 patients (75 %) the disturbance of growth was caused by polio.

Epiphyseodesis has been performed on 46 patients, by stapling in 40 cases, and by *Phemister*'s operation in 6 cases. Epiphyseal stimulation has been attempted on 68 children while both operations have been performed on 11 children.

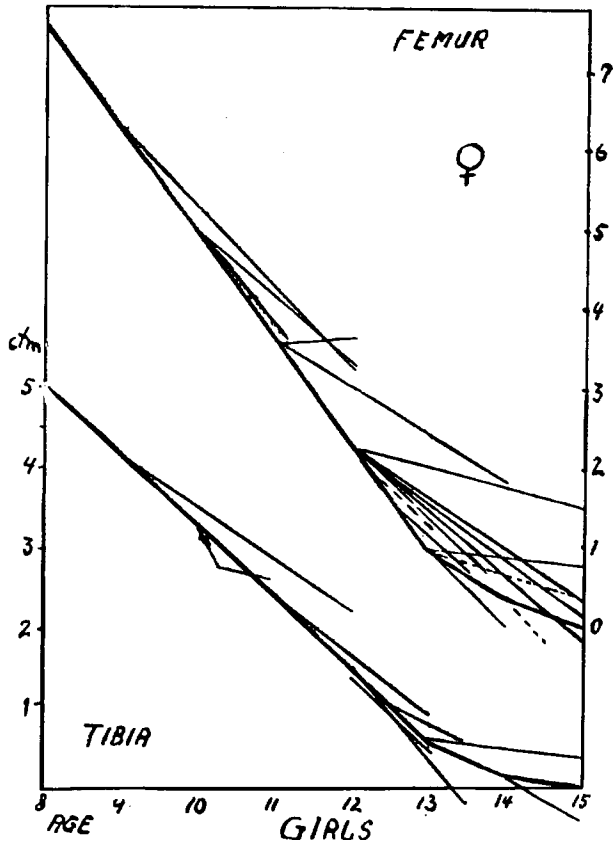


Fig. 2 b.

In these 46 patients (26 girls, 20 boys) epiphyseodesis was performed on 67 epiphyses.

Treating angular deformity unilateral stapling has been performed on 2 patients (3 operations).

The diagnoses of these 46 children were as follows.

Poliomyelitis and essential unilateral hypoplasia are the dominating diseases. It is obvious that several additional operations have been performed.

Out of special interest in this respect lumbar sympathectomy indicated by circulatory disturbances was performed on 8 children.

Complications

On the whole the postoperative course has been extremely uneventful. In one case there was a transitory peroneal paralysis, 2 children had a persistent defect of flexion of the knee which necessitated removal of the staples.

As late complications the staples were found to be loosened in 5 children, who

therefore had a second operation. Some valuable time was lost by these complications which probably were due to the fact that the first staples were made from stainless steel and were too thin. One patient developed an overgrowth of the fibula because of a failing stapling.

In no other case has any manifest growth deformity been observed as a sequelae of the operation.

Results

It will be difficult to give an adequate account of the epiphyseodesis material because the majority of the children are still growing, and a continued correction may be expected.

A survey of the effect in the observation period may be obtained by inserting the single cases into the growth diagram of *Green* and *Anderson.*

As far as the epiphyseal arrest has been effective disparity may be expected to decrease in accordance with the curve. However, it has to be kept in mind that the growth of the injured leg is slower than that of the healthy leg. In order to simplify the pattern, I have not drawn up the intermediate observations but exclusively the measures at the time of the operation and at the latest observation. The full lines represent *Blount's* stapling, the dotted ones the *Phemister*-operations. It may be seen immediately that the latter are close to the growth curve with no considerable deviations. Furthermore, it is evident that the majority of the results more or less are within the probable deviation of the normal growth curve, and only 5 deviate significantly.

The final result can more or less be judged in 20 cases who either have a long controlled growth curve after the operation or who may be regarded as grown up.

For each child the table gives sex, age at the operation, and which epiphyses have been arrested. In all cases the distal femoral epiphysis was arrested primarily, in 11 cases also the tibial epiphysis, however, in 5 cases only at a later stage. In no case has the correction been complete. Based upon the growth curves I roughly estimate a final inequality as shown in the last column in which 6 end up with a final disparity of 1.5 cm. or less, while 7 lack 3 cm. or more in having obtained a complete correction.

It is my impression that the effect is more pronounced in the more recent part of the material—due to more solid staples.

Sympathectomy, as mentioned, has hardly any certain influence on the growth, but in this connection I shall mention a 12 year old girl with the sequelae of polio who in addition to an epiphyseal arrest of the femur had a lumbar sympathectomy performed on the opposite side. During the 3 years of observation not only the disparity of the femur was reduced from 2.7 cm. to 0.6 cm., but in the same period the disparity of the tibia decreased from 4.9 cm. to 3.3 cm. In no other case was a similar effect observed, however, I shall return to the problem in the *Pease* material.

Additional growth stimulation has been tried on 68 patients. The diseases of these children are registered as follows.

Here polio is dominating too. Out of these children 31 were girls, 37 boys. This operation was mostly performed prior to the age fit for epiphyseodesis for which reason the age is lower in this material, half of the children being less than 11 years of age.

Epiphyseal Arrest.

Sex	Age	Years p.op.	Femur	Tibia	Tibia delayed	Disparity on op.	Disparity on follow up	Gain	Final disparity calcul
F	9	3	+	+		8.1	3.2	4.9	0-+
M	10	4	+		+	6.4	4.4	2.0	1.5
F	11	3	+		+	4.2	3.6	0.6	3.0
F	11	3	+		+	4.6	1.5	3.1	1.0
F	12	5	+	•		6.1	2.7	3.4	2.7
F	12	4	+		+	5.6	2.8	2.8	2.5
F	12	3	+			7.6	3.9	3.7	3.0
F	12	3	+			2.0	+0.1	2.1	+0.1
M	12	2	+	+		4.0	2.5	1.5	+0.5
F	12	1.5	+	+		7.4	3.9	3.5	3.2
F	13	2	+			3.4	3.2	0.2	3.2
M	13	4	+	+		7.1	5.6	1.5	5.6
F	13	1	+			1.4	1.4	0.0	1.4
M	13	1	+	+		6.1	5.1	1.0	3.0
M	13	1	+			3.9	3.0	0.9	+1.5
M	13	1.5	+			6.4	5.4	1.0	5.0
F	13	2	+		+	2.9	2.2	0.7	2.0
M	13	1	+	+		5.7	4.2	1.5	1.5
M	13	1.5	+			5.5	5.5	0.0	5.5
M	14	1	+	+		4.9	3.2	1.7	2.0

Fig. 3.
Diagram of twenty cases of epiphyseal arrest. The last column shows the estimated *lasting disparity.*

A part of the material has been excluded either because simultaneous operations (epiphyseodesis, osteotomy) have made measuring impossible or because of lack of control. The preliminary result of the *Pease* operation can be stated in 41 cases.

Among these children 34 suffered from polio, 6 from hypoplasia and one child had a Perthe's disease.

In the second column the total material has been grouped with regard to gain or loss. The majority has improved slightly as 22 have gained 0.1 cm. to 0.5 cm., and 5 some more. In 8 children the disparity has been increased during the time of observation. The extent of the time of observation gives no improvement of results. This has been confirmed by checks of the frequent control measurements. In one patient 0.4 cm. was gained in 3 months, but this was lost again 3 months later. In 11 patients the disparity was constant after the course of 6 months.

In 2 children a lumbar sympathectomy was performed simultaneously. The result in these cases was a correction of 0.2 cm. and 1.3 cm. which might indicate a certain sympathetic effect.

Polio	57
Hypoplasia	6
Aplasia fibulae	1
Myelitis	1
Congen. pseudarthr.	1
Perthes disease	1
Hypertrophia	1

Fig. 4.
Etiology of discrepancy in 68 cases treated by growth stimulation.

RESULTS OF IVORYIMPLANTATION

Correction (centimeters)	Total	Observation period 3-6	6-12	12-24 months
0.0	6	1	4	1
0.1 - 0.5	22	4	11	7
0.6 - 1.0	3		1	
1.1 - 1.5	2			2
+ 0.1 - 0.5	5	1	3	1
+ 0.6 - 1.0	3	1	1	1

Fig. 5.
The results obtained by Pease's operation. In column 3, 4 and 5 the results are grouped according to the time from surgery till the final gain or loss was stated.

In this material the obtained increase of growth is without correlation to the degree of disparity or to the time passed since the acute polio stage. None of the operations has been performed until 3 years after the polio.

The influence of age upon the effect reveals a considerable spread.

This table may give the impression that the effect is more reliable on the elder children (more than 10 years old).

Concluding these results, however, it has to be realized what the figures and results actually express. We can state that the measured corrective effect not only expresses a temporary partial equalisation, but it also means that an increasing disparity has ceased. Based upon several spot measurings before and after the operation we can in the single cases estimate that even an increasing disparity postoperatively does not mean an aggravated condition, but just a continuation of the linear growth curve of the extremity. A stabilization of the disparity may thus in itself be accepted as a result of the stimulation. As a consequence it is probable that the results look more favorable for the elder children, because their rate of growth is slower than for the youngest of age.

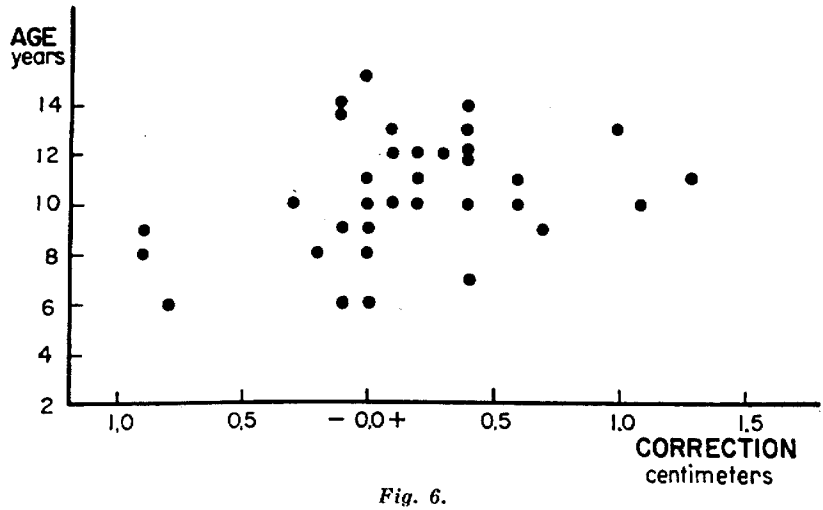


Fig. 6.
The diagram shows the correction obtained by ivory insertion at various ages.

Conclusion

Based upon what I have produced here, I beg to conclude my point of view as follows.

A controlled arrest of growth based upon the growth curves of *Green* and *Anderson*, and use of the operations advanced by *Premister* and *Blount*, ofter a dependable way of obtaining a satisfactory equalisation of the disparity during adolescence. This conclusion is based upon the results reported by reliable authors—and our experience reveals the same thing.

The stimulation of growth may give us some support during the treatment. The results obtained up till now by ivory implantation are minimal. No doubt there is a possibility for further development of the principle, and some day we may have an effective technique at our disposal.

In the Northern countries where the medical control of the population is so well established we have the great responsibility of carrying out these procedures in such a way that both shortening and lengthening osteotomies, and the need of correcting bandages shall be reduced to its proper minimum. This means that we must observe the children clinically and possibly by x-rays, and at the right time—during the age of 8 to 13 years—operate on them. That is why we also have to make great demands upon the confidence of the parents so that the operation on the "sound" leg may be accepted. Our respect for these operations has now—as previously emphasized by *Phemister* and *Wilson*—caused a probably too pronounced conservatism.

A more active approach may lead to more perfect results; on the other hand we must not let our enthusiasm bring our activity too far—to trivial or desolate cases which are both equally far from the true scope of orthopedics.

Summary

Polio is the most frequent cause of discrepancy of leg length. The several other conditions causing overgrowth or shortening are surveyed. In treating unequal length of the legs three possibilities are at hand: 1) bandage, 2) osteotomy for correction by traction or by resection, 3) intervention on the rate of growth: inhibition or stimulation.

An estimate of the several methods reported in the literature is discussed.

Personal results reported have been obtained by epiphyseal arrest (46 cases) and by growth stimulation (68 cases).

Epiphyseal arrest: Among the 46 cases no severe complications occurred, particularly no cases of deformity. One child had a transitory peroneal paralysis, and in two cases a slight flexion contracture of the knee joint. In five cases the staples loosened, and new staples were inserted. Overgrowth of the fibula was noted in one case due to insufficient block of the fibular epiphysis.

In all cases the discrepancy has been reduced. The results obtained are compared with the growth curve by Green and Anderson.

The Phemister operation gave the most dependable effect (6 cases), but even some cases treated by the Blount stapling were equal to the Phemister results.

In spite of the preliminary results being satisfactory a complete equalisation was achieved in no case.

Growth stimulation was attempted by the Pease operation, inserting one or two ivory screws in the metaphyses of the tibia and femur close to the knee. The obtained effect is minimal. The effect appears to occur in the first few months after the procedure. Later the gain is more or less reduced. According to Pease the effect should be estimated in relation to the expected increase of the inequality.

Sympathectomy has not been considered an efficient method according to the literature. In two cases, however, when epiphyseal arrest and ivory insertion were combined with sympathectomy the effect was more pronounced than any other result in the group.

A. Langenskiöld (Helsingfors):

Great differences in the length of the lower extremities often arise and develop during childhood, and the correction of such differences in adults is difficult or impossible. Efforts have therefore been made to solve the problem by regulating bone growth during the period of growth and in this way equalizing the length of the extremities.

The ideal would be to correct the difference by treating the extremity which is the site of the pathological changes, i.e. by stimulating the growth of a too short leg or inhibiting the growth of a leg whose growth has been stimulated by pathological processes.

Table I summarises the conditions that may lead to inhibition of growth of the femur or the tibia, thus to shortening of one leg. Tables I and II are compiled according to a paper by *X. Diedricx* (Belg. tijdschr. geneesk. 9: 17, 1953).

Table II lists the conditions that may result in pathological stimulation of the growth of the femur or the tibia, or both, and hence lead to differences in leg length.

TABLE I

Conditions causing retardation of growth followed by inequality in length of the lower extremities.

Congenital:	Hemiatrophy
	Chondrodysplasia (enchondromas, exostoses)
	Dislocation of the hip
	Hypoplasia of the femur or other bones in the leg
Infectious:	Poliomyelitis
	Tuberculosis (hip, knee)
	Suppurative arthritis
	Osteomyelitis (*epiphysis* of femur or tibia)
Tumors:	Osteochondroma
	Giant cell tumors
	Ostitis fibrosa cystica generalisata
Trauma:	Fracture in the region of an epiphysis of femur or tibia
	Operative measures in the region of an epiphysis of femur or tibia
	Epiphyseolysis
	Roentgen ray irradiation of an epiphysis of femur or tibia

The knowledge that there are exogenic factors with a local effect which may stimulate the growth of a single leg resulted as early as the 19th century in attempts to study the nature of these factors in order to apply them therapeutically.

Pathological processes in the epiphysis and epiphyseal cartilage often result in inhibition of growth, while changes in the diaphysis in particular, often far from the epiphyseal cartilage, result in growth stimulation. The problem of how these diaphyseal processes can stimulate the epiphyseal cartilage to increased growth has been the subject of much speculation. Most investigators in this field believe that the releasing factor is a hyperaemia in the epiphyseal region, but to date this has been impossible to prove.

The first initiative towards systematic operative inhibition of growth of the femur or the tibia to correct differences in leg length was taken by *D. B. Phemister* in 1933. His epiphyseodesis method makes use of the occurrence whereby bony bridges between the epiphysis and metaphysis result in inhibited or arrested growth. *Phemister's* epiphyseodesis definitely arrests growth in the treated epiphyses. The method presupposes that the shortening effect of the operation that will occur during the remaining period of growth can be accurately estimated, and that the time of operation is fixed on the basis of these calculations.

A first condition for such calculations is that the growth-inhibiting effect of the operation on the treated leg can be predicted. Useful tables of the growth in the distal end of the femur and the proximal end of the tibia have been compiled by *W. T. Green* and *M. Anderson* (J. Bone & Joint Surg. 29: 659, 1947).

TABLE II

Conditions causing stimulation of growth followed by inequality in length of the lower extremities.

Congenital:	Hemihypertrophy
	Arteriovenous fistula
	Hemarthrosis in hemophilia (knee joint)
Infectious:	Osteomyelitis (*diaphysis* of femur or tibia)
	Tuberculosis (metaphysis of femur or tibia)
	Syphilis (femur, tibia)
	Elephantiasis after soft tissue infections
	Thrombosis of the femoral vein
	Chronic soft tissue infection
Tumors:	Neurofibromatosis
	Hemangioma
	Lymphangioma
	Giant cell tumors
	Ostitis fibrosa cystica localisata
Trauma:	Fracture of diaphysis of femur or tibia
	Operative measures in the region of the diaphysis of femur or tibia
	(Taking of bone graft)

In order to be able to estimate the length-correcting effect of an epiphyseodesis, however, it must be possible also to evaluate the degree of growth inhibition or growth stimulation in the pathologic extremity. For poliomyelitis, statistical calculations are available regarding the degree of growth inhibition compared with the degree of paresis. As a rule, however, the evaluation is best done by repeated roentgenologic length measurements of the femur and the tibia over a prolonged period.

Obviously, relatively exact methods of measuring the femoral and tibial lengths are required for the calculations necessary for an epiphyseodesis. A method that can be considered to provide satisfactory results for practical purposes is orthoradiography.

The question of treating differences in bone length in children entered a new phase in 1949 *W. P. Blount* introduced his method of epiphyseodesis based on experimental investigations by *S. L. Haas*. Compared with *Phemister*'s method, *Blount*'s epiphyseodesis has the great advantage of reversible growth inhibition, i.e. the bone will resume growth if the staples applied at operation are removed during the period of growth. This reduces the risk of over-correction. However, it does not eliminate the necessity of making accurate length measurements and advance calculations if good results are to be ensured.

Table III shows the indications for the use of *Blount*'s staples in 14 cases operated on at the Orthopaedic Hospital of the Invalid Foundation and the Deaconess

TABLE III

Indication for Blount's epiphyseodesis in 14 cases.

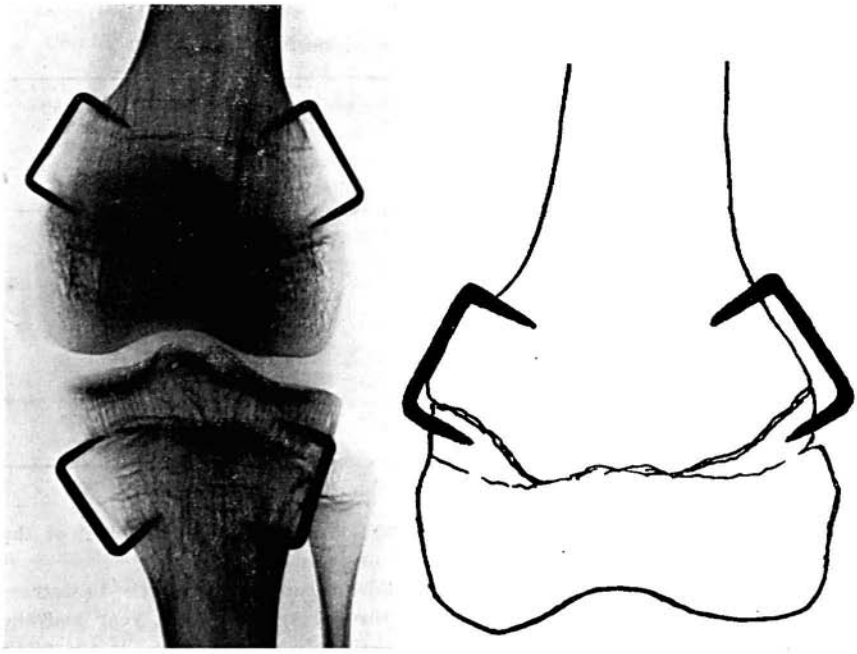
Genua valga	3 cases	(Op. 1951, 1953, 1955)
Shortening of one leg from:		
Poliomyelitis	2 „	(1954, 1956)
Tuberculosis of the hip joint	1 case	(1954)
Epiphyseolysis in the tibia	1 „	(1955)
Ollier's disease (Enchondromatosis)	1 „	(1954)
Hemihypoplasia	1 „	(1954)
Roentgen ray therapy for hemangioma	1 „	(1956)
Lengthening of one leg from:		
Neurofibromatosis	3 cases	(1953, 1954, 1955)
Lymphangioma	1 case	(1954)

Hospital, in Helsinki. The year of operation is indicated in brackets. Most of the cases are too recent to permit final assessment of the results.

In one case of genua valga, with a valgus deformity of approximately 15 degrees in both knees, complete straightening was achieved in just over a year and the staples could be removed, i.e. a perfectly good result. In another case the operation was for some reason performed on one leg only. A year later the leg was straight. The result was apparently good, but the leg not operated on was almost equally straight. It is a known fact that genua valga often have a tendency to straighten spontaneously, which makes it extremely difficult to assess the results of stapling in this condition. A third case of genua valga was also interesting. It was a patient with a serious valgus deformity suffering from vitamin-resistant rickets. Staples were applied to the more seriously deformed leg at a time when the patient was hardly growing at all. As correction through growth seemed unlikely within a reasonable period, and the deformity was very severe, it was considered necessary to resort to osteotomy.

In the four cases in which epiphyseodesis according to *Blount* was performed on extremities with an abnormally increased growth due to neurofibromatosis or lymphangioma, the technical primary result was satisfactory. In all these cases, however, the growth at the lower end of the tibia and upper end of the femur was so vigorous that the difference in the length of the extremities increased in spite of successful epiphyseodesis in the knee region. In one case epiphyseodesis in the distal tibial and fibular epiphyses was attempted, but the impossibility of applying a staple to the lateral side of the tibia resulted in a valgus deformity in the ankle joint. The staples had to be removed, and the pathologically increased growth has since corrected the valgus deformity.

Blount recommends the introduction of three staples on each side of the bone. The staples employed at the Invalid Foundation Hospital were considerably larger than those used by Blount, and only one on each side was applied. In most cases the result was satisfactory, but in one case a phenomenon was noted that is of some interest. Fig. 1 shows that the staples in the femur resulted in a localized



a. *b.*

Fig. 1.
Insertion of only one staple on each side of the bone may result in localized inhibition of growth compensated by a change in shape of the bony epiphysis.
b) a contour drawing of a tomograph of the femur seen in a).

inhibition of growth at the staple site, compensated by a change in the shape of the bony epiphysis. Such formation of a stair in the epiphyseal line, with a change in the shape of the bony epiphysis, can also be provoked experimentally. It must be considered a compensatory phenomenon in localized ossification disorders of the metaphysis (*A. Langenskiöld,* Ann. chir. et gyn. Fenniae *44*: 58, 1955). Therefore, in epiphyseodesis performed according to *Blount,* it is advisable to apply as in *Blount*'s own technique an adequate number of staples to ensure effective inhibition of growth.

Blount's epiphyseodesis must be considered a valuable step forward in orthopaedic surgery but the method requires careful planning and consideration of the indications, an accurate surgical technique with roentgenological checks during operation, and a close follow-up of the patient up to the termination of the period of growth.

The pathophysiological processes which in certain diseases and after certain types of trauma result in localized stimulation of bone growth are still unknown. The literature on clinical and experimental attempts to apply these processes therapeutically is mostly a history of negative results and frustrated hopes.

The methods aimed at stimulating growth can be divided into three main groups:

TABLE IV

Experimental endeavours to stimulate bone growth.

Author	Year	Achieved stimulation
a) *By venous stasis*		
Bergmann	1931	slight
Kishikawa	1936	0.74–1.77 %
Servelle	1948	2.6 –7.6 %
Hutchison & Burdeaux	1954	on an average 1.45 %
b) *By ligation of nutrient artery*		
Ollier	1867	0
Wu & Miltner	1937	0
Tructa	1955	0
c) *By sympathectomy*		
Simon	1930	0
Bisgard	1930	0
Cannon	1932	0
Harris & McDonald	1936	0

(1) those involving the vascular system, (2) those involving the nervous system in the form of sympathectomy, and (3) those involving the bone itself. Table IV gives a review of the published attempts at experimental stimulation of bone growth by methods influencing the blood vessels or nerves. The table shows that a certain, slight growth stimulation has evidently been reached by venous stasis. Sympathectomy in experimental animals has so far never resulted in increased bone growth. Table V lists experimental attempts at stimulating growth by treating the bone itself and Table VI is a review of attempts to stimulate the growth of shortened extremities of man.

The enthusiasm of several authors for the clinical results of operative attempts to stimulate longitudinal growth is in a certain contrast to the experimental findings. This may partly be attributed to the fact that a difference in leg length in childhood may correct itself spontaneously. The clinical results must therefore be viewed with great caution, and more effective methods must be developed on a sound experimental basis. On the other hand, it is undeniable that results with animals are not directly applicable for conclusions concerning the reaction in man. An example is provided perhaps by sympathectomy. *R. I. Harris* (J. Bone & Joint Surg. *12*: 859, 190) noted an increase of up to ¾ in. in leg length on the operated side of patients subjected to unilateral sympathectomy for Hirschsprung's disease. These patients had healthy bones, and the effect of sympathectomy on bone growth in them can hardly be denied, although sympathectomy has never stimulated bone growth in animals.

Table VII compiles the results of a series of experiments carried out to study the growth-stimulating effect of various operations on the tibia in rabbits. The age of the animals at the time of the experiment ranged from 14–36 days. Immediately after the operation both tibiae were x-ray photographed tightly pressed against the

TABLE V

Experimental endeavours to stimulate bone growth by operative measures directed at the bone itself.

Author	Year	Achieved stimulation
a) *Implantation of foreign bodies or injection of different substances into the marrow cavity*		
v. Langenbeck	1869	½ cm in femur (dog) ½ cm in tibia (dog)
Meisenbach	1910	0
Bohlman	1929	0
Wu & Miltner	1937	0
Chapchal & Zeldenrust	1948	minimal
Herndon & Spencer	1953	0
b) *Fracture of tibia of rabbits*		
Levander	1929	3–9 mm lengthening of the *femur*
c) *Curettage of the marrow cavity*		
Wu & Miltner	1937	0
Lacroix	1947	0.5 mm lengthening of the tibia of rabbits
d) *Drilling of the metaphysis*		
Hutchison & Burdeaux	1954	on an average 0.77 %
e) *Loosening of the diaphyseal periosteum*		
Ollier	1867	2–5 lengthening of the tibia of rabbits
Wu & Miltner	1937	Maximum 6 mm lengthening of tibia of rabbits
Lacroix	1947	0.3–2.3 mm lengthening of tibia of rabbits
Brodin	1955	Maximum 1.6 mm increased growth from distal end of tibia in rabbits

same film, and subsequently photographs were taken regularly once a week for 3–8 weeks after the operation. The roentgenograms of living animals were taken at a focal distance of 83.5 cm. Length differences under 1 mm were disregarded as dissimilarities in the epiphyseal shape and picture projection, irrelevant to the problem, may affect such measurements. That the photographic technique permits calculations to an accuracy of 1 mm is evident also from the fact that identical length differences were observed on repeated exposures.

A point of importance is that in 7 of the 15 experiments in which lengthening was recorded, the total lengthening came in the first week and the difference then

TABLE VI

Endeavours to stimulate bone growth in children.

Method	Author	Year	Results
Arterio-venous shunt	James & Musgrove	1950	positive
Sympathectomy	Harris & McDonald	1936	positive
Sympathectomy	Fahey	1936	negative
Curettage of marrow cavity	Ferguson	1933	positive
Metal screws inserted into metaphysis	Wilson	1951	positive
Ivory pegs inserted into metaphysis .	Pease	1952	positive
Loosening of diaphyseal periosteum .	Bertrand & Trillat (with reference to cases treated by: Tavernier, Boppe, Leclerc, Zanoli, Ingelrans)	1948	positive

remained constant. In 6 experiments the lengthening reached its maximum in the second week, in one experiment in the third and in another in the fourth week. A lengthening of 6 mm was obtained in a preliminary experiment by implanting the head of the fibula into the marrow cavity of the tibia, but in none of the 46 experiments listed in the table was anything like this result achieved. Of the 36 experiments in which no fracture resulted definite lengthening was seen in 15. In one experiment only was the operated leg shortened.

A study of the table shows that in the experimental groups in which the diaphysis was subperiosteally wrapped in a plastic film, lengthening was obtained in 8 out of 13 experiments. These groups include the experiments that gave a lengthening of 2-3 mm. In several of these experiments marked formation of callus was noted, in a couple of cases with sequestration of the wrapped part of the diaphysis without manifest infection. However, in the experiment resulting in 3 mm lengthening the callus formation was insignificant.

The results of these experiments seem to indicate that the growth-stimulating effect, known for 90 years (*Ollier* 1867) to be achievable by loosening the periosteum of the diaphysis, can be increased if the periosteum is prevented from adhering again to the diaphyseal surface during growth. It is hardly probable that the plastic film as a foreign body stimulated the growth, bearing in mind all the negative results from experiments with implanting foreign bodies.

So far at least, the results cannot be applied clinically. Prolonged isolation of the periosteum from the diaphysis obviously involves a risk of sequestration and pathological fractures. The experiments will be continued.

Is it possible at the moment to stimulate growth in cases where growth stimulation is desirable?

The answer is that with the means at our disposal today we should not try to correct great differences in leg length by growth-stimulating operations. Loosening the periosteum from the tibial and fibular diaphyses, however, is a fully justified operation complementary to an epiphyseodesis of the longer leg. This applies parti-

TABLE VII

Own experiments on tibia of rabbits.

Procedure	No. of animals	Lengthening	
		No.	Amount
1) Marrow cavity plugged with head of fibula or fragments of diaphysis ...	8	2	(1 mm, 1 mm)
2) Loosening of diaphyseal periosteum with or without implantation of bone around the diaphysis	6	1	(1 mm)
3) Loosening of diaphyseal periosteum and curettage of marrow cavity with or without implantation of bone around the diaphysis	5	2	(1 mm, 1 mm)
4) Loosening of diaphyseal periosteum and implantation of plastic film around the diaphysis	7	4	(1 mm, 1 mm, 1 mm, 3 mm) (2 mm shortening in one animal)
5) Loosening of diaphyseal periosteum, curettage of entire marrow cavity and implantation of plastic film around the diaphysis	4	2	(1 mm, 1 mm)
6) Loosening of diaphyseal periosteum, plugging of marrow cavity with head of fibula and implantation of plastic film around the diaphysis ...	4	4	(1 mm, 2 mm, 2 mm, 1 mm)
7) Injection of growth hormone around the diaphysis	2	–	
8) Fracture in connection with operation or after it	10	–	(No acceleration of growth after consolidation)
	46		
	Not broken 36	15 lengthened	

cularly to cases in which epiphyseodesis cannot be expected to result in complete correction of the difference in length. If growth stimulation by loosening of the periosteum is attempted, it should be done during a period of intense growth because it is only then that the uncertain and in any case shortterm stimulating effect may emerge.

DISCUSSION:

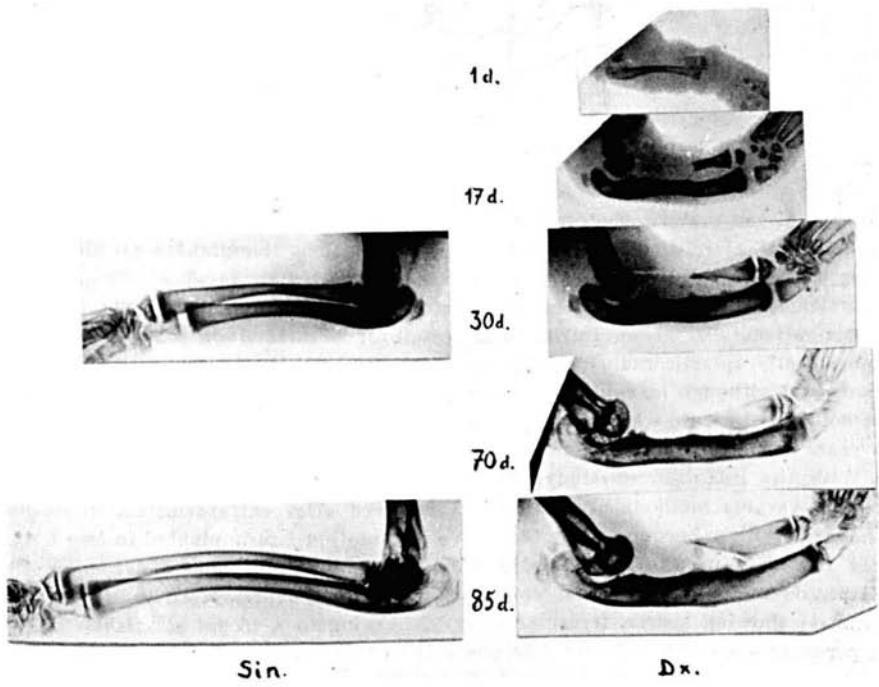
K. Kallio (Helsinki). I should like to suggest continuing with these interesting experiments by placing a free skin graft between the periosteum and corticalis instead of a foreign body.

P. Lütken, Aalborg.

B. Eriksen (Aarhus). An account is given of 40 patients operated on from 1951–55, all polio patients, suffering from disturbances of growth in the lower extremities. Even now at this time it can be seen that epiphyseal blocking on the tibia alone has not produced satisfactory results. In various cases the staples slipped, cut through or even broke. We have therefore changed to blocking mainly the femoral epiphysis. In those cases where it is also necessary to prevent tibial growth Phemister's operation is now used on the tibial epiphysis.

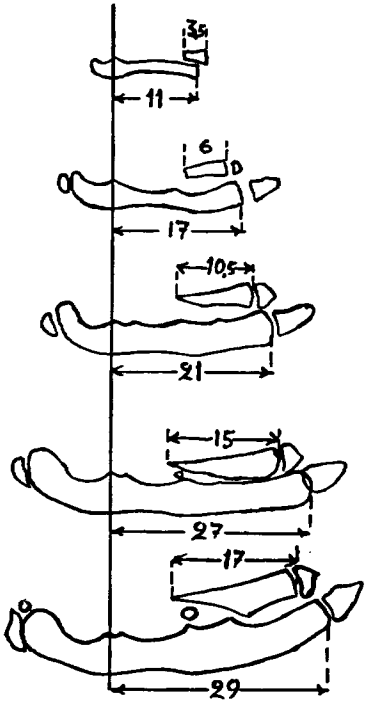
K. Jansen, Copenhagen.

H. V. A. Heikel (Helsingfors). It is generally thought that epiphysis cartilage cannot survive a transplantation but dies after a period of latency—only minor parts of such a



Picture 1.

Roentgen pictures of the rabbit's right foreleg 1, 17, 30, 70 and 85 days after the experiment and for comparison, its left foreleg 30 and 85 days afterwards.



Picture 2.
Line drawing following the rtg. pictures of the right foreleg.

transplant can survive. *May*, however, in experiments on dogs, the radius of which he removed after dissection subperiosteally and then reimplanted on the same site, ascertained that the epiphysis cartilage preserved or regained its power of function, so that the growth in length of the re-implant took place at a normal tempo after four weeks. During an account of a method of compensating for congenitally aplastic radius in man by means of a fibula implant, *Riordan* mentions that although he could not prove growth in length by the implant *Haas* had demonstrated a case where the epiphysis line of a bone transplant was open after 6 years and measurable growth in length existed.

With the intention of studying congenital radius-aplasia and experimentally testing various methods of treatment I removed after extraperiosteal dissection the right radius. Encouraged by the above information I re-implanted in two 5 day old rabbits a part of the recently removed radius comprising 3–4 mm of the diaphysis and also the distal epiphysis. Roentgen pictures were taken of both animals showing sparse, irregular intervals. Owing to a technical mishap in the experiment the implant inclined to one side so that the growth could not be satisfactorily measured on the pictures. Roentgen pictures (picture 1) of the other animal show that the *ulna* of the side treated is curved with the concavity on the radial aspect, in contrast to the ulna of the normal untreated side, the concavity of which is on the ulnar aspect; the former is shorter but at the same time thicker

than the normal ulna (an identical result, if the ulna deformity present in man in congenital radius aplasia has arisen in all the experiments in which I have removed the radius of young animals): in the epiphysis of the radius implant a centre of ossification arose of normal appearance, the epiphyseal line was still open and the diaphysis had increased in length. On more detailed analysis of the pictures and comparison between the ulnar length (from the proc. coronoideus to the distal epiphyseal line) and the length of the radius-implant (from its proximal border as far as the epiphyseal line) at various times, the following findings may be given (picture 2).

From 1 to 17 days after the intervention the ulna increased in growth 6 mm, while the implant increased only 2.5 or 3.5 mm less than the ulna. From 17 to 30 days the ulna grew 4 and the implant 4.5 mm, from 30 to 70 days 6 and 4.5 mm respectively and from 70 to 85 days both increased 2 mm in growth. From 17 to 85 days the ulna increased 12 mm in length and the implant 11 mm. Therefore the implant, after a period of latency the length of which cannot be exactly determined from the experiment, increased with almost exactly the same speed as the ulna.

Experiments recently initiated, in which to replace a radius just removed I inserted a fibula autotransplant taken by extraperiosteal dissection, seem to show similar growth conditions in the transplant. I shall make a report on these experiments later.

EXPERIMENTAL STUDIES ON CHANGED GROWTH IN THE TIBIA OF RABBITS

by *H. Brodin* (Linköping)

Intravenously administered fluorescent substances, both soluble and insoluble in water, penetrate the epiphysis cartilage of rabbits *chiefly* from the metaphysis side. When accelerated growth was obtained from epiphysis cartillage through freeing the periosteum, it could be demonstrated that the supply of blood had increased in the neighbouring metaphysis. A diaphysis fracture proximally of the foramen nutritium produced an increase in the supply of blood to the distal metaphysis.

The method was described. The requirements for a fluorescent substance suitable for such studies were stated.

DISCUSSION:

C. Hirsch, Upsala, *A. Langenskiöld*, Helsingfors, *G. Wiberg*, Lund.

ON THE DEVELOPMENT AND GROWTH OF THE LONG BONES

by *Poul Lütken* (Aalborg)

For more than 200 years the problem of skeletal growth has attracted investigators and has set minds at work. Many details have been explained, but there has been constant discussion, not to say disagreement, on the fundamental conditions.

Constantly one of the chief problems is whether the skeleton grows interstitially or more correctly, whether completely developed bone tissue performs this func-

tion. Most authors today are of the opinion that the bones grow in aposition. Growth in thickness occurs in direct aposition under the periosteum. Growth in length takes place indirectly through the interstitial cartilaginous growth of the epiphysis lamellae and the out-break and replacement of cartilaginous tissue by bone tissue. Added to this mode of growth there comes an outer resorption, which gives form, and an inner reconstruction through resorption and new formation.

However there are constantly scientists who believe that bone tissue grows interstitially and that the actual growth of the skeleton cannot be explained without this assumption, because simple aposition—resorption is not, in their opinion, equal to the task. In the north, in most recent times, *Hellstadius* has been the spokesman for this theory. I personally may declare myself as a supporter of the aposition-resorption theory, judging from embryological investigations of the development of the epiphyses and investigations concerning the site of the canals of the larger vessels and the direction of corresponding left and right bones with the modifications which result from the fact that all epiphyses (arthrophyses and apophyses) grow without any actual periskeletal ossification arising, in contrast to the diaphyses which always have periskeletal ossification. This view is further strengthened by certain as yet unpublished investigations into shape and growth, into the transition of specially curved bones from curves with a small radius to curves with a larger radius.

One of the main difficulties in speaking of bone growth consists in obtaining agreement about what is under discussion. Grounds for misunderstanding are already present in merely stating the problem, interstitial growth versus aposition.

I will begin by saying that *all growth of tissue is fundamentally and without regard to the type of tissue interstitial in growth* in the sense that cell division and the formation of intercellular substance is an expansive, volume-increasing process. Bone tissue is subject to the condition that when the fundamental substance is transformed into real bone tissue, further increase in the volume of this completed area is not possible; on the other hand new areas can add themselves to and can increase the bone mass.

Stated in another way: *bone tissue during development* grows like all tissue interstitially, but *bone regarded as an organ grows in aposition*, but not proportionately in aposition. Growth in length varies at the two ends of a long bone, a condition which can be directly observed from the direction of the vessel canals and their greater or lesser rigidity (Langer and Schwalbe). The growth in thickness of the diaphyses depends on the increase in size of the periphery of the epiphyses.

Another condition which has given rise to very heated debate is form-producing resorption. If certain unproved or directly false premises are accepted the problem can be set in such a way that the form-producing resorption must occupy such a colossal area that for this reason alone it is doubtful.

Leriche, for example, cannot understand how the volume of the cranium can be increased after the age of 3 years for at this point the sutures are closed, or rather he can only explain it by an enormous inner resorption and existing outer aposition; even if this is possible it becomes difficult to explain how diploe vessels and emissaries maintain their relative places in the bones and this indeed they do.

First of all it is not correct that the sutures are closed in 3 years and as long as sutures exist growth here is not only possible but probable. Secondly simple calcula-

tion facilitates understanding of the method of growth and the extent of the necessary inner resorption. Such reflections are naturally no proof, since it must not be forgotten that mathematics can be dangerous; one of the classic examples is Wolff's attempt (1870) to produce mathematical proof that all skeletal growth is interstitial.

On one occasion in my youth I was presented with the following problem at a society meeting: think of a globe the size of the earth and a ring lying tightly round the equator. The periphery of the ring is lengthened by 1 metre, how long will be the distance of the ring from the surfaces of the globe hereafter? The answer must be given quickly and without making calculations. The majority reply that when the ring's periphery is increased from 40 million to 40 million and one, the increase is so slight, that it will hardly produce any demonstrable looseness of the ring. The truth is that everywhere the ring will have a distance of 16 cm from the surface. This can be seen from the known formula, periphery = 2 Pi r; every time the periphery is increased by 1 metre, the radius is increased by approx. 16 cm. The statement also applies to very small sizes. For every time a total increase of 100 mikron occurs in the periphery of the skull from growth of the cranial sutures and the increase corresponds to a thickness of about 10 new cell layers, then the inner diameter of the skull increases by 2 × 16 m. There is therefore room for a new cell layer of a thickness of about 10 mikron and yet the volume of the skull increases without inner resorption only by the growth from sutures. There is however no one who says that the growth in thickness demands a new layer of cells each time the periphery is increased 100 m.

The same considerations apply to the growth of the pelvis or the growth of the spinal medullary canal. It is not at all my intention to say that inner resorption does not occur, only that it is improbable that it is of a particularly large extent. It is however present to the degree required for transforming curves with a small radius to curves with a larger radius.

There has also been much discussion about the considerable resorption necessary for e.g. the tibial tuberosity to be able to maintain its place and not finish by settling on the middle of the tibia.

This point is incorrect, because the tibial tuberosity and other similar tuberosities are epiphyseal parts and follow the epiphyses during growth. Therefore no sizeable form-producing resorption occurs in these tuberosities: it does not exceed what arises in the tubulation of the long bones.

It is a fact that, for example, the distal part of the femoral diaphysis changes form during growth, so that those areas which had a strong oval shape ◯, are changed to more ◯ ; this happens in resorption from the borders during simultaneous growth from front to back and as far as I can judge, always in such a way that the total periphery is increased, i.e., that the growth in thickness taken as a whole exceeds the resorption.

A first principle concerning osseous growth is that pressure hinders growth and that the absence of weight-bearing promotes it. We take advantage of this fundamental law in operations to regulate growth in length. The rule can be demonstrated very clearly in histological sections when the reconstructions of curves are observed. The documentation for this must wait until another time.

ASPECTS ON EPIPHYSEODERIS

by *N. Högberg* (Stockholm)

ARTERIOVENOUS ANASTOMOSES AND ACCELERATION OF BONE GROWTH

by *T. Hiertonn* (Stockholm)

Congenital arteriovenous communications of an extremity often result in an increased length of the affected extremity. Consequently attempts have been made to copy this mechanism in order to stimulate growth where it has been retarded due to polio.

At the Orthopaedic Department of the Karolinska Institutet, Stockholm, in 1950–51 we operated on five children and performed a side-to-side anastomosis between the femoral artery and vein. Three weeks later the femoral vein was ligated proximal to the fistula.

Follow up June 1956.

Case	Age at op.	Difference in length of extremities before op. 1950-51 (cm)	1956 (cm)
1	12 years	6.5	2
2	11 „	7	3
3	9 „	4	1
4	6 „	5	3
5	5 „	5.5	1.5

In case 1 (now 17 years old) resection of fistula and reconstruction of the femoral artery is carried out. Case 2 will be hospitalized soon for closing the fistula. The other cases still have open epiphyseal lines and a further effect on growth will be expected. All the cases are regularly checked with particular respect to heart size, blood volume.

The growth-stimulating effect, which is evident, may be caused by the increased temperature and vascularization at the sites of epiphyseal lines. The study of this series will be published in Acta Orthopaedica Scandinavica.

DISCUSSION:

S. v. Rosen (Malmö), *T. Hiertonn.*

PLUGGING OF THE MARROW CAVITY OF THE TIBIA FOR STIMULATING GROWTH IN LENGTH

by *F. Ståhl* (Lund)

As is known, several different factors are capable of more or less intensely stimulating growth in length of a bone. Common to all of these factors is that they presumably increase the flow of blood through the growth zone of the bone. It has

been shown experimentally, for example, that ivory or metal screws placed near the epiphyseal cartilage, loosening of the periosteum, drilling of the cortex, curettage of the marrow cavity etc. produce growth in length for a limited period just as do experimental fractures. The long known clinical observation that septic osteomyelitis or fracture is often followed by a growth in length of the injured bone has often been confirmed. *Trueta* believes such increased growth to be due to occlusion (blockage) of the marrow cavity with destruction of the nutrient artery and consequent prevalence of the metaphyseal perforating vessels with increased activity in the epiphyseal cartilage. He claimed to have proved experimentally that increased growth in length requires not only destruction of the nutrient artery but also destruction of the periosteal vessels. Trueta applied the experiment clinically in the treatment of children with legs of unequal length, but, as far as I know, he has not yet published the results of any such operations.

At the department of orthopedics, Lund, I have performed operations in accordance with these principles on children with legs of unequal length after poliomyelitis. The surgical method was as follows: From a longitudinal incision over the tibia the periosteum round the tibia was loosened along a distance of 7–8 cm. A hole 1 cm^2 was chiselled up in the cortex, the bone marrow was carefully scooped out, after which the marrow cavity was tightly plugged with chips of cortex from the bone bank, the lid was replaced and the wound closed. The children were allowed to get out of bed as soon as the wound had healed.

The patients should of course, be instructed to be somewhat careful for some time afterwards. In one case there was a fissure a few weeks later at the site of the operation. Otherwise no complications were noted.

The size and composition of the material are summarised in the table

The procedure was regularly followed by a certain growth in length of the leg treated. As expected, the best result was obtained in the case in which sympathectomy was performed at the same time, but even in the other cases growth in length was appreciable. It is noteworthy that the operation seemed to stimulate not only the epiphyseal cartilage of the tibia but also that of the femur. Growth in length was due in part to increase in length of the femur.

Though the material is too small to permit valid conclusions, there appears to be reason to expect a certain growth in length, but probably only for a limited period, since theoretically the stimulation ceases as soon as the marrow cavity has re-formed and normal circulation is restored. The chief indication for the operation is moderate shortening of the lower leg. An advantage of this simple operation

TABLE

	Age in years at op.	Time after polio	Difference in leg length before op.	Difference in leg length after op.	Improvement	Follow up	Remarks
♂ K-A. J	12	10 years	4 cm	1 cm	+ 3 cm	$3^1/_2$ years	Combined
♀ B. A.	12	7 years	2,5 cm	1.5 cm	+ 1 cm	$2^3/_4$ years	with
♂ B. N.	7	6 years	7 cm	5 cm	+ 2 cm	$1^1/_2$ years	lumbar
♀ A-G. G.	12	9 years	2 cm	1.5 cm	+ $^1/_2$ cm	$^1/_2$ years	sympa-
♂ J-H. L.	9	$8^1/_2$ years	4 cm	3 cm	+ 1 cm	$^1/_2$ years	thectomy

is that it can be performed at any time—one need not abide the proper moment for epophyseodesis—and what is more, it does not prevent any type of subsequent equilibrating operation that might be found desirable. The method seems to deserve further trial.

DISCUSSION:

J. Agerholm Christensen (Oxford), *G. Wallgren* (Helsingfors).

STIMULATION OF GROWTH IN LENGTH AFTER HUMERUS FRACTURES IN CHILDREN

by *Hans Emneus* (Lund)

It has been known for a long time that fractures of the long bones in children stimulate growth in length. It can hardly be said that a conclusive explanation of this phenomenon exists, although the majority seem to favour the theory of an increased blood supply to the epiphysis cartilage.

Trueta has primarily considered that the pure diaphysis fractures induce the greatest stimulation and he explains that this results from the blocking of the medullary cavity and the destruction of the a. nutritia.

We asked ourselves 4 principal questions in this respect.

1. How consistent is the phenomenon of the stimulation of growth in length following long bone fractures in children?
2. Does the site of the fracture (primarily the relationship diaphysis-metaphysis) possess any importance?
3. Has the type of fracture, dislocation or method of treatment any influence?
4. When does the stimulation begin and how long after the fracture does it continue?

We chose the humerus as the object of the investigation primarily for the reason that we have here two relatively typical and clear metaphysis fractures, the supracondylar and collum chirurg. fractures.

The measuring technique was developed and the orthodiagraphic pictures were taken by Olof Norman, M.D., chief of rtg. diagnostic department II at Lund. The technique is sufficiently exact to give a reliable reading to 1 mm.

It has all been planned as two investigations. *1.* A normal follow-up investigating once a series of humerus fractures with *one* measurement. 2. An investigation in which we intend to follow all the humerus fractures in children over a long period with measurements at intervals. We hoped to obtain from the first investigation certain indications regarding the extent to which growth in length actually occurs. This is now sufficiently advanced for a report to be made. It gives a rough answer or part answer to some of the above four questions, as follows:

1. The incidence of stimulated growth in length after humerus fractures seems to be high provided that the epiphysis cartilage is not affected by the fracture. Out of 40 fractures of the upper arm which did not affect in any way the epiphysis, 38 proved to be longer than the uninjured side. In at least 30 cases the lengthening was so considerable that it may be certainly counted as stimulated growth.

2. The metaphysis fractures which are included in this investigation show a

marked stimulation in the same way as shown in other investigations bearing upon femoral diaphysis fractures. (Levander, Blomquist, Rudstrom, David, Trueta).

3. It is difficult to say with certainty if the dislocation has any influence on the stimulation in the individual case. From the present investigation one would prmarily draw the concluson that the stimulation is independant of the dislocation.

In four of the 43 cases open reduction was performed. These do not differ from the others with respect to stimulation.

4. The duration of stimulated growth in length is considered by Trueta to be 2–3 years. The investigation reported here can give no answer at all to this question, but we hope to have this settled by the investigation discussed above but not yet concluded.

TABLE I

Supracondylar fractures.

No certain difference	*1*	(1 mm shortening)
Lengthening 2–5 mm	7	(2; 2; 2; 3; 4; 4; 5;)
Lengthening 6–9 mm	*11*	(6; 6; 7; 7; 7; 8; 8; 8; 8; 9; 9;)
Lengthening 10–17 mm	*12*	(10; 11; 11; 11; 11; 12; 12; 14; 14; 14; 14; 7;)
	31	

Diaphysis fractures.

No certain difference	1	(1 mm shortening)
Lengthening 7–10 mm	3	(7; 7; 10;)
	4	

Collum chirurg. fractures without involvement of the epiphysis cartilage.

Lengthening 2 mm	1	
Lengthening 6–20 mm	4	(6; 8; 15; 20)
	5	

Collum chirurg. fractures with involvement of the epiphysis cartilage.

Shortening 10–25 mm	3	(10; 17; 25;)

TABLE II

Almost exactly reduced.

No certain difference	1	(1 mm shortening)
Lengthening 2–6 mm	6	(2; 2; 3; 4; 6; 6;)
Lengthening 7–11 mm	11	(7; 7; 7; 8; 8; 8; 8; 9; 11; 11; 11;)
Lengthening 12–20 mm	6	(12; 14; 14; 15; 17; 20;)

Reduced to an acceptable position.

Lengthening 2–6 mm	3	(2; 4; 6;)
Lengthening 7–12 mm	6	(7; 7; 8; 10; 11; 12;)
	9	

Reduced to a less satisfactory position.

No certain difference	1 (1 mm shortening)
Shortening 10–25 mm	3 (10; 17; 25;)
Lengthening 3–5 mm	2 (3; 5;)
Lengthening 9–14mm	4 (9; 10; 14; 14;)
	10

The differences in length between the previously fractured side and the healthy side are calculated according to a method which gives at most 1 mm margin of error and therefore the figures are in fact relatively exact; I would point out however that too much importance should not be attached to individual values, since the initial shortening is not taken into account, and consequently the figures obtained in table I have little significance apart from their relative values.

In table II under the heading "almost exactly reduced" the lengthening of the fractured side when compared with the healthy side is a relatively exact measure of the stimulation in growth.

A question which, as far as I can understand, will not be answered by an investigation of this clinical type, is, which epiphysis is stimulated? This would have required an indicator. Thus we do not know if the supracondylar fracture stimulates the distal epiphysis, the proximal one or both. The same problem occurs of course with both the other forms of fracture.

Moreover we do not know for certain from the existing series whether, after the stimulation diminishes, the growth of the uninjured side keeps pace with that of the injured side. Those cases we have in the series presented here with closed epiphyseal lines and those where the epiphyseal lines are on the point of closing, reveal continued lengthening, in one case as much as 20 mm when compared with the healthy side. Judging from the animal experiments of Bisgard in this field one would primarily expect the healthy side to retrieve some of the ground gained in the advance to closure of the epiphyseal lines. We shall be able to reply to this question later.

ON BONE GROWTH IN JUVENILE POLYARTHRITIS

by *E. Sairanen* (Helsinki)

THE INFLUENCE OF SOMATROPIC AND THYROTROPIC HORMONES ON GRANULATION TISSUE

by *L. Saikku* (Helsinki)

AN OBJECTIVE METHOD FOR JUDGING AND REGISTRATION OF THE POWER OF GRASPING IN THE HAND APPLICABLE IN RECONSTRUCTION SURGERY

by *E. Moberg* (Gotenburg)

DISCUSSION:

L. Hagelstam, Helsingfors. *E. Moberg*, Gotenburg.

TENDON TRANSPOSITION IN THE LOWER LIMB IN POLIOMYELITIS (FILM)

by *L. Zachariæ* (Copenhagen)

DEMONSTRATIONS AT THE INVALID INSTITUTE

by *F. Langenskiöld*

1. Girl with two hand prostheses, mobile at will, with which she writes with full legibility.
2. Man with a thigh stump after amputation, provided with an adhering prosthesis without suspension or vacuum.
3. A number of patients with Milwaukee corsets.

ARTHROPLASTIA CUTANEA

by *K. E. Kallio* (Helsingfors)

The author reported his new method, called skin arthroplasty of the hip joint, in which a fresh autogenous whole-thickness skin graft is used as interposition material. The operation is based on animal experiments dealing with the fate of the skin graft concerned buried in a tissular defect in general. Specific experiments, in which a skin graft is used as interposition material in arthroplasties of the hip joints on cats have been further carried on. They have showed that the interposed skin graft preserves its vitality and develops into new tendonlike tissue between joint surfaces and replacing cartilage. The technique was illustrated by a colour film. A total of 49 skin arthroplasties had been performed by the author. Their results compare favourably with authors' results of 118 cases of arthroplasties with cups or endoprostheses. Owing to the ideal plasticity of the skin, it is possible to retain the shapes of the articulating surfaces so that the original adaptation of the caput in the acetabulum can be left as such, and in case the statics of the joint is correct, the result is a feeling of a natural joint in walking. Because no infections or other complications whatever have occurred in a series of 49 consecutive cases, the skin arthroplasty has proved to be a safe method to be recommended.

DISCUSSION:

T. Hiertonn (Stockholm). It was interesting indeed to hear about Professor Kallio's work on hip arthroplastics, utilizing skin as interpositum. It is known that changes take place in transplanted tissues as a result of function and adaptation. I should like to ask Professor Kallio if he has observed any metaplasia and cartilage formed in the transplanted skin?

Against the same background as that of Professor Kallio—late troubles with broken and loosened acryl-prostheses—interests was also stimulated at the Orthopaedic clinic of the Karolinska Institutet, Stockholm, into trying biological and autogenous material instead of foreign bodies of different kinds for arthroplasty.

In order to get a suitable interpositum for the hip we have cultured small slices of rib cartilage in a specially fenestrated mould which subcutaneously was kept by the patient for 6 months. During that time connective tissue invaded the small pieces of rib cartilage so that a fibrocartilaginar cup of autogenous tissue was formed. It was used for replacement of diseased cartilage of the femoral head of the same patient. Of particular interest was the fact that the histologic picture of the transplant strikingly resembled cartilage of hyaline type.—For the moment we do not know enough about the function of the transplanted cartilage but so much can

be said that the early postoperative hip function was about the same as for those operated on with the Judet-technique. This method of getting autogenous cartilage of any model and size have been used by plastic surgeons for repair of ears and noses and a few hips according to Peer 1954. The advantage of using autogenous tissue is evident. If the primary result will stand the test of time the method may be useful for orthopaedic reconstructions as well.

H. Støren (Stavern). It seems to me that there are two main points which arise from Kallio's "Cutaneous Arthroplasty".

A skin transplant is not 100 % sterile like fascia lata, subcutaneous strips of fat and the vitallium cup.

We know that bacteriae and bacterial spores keep alive in the deeper layers of the skin, in the sebaceous and sudoriferous glands, in spite of the most intensive surgical cleansing. Most surgeons carefully cover the skin round the operation wound in spite of thorough previous washing and disinfection—so that the skin shall not have any contact with the wound. From this standpoint it seems directly repellent to me, to place skin as covering material in a joint.

Abdominal skin is certainly less infectious than that of the hand—but what has been said also applies to this. Kallio's cases have not shown any signs of infection—and perhaps I am expressing an unjustified fear based on old medical postulates which demand revision, but on the other hand Kallio's series of 25 cases does not provide sufficient evidence, on its own, to exclude the possibility of this special source of infection, which is not present in other arthroplasties.

Kallio himself says in his article in "La Semaine des Hopitaux de Paris" that the method cannot be used in cases of advanced degenerative condition or necrosis of the caput.—There is then a relatively small field of action where the conditions required for the employment of this operation are present.

Those cases we saw were also "good-looking cases"—with few changes in the bone substance of the caput and acetabulum and relatively few changes in the shape of the caput and acetabulum. If there is fairly large incongruency between caput and collum then one is compelled to adapt their shape the one to the other.

But there can be no doubt at all that the results presented by Kallio were very handsome.

K. E. Kallio (Helsingfors). As I said there have been no infections or other complications in a total series of 49 consecutive cases.

SUBSTITUTION OF CARPAL BONES BY ACRYLLIC PROSTHESES

by *J. Agerholm-Christensen* (Oxford)

EARLY DIAGNOSIS AND TREATMENT OF CONGENITAL DISLOCATION OF THE HIP JOINT

by *S. v. Rosen* (Malmö)

Since 1952 clicks (ad mod. Ortolani) have been observed in 14 hip joints out of eight newborn girl children. In all cases the X-ray investigation revealed a dislocation upward and/or laterally of the upper end of the femur. Treatment was

commenced immediately. Six children were given ambulatory treatment by keeping the legs in the abduction position by means of a cushion or plate. It was necessary to admit two children to the orthopedic clinic for a period of plaster treatment. The follow-up examination shows roentgenologically normal or almost normal hip joints with the exception of one joint which reveals a slight subluxation.

The cases reported show that it is of great—perhaps decisive—importance that the treatment should be started immediately after birth.

In the city of Malmö (approx. 200,000 inhabitants) since 1952 almost all newborn infants have been examined by pediatricians for Ortolani click amongst other things. By this means all the new cases of hip joint luxation seem to have been discovered.

Early diagnosis and early treatment presuppose cooperation between pediatricians in the maternity department, radiologists and orthopedic surgeons. Achieving this is a problem of organisation. The treatment should be guided and supervised by the orthopedic surgeon since he has the best qualifications for judging the development of the condition during the course of the treatment.

(The study will be published in complete form in the Acta orthop. scand.).

DISCUSSION:

A. R. Klossner, Åbo.

J. Alvik (Oslo). Early diagnosis with the aid of Ortolani's manipulation represents an important step forward, but treatment by Freyka's pad has been disappointing in many cases. Even if the position corresponds more or less to Lorenz' position 1., it is in many cases an incorrect position. Many of these hips have strongly increased anteversion, both owing to dysplasia of the joint and because the children are young. The physiological anteversion is considerably reduced in the first two years after birth. The result of Lorenz' position 1. in these small hips with increased anterversion is that the hip remains in forward luxation. The longitudinal axis through the collum-caput should be fairly vertical to the plane of the acetabulum (vertical angle of incidence). As a rule, in a position corresponding to 60–70 degrees abduction, rather slight flexion and some inward rotation should be obtained corresponding to the degree of anteversion. Infants can well be put into a plaster cast corresponding to this position, and the plaster can be removed as often as is necessary. This is at least as practical as Freyka's pad.

N. Lindström, Härnösand.

L. E. Laurent (Åbo). What is the incidence of congenital hip luxation in Malmö? An investigation by Severin showed that the incidence of the disease in Sweden was a little under 1 per thousand. On calculating the incidence in Finland in 1948 I arrived at a similar figure. Of recent years in Åbo close collaboration has been established between Dr. Korttila and the pediatricians in the town for the purpose of tracing congenital hip luxation in newborn infants. As a result, to the best of my memory, 7–8 cases have been sent for treatment this year. Calculating from the number of inhabitants in Åbo and its environs this incidence would considerably exceed 1 per thousand. Is it then possible that the incidence of congenital hip luxation is in fact larger, but that in a number of cases spontaneous healing occurs, and that these cases therefore have not been previously diagnosed?

G. R. Wallgren, Helsingfors. *F. Langenskiöld*, Helsingfors. *J. Agerholm-Christensen*, Oxford. *K. E. Kallio*, Helsingfors. *S. v. Rosen*, Malmö.

PARTIAL INTRA- + JUXTA-ARTICULAR ARTHRODESIS WITH SIMULTANEOUS NAILING ACCORDING TO WATSON-JONES

by *N. Lindström* (Härnösand)

In suitable cases hip joint arthrodesis seems to be superior to arthroplasty, since the arthrodesis produces freedom from pain and stability while after arthroplasty a large percentage have residual pain and a very great number of patients have to use a stick.

However it proved difficult to obtain bone union and the total number of intra-articular arthrodeses resulted in 50 % pseudarthroses. By the introduction of simultaneous inner fixation the results were considerably improved but the disadvantages of long fixation in plaster remained. Attempts at total intraarticular arthrodesis and inner fixation alone were not encouraging. In the total intra-articular arthrodesis a small joint head is obtained in a large joint cavity with consequently incongruent surfaces and poor healing conditions. Experience of the nailing method alone according to Watson-Jones, shows that this is only suitable for almost stiff joints. If, in order to free the knee joint, one wishes to fix the joint by nailing alone, it is necessary to create very good conditions of healing.

This was the train of thought leading to the operative method which I gradually developed and which I have employed since 1947, partially influenced by a publication of 10 cases by Dickson and Willien in the same year. The method consists of a partial intra- and juxta-articular arthrodesis with simultaneous nailing, according to watson-Jones. The cartilage is chiselled from the acetabular roof and the upper part of the caput and the articular surfaces are split up without dislocation of the joint. Possible defects are filled with abundant cancellous bone and juxta-articular arthrodesis is performed with a bone from the trochanter region up in the pelvis. The patients are allowed to lie freely in bed and as a rule get up and put weight on the leg 6 weeks after the operation.

From 1947–55 I have personally operated on 41 cases by this method, 16 men and 25 women aged between 15–60 with an average age of 45 years. 37 were pure deformans cases, 1 case was a pain condition following a Smith-Petersen arthroplasty and 3 cases collum pseudarthrosis and caput necrosis.

No infection appeared. 3 patients had leg thrombosis and one patient pneumonia. One sustained a subtrochanteric fracture of the femur the same day she was discharged and had to lie in a hip-knee-foot plaster for 3 months. In 4 other cases, where certain clinical ankylosis was not present 6 weeks after the operation, the patients were required to have a hip plaster 1, 2, 3 and 4 months respectively.

Hospital care for arthrosis deformans cases lasted on average 2½ months, for the 3 cases with collum pseudarthrosis and caput necrosis 5½ months, while the case with a previous arthroplasty was nursed 2 months.

One patient has died of cancer and so the follow-up comprises 40 cases. The post-operative period varies between 6 months and 6½ years, with an average of 2 years and 2 months.

Bone ankylosis exists in 38 cases, that is, 95 % healing. In a further case there was clinical ankylosis and freedom from pain and the patient works full-time as

a foreman in a curing house 6 years after the operation. 33 patients possess full mobility in the knee joint and only 1 patient has less than 90° of flexion. 37 patients are working, from domestic work to fairly heavy factory work and agriculture. Only ⅛ of the arthroplasties of a previously published series are working.

Thus this method has demonstrated very good results with 95 % bony union out of 40 cases operated by myself and followed-up. By this method hospital care can be considerably shortened, there are good prospects of obtaining good mobility in the knee joint and the patient escapes long and troublesome bed rest in plaster.

Arthrodesis ought to be advised for patients with unilateral hip joint changes or slight changes in the other hip joint or in cases where plastics are planned or have been performed on the other side with the proviso that the lumbar back is satisfactory and the mobility of the knee joint good.

(The paper will be published in the Acta orthop. scand.).

DISCUSSION:

Johs. Mortens (Copenhagen). In old people with arthrosis of the hip we have employed at department III, the Orthopaedic Hospital, Copenhagen the *Charnley* Central-dislocation-operation in about 30 cases. We do not use any internal fixation as the aim of the operation, as we use it in old people, is not to produce an osseous anchylosis, but a stable hip. The plaster is cut short freeing the knee 3 weeks after operation. Weight bearing is allowed 4 weeks after operation and the spica discarded 6 to 8 weeks after operation. The first 12 cases are now followed more than one year: 7 with excellent results (an osseous anchylosis in three and a painless fibrous anchylosis in four), 2 are only "bettered" and 2 have developed a creeping fracture. One died the third week of pulmonary embolism.

We have been operating on cases where we otherwise would have done either an arthroplasty or a displacement osteotomy, the age of the patients being between 50 and 70 years. We only perform an osteotomy when spondylosis of the lumbar spinal does not warrant an anchylosed hip. The great advantage of the *Charnley* stabilizing procedure is that it permits early knee movement and early ambulation. We feel that the *Charnley* operation will give better results than the displacement osteotomy because of the fibrous anchylosis it produces with a bone block for adduction, and think our results quoted above give some evidence that this is true, the patients being at work again 4 to 5 months after operation. The average good result of an osteotomy is not better than the two cases of ours classified as "bettered".

The operation is in some instances followed by sequels of impaired blood supply in the same way as we know it from almost all other operative procedures on the hip. However, the two patients which developed a creeping fracture have a stable hip and experience only slight pain in walking.

N. Lindström, Härnösand.

K. E. Kallio (Helsingfors).—to Lindström. An arthrodesis is of course always a good operation especially for heavy workers. My congratulations on the fine technique and on the excellent results.

BIOMECHANICAL VIEW POINTS ON SOME ORTHOPEDIC PROBLEMS

by *C. Hirsch* (Upsala).

ARTHROPLASTY IN THE KNEE JOINT WITH PLASTIC PROSTHESIS (FILM)

by *Börje Walldius* (Stockholm)

A film demonstrating a new operative procedure developed by the author and in which the following is made clear:

The prosthesis consists of acrylic plastic and is constructed like a hinge joint with a range of movement of 180°–90°. The strength of the prosthesis has been tested in a machine built specially for the purpose. The prosthesis is stable both from the side and forward-backward and thus replaces the collateral and cruciate ligaments cut at the operation.

The instruments used for the operation are simple and consist of a measuring block of acrylic plastic to be used as a direction guide, a drill for making canals in the marrow cavities and two punches to drive the halves of the prosthesis into the tibia and femur.

Operative technique: transverse curved incisions are made according to Textor. The tibial tuberosity is chiselled away and the capsule is cut in the shape of a Y. The patella is kept intact. The articular surfaces are sawed away at right angles to the longitudinal axis of the leg; approx. 1.5 cm are taken from the tibia and 2.5 cm from the femor. The prosthesis is fixed in the bone by medullary pins and lips projecting from the prosthesis. The tibial tuberosity is sutured with strong silk and the capsule with catgut. A knee plaster is applied for 3 weeks.

After-treatment is given with physiotherapy and baths. Walking exercises are commenced 6–8 weeks after the operation. The period under hospital care is from 2–3 months.

Indications for operation: patients of extreme invalidity resulting from rheumatoid arthritis with contractures and pain in the knee joints, for which all other treatment has produced a negative result.

Complications: chiefly infection whereby the prosthesis is extracted and an arthrodesis performed.

Results: in 75 % of the 32 joints operated on mobility was maintained at 180°–90°, with freedom and complete stability.

Demonstration of two patients with 90° extension defect in both knee joints and inability to walk for 10 and 3 years respectively. Both were operated on bilaterally with arthroplasty and after the operation they could bend both knee joints 180°–90° and also walk without support.

(A full account of the operating procedure and clinical results has been published in Acta Orth. Scand., Supplementum 24, 1957).

DISCUSSION:

K. E. Kallio (Helsingfors). I have seen a patient, operated on by Professor Fabian Langenskiöld 28 years ago, where fascia lata was used as interposotion material in a knee arthroplasty. The patient said that she had had no pains and no trouble whatever with this fascia lata joint. The range of extension-flexion was about 165–130 degrees and the joint space looked surprisingly good on the X-ray.