PROCEEDINGS OF
THE NORDISK ORTOPEDISK FÖRENINGS
30TH ASSEMBLY IN OSLO

JUNE 1960

The meeting of the Scandinavian Orthopaedic Association was held in Oslo under the presidency of J. Alvik.

INNERVATION AND CENTRAL NERVOUS CONTROL OF SKELETAL MUSCLES

by *Jan Jansen Jr.* (Oslo)

In the following we shall briefly discuss certain aspects of the nervous control of skeletal muscles in the light of some recent investigations. The first problem is whether striated muscle obeys the "all or none law", *i.e.*, whether a stimulus strong enough to produce a contraction of a muscle fibre always causes maximum contraction. The other is whether rapid, phasic contractions and slow, tonic contractions are produced by different muscle fibres. New evidences have to a certain extent clarified these problems. In addition, a brief survey of the main reflex connections of afferent impulses from the muscles shall be attempted.

In primitive vertebrates the existence of two fundamentally different kinds of extrafusal muscle fibres is now well established (Kuffler & Williams 1953 a, b). The socalled slow fibres are characterized by their histological appearance, multiple innervation and motor endplates of the "en grappe" type (Krüger 1952) as well as by their slow and graded contractions, slow relaxation and inability to conduct action potentials. Motor nerve impulses produce fairly long lasting depolarization of the slow muscle fibres. Later impulses and activity in other nerve fibres may add to the depolarization and the resulting contractions depend upon the degree of depolarization of the muscle fibre. Thus, slow muscle fibres do not obey the "all or none law".

On the other hand, the twitch muscle fibres have motor end plates of the "en plaque" type. Motor nerve impulses produce a localized depolarization of the muscle fibre in the end plate region. The end plate potential initiates an action potential which is propagated along the muscle fibre and acts as a trigger for the contractile mechanism. The twitch fibre contraction and relaxation are fairly rapid processes. Under physiological conditions the twitch fibres behave according to the "all or none law".

There is thus in the lower vertebrates a group of muscle fibres characterized by slow graded contractions. In the frog these are found particularly in postural muscles (Kuffler & Vaughan Williams 1953 b), whereas the twitch muscle fibres are primarily concerned with phasic movements.

As regards the next problem, whether similar slow muscle fibres exist in mammals and man, some controversy still remains. It has, however, with modern physiological methods not been possible to find slow extrafusal muscle fibres with graded contractions in mammals. As far as we know extrafusal muscle fibres of mammals

are all of the twitch type with contractions triggered by action potentials. Thus, the problem of maintained, tonic contractions is entirely different in higher vertebrates and in order to elucidate it, we have to look at the sense organs in the muscles and their reflexes.

Two well defined groups of receptors exist in skeletal muscle, the muscle spindles and the Golgi tendon organs. Of these the muscle spindles are by far the most complicated. They consist of specialized, encapsulated thin muscle fibres, intrafusal muscle fibres, with afferent nerve terminals in their central region. Two groups of afferent nerve fibres enter the muscle spindle, some thick fibres ending in the socalled primary ending and some thinner fibres which supply the secondary ending. Little is known about the functional significance of the latter group.

The receptors in the muscle spindles are excited by passive stretch of the muscle and their discharge frequency increases with increasing extension. During extrafusal muscular contraction, however, the muscle spindles pause as they are in parallel with the extrafusal muscle fibres and this provides a means for their identification in physiological experiments. On the other hand, contraction of the intrafusal muscle fibres will increase the tension in the central receptor region of the spindles and thereby the frequency of afferent impulses (see Granit 1955 for references). Being in parallel with the extrafusal muscle fibres the spindles will record the length of the muscle, whereas the tendon organs which are in series with the main muscle will record its tension.

The activity of the intrafusal muscle fibres and thus the afferent spindle discharge is controlled by the central nervous system through their motor innervation. They are supplied by a particular group of motor fibres which have been called the gamma fibres on account of their small diameter. Of considerable importance is the question of the nature of contraction in the intrafusal muscle fibres. Is it of the twitch or the tonic variety described above? This problem can not be regarded as settled. Recently Eyzaguirre (1960) has succeeded in recording action potentials from intrafusal muscle fibres in the cat, and this is good evidence for the existence of an intrafusal twitch system. Other observations, however, suggest intrafusal contractions of the slow type (Kuffler, Hunt & Quilliam 1951). The recent histological work of Boyd (1959) is of considerable interest in this connection. He describes two types of intrafusal muscle fibres, the one with localized and the other with diffuse motor endplates reminding one of the twitch and slow muscle fibres in lower vertebrates. Thus, there is possibly a histological substrate for both rapid and slow intrafusal contractions.

The possible importance of this may best be inferred from a study of the reflex effect of the muscle proprioceptors. The investigation of these problems has to a certain extent been aided by the fact that the afferent fibres from one type of receptors tend to be of fairly uniform diameter. The afferent fibres in the dorsal roots can be classified into different groups according to their diameter and these groups have been called I (20–12 μ), II (12–4 μ) and III (4–1 μ) (Lloyd 1943 a). The afferent impulses from the primary ending of the muscle spindle and from the Golgi tendon organs run in group I fibres whereas the impulses from the secondary ending of the spindle run in group II fibres. As nerve fibres of different diameter have different physiological properties (conduction velocity, threshold to electrical stimulation, resistance to mechanical pressure and local anesthetics) it has to some extent been possible to study the reflex effects of the different afferents separately.

It is now well established that the thickest fibres in the dorsal roots (group 1 a), originating in the primary endings of the muscle spindles, make direct excitatory synaptic connections with motoneurons in the anterior horn belonging to the same muscle. This loop constitutes the pathway for the stretch reflex (Lloyd, 1943 b). The excitatory stretch impulses from the muscle receptors will reflexly tend to keep the muscle at the same length. More recent investigations show that the excitatory effect of group 1 a afferent impulses is more widespread than formerly believed. Not only does it affect the motoneurons of the muscle itself and its synergists but muscles operating neighbouring joints may also be influenced in a fairly complicated pattern which has been related to the action of the different muscles in integrated movements (Eccles & Lundberg 1958).

The group I afferent impulses, furthermore, has powerful inhibitory effects on the antagonistic muscles. The inhibitory action is probably transmitted through interneurons in the spinal cord (see Eccles 1957 for references). Thus, the group 1 a afferents with excitatory effects on synergistic and inhibitory effects on antagonistic muscles is one of the mechanisms for Sherrington's important principle of reciprocal innervation of the skeletal muscles.

The main reflex effect of the impulses from the Golgi tendon organs (group 1 b) in extensor muscles appears to be inhibition of extensors (autogenetic inhibition) and reciprocal facilitation of flexor muscles (Granit 1955). The effects are mediated via polysynaptic pathways. The autogenetic inhibition has been regarded as a protective reflex preventing possible damage from excessive tension in the muscles. Furthermore, the group 1 b afferents presumably take part in the integration of movements for instance in walking (Eccles & Lundberg, 1959).

As regards the reflex effects of the two last groups of afferent fibres from the muscles (groups II and III) the picture is at present far from complete. That is partly because the receptors of the group III fibres have not been identified. The group II fibres supply the secondary endings of the muscle spindles. On electrical stimulation the group II and III fibres exert excitatory effects on flexor and inhibitory effects on extensor motoneurons. This action is in accordance with the flexor reflex and the effects are elicited from flexor as well as from extensor motor nerves (Eccles & Lundberg, 1959).

After this brief summary of the reflex effects of afferent impulses from the skeletal muscles the mechanism of sustained, tonic contractions shall again be considered. The muscle spindles and their efferent innervation are of particular importance in this connection. Even during resting conditions there appears to be a steady tonic discharge in the gamma motoneurons innervating the intrafusal muscle fibres (for references see Granit 1955). The resulting intrafusal contraction will produce a steady stream of afferent impulses through the group 1 a afferents with excitatory action on the corresponding alpha motoneurons innervating the extrafusal muscle fibres.

For some time it has been known that the extrafusal muscle fibres of many mammals are differentiated in two types, so called red and white fibres (Denny-Brown, 1929). Both, however, have the characteristics of the twitch fibres described above. Even so the contractions of the red muscle fibres are fairly slow and they are found predominantly in postural muscles. From the extensive investigations of Granit and collaborators it now appears that these "tonic" extrafusal muscles fibres are innervated by a particular group of spinal motoneurons characterized by their ability

to discharge tonically in response to maintained group 1 a afferent impulses (Granit, Phillips, Skoglund & Steg 1957). Here is thus a system of tonically firing gamma-motoneurons possibly causing slow intrafusal contractions and thereby maintained afferent impulses acting particularly on motoneurons innervating postural muscles; a system remarkably adapted for maintenance of reflex tone.

The activity of the gamma-motoneurons is to a large extent influenced by activity in the suprasegmental parts of the central nervous system (Granit & Kaada 1952). This can be studied particularly well in the decerebrate animals in which the gamma-motoneurons apparently are released from descending inhibition. The resulting hyperactivity in the gamma-motoneurons and spindle loop contributes to the remarkable increase in tone in the extensor muscles seen in such preparations and known as decerebrate rigidity. Once the spindle loop is broken for instance by section of the dorsal roots, the rigidity disappears as shown by Sherrington (1898) but the increased gamma-activity persists (Granit 1955). As suggested by Granit it appears likely that a similar "gamma-release" may be of considerable importance in spastic states so often encountered in the neurological clinic.

Even from this brief and simplified summary it should be clear that our knowledge of the nervous control of movements is still far from complete. It can safely be assumed, however, that the continuing experimental study of these problems will prove to be of increasing value also for the practical problems involved in the diagnosis and treatment of disorders of motility and tone.

References:

Boyd, I. A.: Simple and compound mammalian muscle spindles. J. Physiol., *145*: 55–56, 1959.

Denny-Brown, D.: The histological features of striped muscle in relation its functional activity. Proc. roy. Soc. Med., *104 B*: 371–410, 1929.

Eccles, J. C.: The Physiology of Nerve Cells. Baltimore, The Johns Hopkins Press, 270 pp., 1957.

Eccles, R. M. & Lundberg, A.: Integrative pattern of 1 a synaptic actions on motoneurones of hip and knee muscles. J. Physiol., *144*: 271–298, 1958.

Eccles, R. M. & Lundberg, A.: Synaptic actions in motoneurones by afferents which may evoke the flexion reflex. Arch. ital. Biol., *97*: 199–221, 1959.

Eyzaguirre, C.: The electrical activity of mammalian intrafusal fibres. J. Physiol., *150*: 169–185, 1960.

Granit, R.: Receptors and sensory perception. New Haven, Yale Univ. Press, 366 pp., 1955.

Granit, R. & Kaada, B. R.: Influence of stimulation of central nervous structures on muscle spindles in cat. Acta physiol. scand., *27*: 130–160, 1952.

Granit, R., Phillips, C. G., Skoglund, S. & Steg, G.: Differentiation of tonic from phasic alpha ventral horn cells by stretch, pinna and crossed extensor reflexes. J. Neurophysiol., *20*: 470–481, 1957.

Krüger, P.: Tetanus und Tonus der quergestreiften Skelettmuskeln der Wirbeltiere und des Menschen. Leipzig, Akad. Verlag, 431 pp., 1952.

Kuffler, S. W., Hunt, C. C. & Quilliam, J. P.: Function of medullated small-nerve fibers in mammalian ventral roots: efferent muscle spindle innervation. J. Neurophysiol., *14*: 29–54, 1951.

Kuffler, S. W. & Vaughan Williams, E. M.: Small-nerve junction potentials. The distribution of small motor nerves to frog skeletal muscle, and the membrane characteristics of the fibres they innervate. J. Physiol., *121*: 289–317, 1953 a.

Kuffler, S. W. & Vaughan Williams, E. M.: Properties of the "slow" skeletal muscle fibres of the frog. J. Physiol., *121*: 318–340, 1953 b.

Lloyd, D. P. C.: Neuron patterns controlling transmission of ipsilateral hind limb reflexes in cat. J. Neurophysiol., *6*: 293–315, 1943 a.

Lloyd, D. P. C.: Conduction and synaptic transmission of the reflex response to stretch in spinal cats. J. Neurophysiol., *6*: 317–326, 1943 b.

Sherrington, C. S.: Decerebrate rigidity and reflex co-ordination of movements. J. Physiol., 22: 319–332, 1898.

MUSCLE FUNCTION FOLLOWING TENDON TRANSFER

by *Knud Jansen* and *Kaare Nyholm* (Copenhagen)

In an attempt to analyse the problems related to muscle coordination following tendon transfer we have obtained a certain impression of the influence of the centrally-regulating mechanisms on the functional result by electromyographic recordings from different muscles in varying combination. We shall only quote a few observations from our work.

The experiments were performed with a Disa electromyograph with 3 channels, one of which was connected to an integrator, allowing a comparison of the activity from 2 different muscles or musclegroups. With surface electrodes placed longitudinally above the middle of the muscle belly, activity was recorded during isolated joint movements, and as far as the lower extremities are concerned, in some cases during walking.

The present experiments were made on 28 patients with different tendon transfers. 11 elbow paralysis, of which 10 were operated ad modum Steindler and 1 ad modum Clark. 6 quadriceps plasties, 3 tendon transfers ad modum McCarroll-Schwartzmann, and 8 with various tendon transfers on the foot.

The 10 Steindler plasties were performed on 8 patients with polio sequelae, and in 2 cases on patients with traumatic lesion of the brachial plexus.

In our recordings we decided to differentiate between the 3 main muscles groups on the forearm, as apart from the flexor- and extensor group we distinguished the radial extensor group, which we find has special interest with respect to its synergistic function in elbow bending.

Activity was recorded during movements of the wrist with the foream in horizontal position of rest. Moreover, elbow flexion was illustrated by the various forms of technique, which Steindler patients employ.

A clinical investigation of elbow flexion distinguished 3 as excellent with a flexion strength of about 4. All 3 were characterised by a normal strength in the forearm muscles before the operation; 5 had varying strength about 3, and in a single case was found reinnervation of the normal elbow flexors.

In isolated wrist movements (extension and flexion) the pattern of activity was found to be uniform in all patients and does not differ from findings in normal controlpatients. With greater strength an increasing dominance of the integrated activity was found of the flexing and extending muscle groups with slight activity

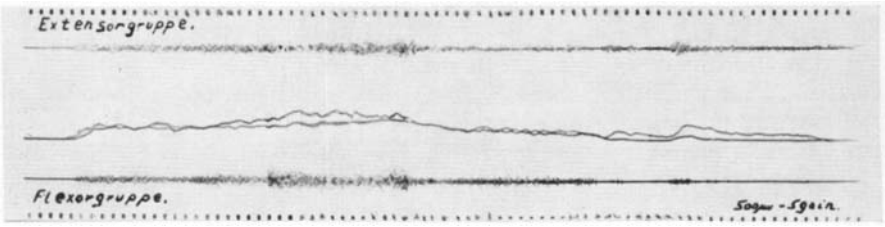


Fig. 1.
Electromyographic recording of activity during elbow flexion-extension movement in a 10 year old girl operated according to Steindler (normal findings).

of the antagonistic group. (Hand and fingers were, as far as possible, held in a relaxed position during the movements). During the total flexion-extension movement in the elbow from 150°–60° and back to the position of rest, the activity relationship between the two groups was found to be uniform in 5 out of 6 cases (fig. 1). Beside the strong and increasing activity of the flexor group we found the same condition in the extensor group, in which the strength achieved may influence the elbow joint to an increasing extent during flexion. This argues in favour of using this strength in cases of elbow paralysis by simultaneously transferring the common head of the extensors, especially in those cases where the radial extensors are strong and can assist in stabilizing the wrist. These integrated activity curves were found to be identical at elbow flexion during different positions of the lower arm and hand.

Thus the varying forms of hand and forearm position do not alter the activity curves.

The activity of the radial extensor group shows the same increase in activity as the 2 other groups and so works synergistically with the flexors as far as the elbow flexion is concerned.

The typical finding in these patients is a strong innervation of both forearm flexors and extensors and radial extensors, and antagonistic activity, corresponding to the wrist, is graduated during elbow flexion.

One single case differed considerably from the others, since the activity of the extensor group was found to be slight by comparison with that of the flexor group (fig. 2), and moreover, this was very constant throughout the whole movement. The patient was operated on bilaterally, and the mild extensor activity was identical on both sides corresponding to the activity in a moderate wrist extension. On examination he came out with the strange fact that he could carry out the movement without preceding intense cerebral concentration. This was the only case in which we could demonstrate a reduced activity of the extensor group, i.e. a partial segregation of the flexor and extensor actions.

The patient who revealed reinnervation of his normal elbow flexors was also found to be particularly interesting, since in spite of clinically slight flexor ability in the albow, he was not capable of innervating the biceps and the transposed forearm muscles at the same time but employed exclusively his reinnervated, normal elbow flexors.

Before the Steindler operation wrist arthrodesis was undertaken together with 3

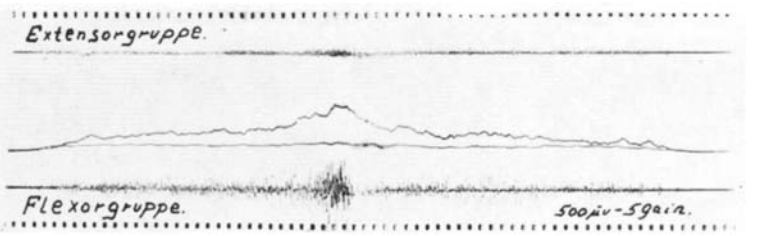


Fig. 2.

Electromyographic recording of activity during elbow flexion-extension movement in an 18 year old male operated according to Steindler (bilaterally). Note the slight extensor activity. Reduction of activity of the extensor group was found to be identical on both sides.

tendon transfers on the hand with muscles from the transposed flexor group, and a distinct rise in activity of the flexor group was noted with the corresponding finger movements.

Thus there were 2 possibilities of explaining the absent flexor innervation in elbow flexing. Either the patient was not capable of activating the 2 groups of elbow flexors simultaneously, or the tendon transfers had offered the flexor group an alternative, and it had chosen the function of the hand.

In 8 patients with tendon transfers on the foot, 7 cases underwent transposition of one of the peroneal muscles, which gave a uniform result in the simultaneous recording of activity of the two muscles, since it was not possible in any of the cases to differentiate the activities of the two muscles. This is in accordance with our findings in the quadriceps plasties, in which a single muscle was functionally transposed from a group with a common function to a group with reverse or diverging function. In these conditions the transposed muscle seeks functional acceptance in the new group without altering its relationship to the old one. In only one case we saw a total reversal of an individually transposed muscle, and this was the tibialis anterior moved to the heel tendon.

Respecting our 6 patients with quadriceps plasties and also 3 patients operated ad modum McCarroll-Schwartzmann, the observation period is still too short to draw up the final results, but in 5 cases, including 2 operated ad modum McCarroll-Schwartzmann, increasing activity was demonstrated during knee extension, while activity during knee flexion was unchanged—a result which corresponds with findings in single tendon transfer on the foot.

One patient was especially interesting since she constantly complained of walking trouble when starting to walk following a McCarroll-Schwartzmann operation 5 years earlier. After a moment's concentration she was able to resume walking without trouble. This patient had certain points of similarity with the above-mentioned Steindler patient. Electromyography showed strong activity of the semitendinosus, both during knee flexing and knee extending. When recording during walking, signs were found of prevention of activity of the semitendinosus but no phase displacement.

Finally we wish to report briefly the only one of the patients with quadricepsplasties, in whom all the medial flexors and the biceps were transposed and who

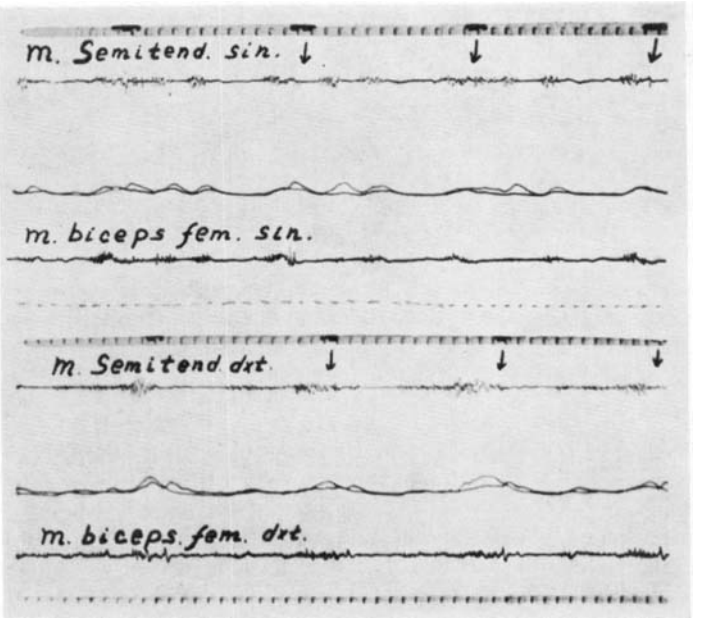


Fig. 3.

Electromyographic recording of walking in a girl aged 12 with right-sided quadriceps plasty (all the hamstring muscles transposed to the quadriceps tendon).— *Top:* Left lower extremity (control)—marking: left heel contact.—*Bottom:* Right lower extremity—marking: right heel contact. Note the cessation of activity of the transposed muscles in the stance phase and the accumulation of activity last in the swing phase.

clearly differed from the other patients by total absence of activity during isolated knee flexion and with strong activity during knee extension.

The patient was a girl, aged 14, who underwent the above-mentioned tendon transfer 5 years earlier. The patient had fully capable glutaeus maximus muscles and gastrocnemius muscles. On the right side all the medial muscles and the biceps were transposed to the quadriceps tendon. When comparing the two lower extremities during walking a powerful knee extension—almost hyperextension—was observed on the right side at the conclusion of the swing phase. If the medial side of the right femur was watched, a brief, powerful muscle contraction was to be seen, corresponding to the transposed semiflexors in the same phase.

When comparing the electromyograms from the semitendinosus and the biceps of the femur on the two sides (fig. 3), normal phase activity is found corresponding to the conclusion of the swing phase and the whole of the stance phase on the left side (the non-operated side). On the right side a total cessation of activity is found during the stance phase, while a powerful and brief accumulation of activity occurs of the muscles at the conclusion of the swing phase. There seems therefore to be a complete cessation of muscle function in the stance phase after tendon transfer. From symmetrical recording of the glutaeus maximus and gastrocnemius medialis

no change is found in the localization phase, but with the medial gastroenemius increasing activity is found on the right side in the stance phase. The latter muscle seems thus to have strengthened its stabilizing function on the knee joint in the stance phase.

With the aid of film and electromyograms a total reversal of muscle function is demonstrated in a 14 year old girl with quadriceps plasty, in whom a whole functionally and anatomically correlated group (all the semiflexors) was transposed to the quadriceps tendon.

Conclusion:

Our present observations have revealed that selective tendon transfers give rise to considerably greater problems of function than the anatomical conditions seem to indicate. This is most likely due to the fact that the interventions undertaken have a penetrating influence on fundamental innervation patterns, after which new balance must be established solely through central cerebral regulation.

IMPROVEMENT OF MUSCLE STRENGTH AFTER ISOMETRIC, MAXIMAL CONTRACTIONS

by *Harald Brodin* (Lund, Sweden)

41 test individuals aged 20–23 years practised for 6 seconds daily the isometric and maximal contraction of the abductor muscle of the fifth finger of their best hand for 5 days of the week. After 8 weeks' exercise an increase in the abduction strength was obtained of 214 ± 47 gf, i.e., 20 %.

Insignificant increase in abduction strength in the little finger of the other hand was also observed ("crossed education"). A control series of 41 test individuals of approximately equal age obtained after 8 weeks a slight increase in strength in the abduction function of both little fingers.

Statistical analysis showed that the increase in strength in the trained group was statistically certain even when taking into consideration the slight but general increase of strength in the control series.

Conclusion:

The training method tested gave such small results that it can hardly be recommended for clinical use. The discrepancy between these findings and previously published laboratory results of the training method were not discussed.

EXPERIENCE WITH TENDON TRANSPOSITIONS IN POLIO SEQUELAE IN CHILDREN

by *Lis Zachariae* (Copenhagen)

Introduction:

Tendon transposition operations in polio sequelae have been carried out for many years, but have always been a much discussed problem. Where adult individuals are concerned, it is agreed that it is best to combine the tendon transposition with an arthrodesis. If, however, asymmetrical paralyses are involved in younger children

arthrodesis cannot be performed and in such cases a well planned tendon transposition can many times prevent the arrival of the severe deformities which occur during growth.

The principle in all tendon transposition is that the deforming factor must be removed and also that this tendon is to be used to restore as normal a balance as possible.

At the Orthopaedic Hospital, Copenhagen, Dept. II, we have operated on a number of younger children from the polio epidemic of 1952 with asymmetric paralyses in the feet. The establishment of indications and methods of operation were so uniform that it may be of interest to record the results, since in this way one may possibly obtain lines of guidance for future principles of treatment.

Series and methods:

The series consists of 58 children, 24 boys and 34 girls, whose age distribution appears in fig. 1, and who had polio in 1952. They all had asymmetric paralyses in the lower legs and feet with initial deformities as sequelae. Tendon transposition operations were performed 2 years after the acute stage, since the pareses are considered to be stationary at this time. The period from the operation to the re-examination is 5–6 years.

Fig. 1.

Age distribution of 58 children operated on for polio sequelae by tendon transposition.

Age at op.:	No. of children:
5 years	38
5–9 years	20
Total	58

6 of these children were operated on bilaterally.

Fig. 2.

Tendon transpositions undertaken on 64 feet with polio sequelae.

Type of tendon transposition:	No.
Tib. ant. or post. moved laterally	9
Peroneals and/or tib. post. moved to heel tendon	25
Toe extensors moved to tib. ant. and/or peronaeus brev. to tib. post.	28
Peronaeuslong. moved to the dorsum pedis	2
Total of feet	64

In fig. 2 a survey is given of the type of tendon transposition. The total result of the whole series has not been recorded, since the deformities are so different in type; instead each group is estimated individually.

From fig. 3 it will be seen that more than half the patients did not terminate treatment with the primary operation but had to be operated on again.

In 24, supplementary operations had to be performed for the same deformity; 3 of these were reinsertions and 3 were lengthening of the heel tendon, and in several of the remainder supplementary transpositions which ought to have been undertaken at the 1st operation, e.g., transposition of lateral muscles to the heel

cord. With greater experience, one can undoubtedly almost avoid this form of re-operation. More serious complications which demand reoperation are new deformities which arise as a consequence of the primary tendon transposition; there are 14 of these. In 3 a Z position of the 1st toe was involved following transposition of the tibialis anterior and here transposition of the ext. hall. longus to the 1st metatarsal was undertaken. In the remainder all cases involved overcorrection in varus following tendon transpositions in valgus feet.

Fig. 3.
Number of reoperations on 64 feet treated with tendon transposition.

	Number of feet:
Reoperation for same deformity	24
Reoperation for different deformity	14
Total	38

By reoperation for a different deformity is meant a deformity arising after the primary operation.

The series is divided into 3 major and 1 minor group, fig. 2. In each group the deformities and the tendon transpositions undertaken are of mainly the same type, although it must be made clear that there is an infinite number of variations in the mutual interplay of the various muscles. In establishing indications for the operations an assessment was attempted not only of the degree of the pareses but also of the static and loading of the foot and the function of the small foot muscles was also taken into consideration. Only muscles which were sufficient for the task were moved since it is calculated that they lose some strength on removal and before the tendon transposition operations the existing deformities have been corrected as far as possible e.g., by redressements or operations, e.g., lengthening of the heel tendon.

Concerning the calcaneus-feet the result is differentiated in different qualities, while all other feet are only classed as good or bad. By poor result is meant unchanged or increasing deformity of the same kind as before the operation or overcorrections, and by good result is meant that the balance of the foot is restored and that the deformity is obviously improved.

Varus deformity.

This deformity arises from weakness of the peroneal muscles and/or the extensor digit. longus. Often an equinus position is found at the same time and greater or lesser cavus according to the strength of the tibialis posterior, but drop foot is rarely found, although dependent on the strength of the tibialis anterior. Here the operations were transposition of the tibialis anterior or posterior to the lateral border of the foot depending on which of these 2 muscles is estimated to be the most important deforming factor.

In many cases the tendon transpositions must be combined with lengthening of the heel cord and/or moving the extensor hall. longus to the 1st metatarsal. When transposing the tib. post. it is conducted through a hole cut in the interosseous membrane. The transposed tendon is fixed by means of drillholes in the os cuboid bone by pull-out-wire. The results appear in Fig. 4.

Fig. 4.

Results of tendon transposition with varus position in 9 feet with polio sequelae.

Type of tendon transposition:	Results: good	poor
Tib. post. transposed laterally	3	1
Tib. ant. transposed laterally	4	1
Total	7	2

Supplementary to the tendon transpositions 3 interventions of heel-cord lengthening were undertaken and 3 Jones.

In all, 9 of these operations were undertaken, 7 of which were undertaken, 7 of which were excellent, in 3 of these a Jones operation was performed and in 3 a lengthening of the heel cord. 2 were poor, the one, where the tib. post. was transposed, has constant varus position and in addition drop foot, probably because the tib. post. tendon was too short and could not reach down to the lateral border of the foot, so that it was ineffective. An attempt was made to improve the result by moving the toe flexors to the peronaeus longus, but without effect. In the second case the tib. ant. was moved but the tendon came loose on being fixed and on re-operation it could not reach down; then the tib. post. was transposed and the varus position was prevented, but there is now very considerable drop foot.

Conclusion:

In varus position owing to polio sequelae in feet, transposition of the tib. ant. or post. to the lateral border of the foot shows good results.

In many cases the operation must be supplemented by lengthening of the heel cord or by the Jones operation.

Valgus Deformity:

This deformity arises through weakness of the tibialis anterior and/or tibialis posterior. Often an equinus position is found at the same time and varying degrees of cavus or planus according to the strength of the tibialis posterior. Fig. 5 shows the results of the tendon transpositions undertaken.

With paresis of the tib. ant. but with an intact tib. post., transposition of the extensor hall. longus is carried out to the site of insertion of the tibialis anterior or of all long toe extensors to the same site. In all, 13 of these operations were undertaken, 6 with all toe extensors, all of which were good, and 7 with the extensor hall. longus alone, 4 of which were good and 3 poor. Of the three poor 2 had such pronounced drop foot, that although the peronaeus longus was transposed to the dorsum pedis, this had no effect on the drop foot, and at the follow-up this was found to be due to heel cord tightness. The last case had pareses of the tib. post., therefore transplantation was not sufficient. In pareses of the tib. post. but with an intact tib. anterior transposition of the peronaeus brevis to the tib. posterior tendon was undertaken. This operation was undertaken in 5 cases, all of which were poor. In 4 the transplant had no effect and the deformity was unchanged, in 1 there was overcorrection in varus. In pareses of both tib. anterior and posterior a combination of these 2 operations was undertaken, i.e., transposition of the pero-

naeus brevis to the tib. post. and of toe extensors to the tib. ant., either in one or several sessions.

Fig. 5.

Results of tendon transposition in valgus postion of 28 feet with polio sequelae.

Type of tendon transposition:	Results: good	poor
Ext. hall. long. → tib. ant.	4	3
Ext. dig. long. → tib. ant.	6	0
Peron. br. → tib. post.		5
Combination of these	2	8
Total of feet	12	16

This was performed in 10 feet, 4 of which had overcorrection in cavus varus; these were very difficult to correct again, they were operated on several times later and only 1 achieved a fair result. In 4 no effect was obtained from the transplants and deformity remained unchanged. Only 2 were good but in both no function was gained from the transposed peroneaeus brevis and only the transposed toe extensors now function and give a good result.

Conclusion:

In valgus position owing to polio sequelae in feet the transposition of toe extensors to tib. anterior produces good results, while the transposition of the peronaeus brevis to the tib. posterior in all cases gives poor results, since this transposition, if it works, produces overcorrection in varus. In many cases heel cord lengthening must be undertaken simultaneously with tendon transposition.

Calcaneous deformity.

This deformity arises from weakness of the triceps. The operation is transposition of the peronaeus longus and brevis and/or the tib. posterior to the heel tendon.

Fig. 6.

Results of tendon transpositions in calcaneus position in 25 feet with polio sequelae.

Type of tendon transposition: Peron. and/or tib. post. to heel cord.	
Osseous deformity:	
unchanged	20
increased	3
decreased	2
Triceps sufficient	7
Triceps insufficient	18
Complications:	
Deformity	5
Instability	12

The results appear in fig. 6.

It will be seen that the essential effect of tendon transpositions is that the osseous heel deformity does not arise, so that a later arthrodesis is facilitated.

Out of 25 cases only 3 experienced an increase in the osseous deformity following tendon transposition, 20 were unchanged and in 2 the deformity was reduced. In only 7 cases did the triceps remain sufficient in strength after the operation, and in these cases the muscle was not O before the operation. The reason for this is presumably that the transposed muscles are not in themselves sufficient in strength to function as triceps. The most important complication is instability of the foot joint and subtalar joint when the lateral muscles have been transposed; this is found in almost half of the cases. In moreover 5 cases secondary malpositions arose owing to an intact tib. posterior. In 2, heel tendon tightness arose after the operation.

Conclusion:

In the calcaneus position arising from polio sequelae the transportation of the peronaeus and tib. posterior to the heel cord can prevent the osseous heel deformity from developing. The triceps becomes, however, seldom sufficient in strength and in about ½ of the cases instability occurs in the foot. One must always transplant all the lateral muscles at the same time.

Drop foot deformity.

This deformity arises from weakness of the tib. anterior and toe extensors. The operation practised in transposition of the peronaeus longus to the dorsum pedis, i.e., to the insertion of tib. ant. This was only performed in 2 cases, both of which were poor. Both had calcaneus position because the triceps was too weak.

Overall conclusion:

These series show that certain tendon transpositions may be of value in preventing foot deformities from occurring in children with assymmetrical pareses following polio. In a number of cases an existing deformity may disappear following the operation. It is important to plan carefully the tendon transposition and as far as possible to correct contractions, i.e., equinus, before or during the operation.

One tendon transposition, namely, peronaeus brevis to tib. posterior, gives in all cases poor results and must be avoided.

Fig. 7.
Results of Grice's operation on 15 feet with polio sequelae and tendon transpositions undertaken.

Type of deformity:		Results:	
plano-valgus	9	good	10
calcaneo-valgus	3	poor	5
varus	3		

With many of the patients it is necessary later to undertake arthrodesis operations. In 15 cases of the recorded series it was found necessary in the course of the

observation period to undertake a Grice operation, i.e., the insertion of bone chips in the sinus tarsi (Fig. 7). Out of these 15 there were 10 good results with clinical subtalar fixation and correction of the malposition. But only 8 showed radiological healing of the bone chips. The remaining 5 were poor, since there is no subtalar fixation, neither clinically nor radiologically, and the malposition has increased.

The poor results are found especially in strongly paralytic feet, irrespective of which malposition was primarily involved.

DISCUSSION:

H. Nilsonne (Stockholm):

Tendon transplantations in polio have their given area of indication, very limited, however, especially when a patient of a growing age is concerned. One can never estimate by means of a muscle test the forces which may influence during growth the deformity of the leg and of the arm.

The transplantations are, however, of no small value in securing the best dynamics for the extremity during growth.

A polio child should never be operated on for tendon transplantations, however, without emphasising to the parents that it is probably a palliative and temporary operation and that it is very probable that on puberty or afterwards a skeletal operation with a permanent value will become necessary. By means of the first operation a better starting point will have been established.

MUSCLE FUNCTION OF TRANSPLANTED FLEXOR MUSCLES IN THE THIGH IN PERIPHERAL PARALYSIS OF EXTENSOR MUSCLES

by *Kaare Haug* (Stavern, Norway)

Summary:

A survey is given of earlier opinions of the range of indications for transplantation of thigh flexors in paralysis of the quadriceps in residual poliomyelitis. The theoretical basis for the principle of transposition is to be sought in the static equilibrium of the body. Important details of the operation are pointed out and the surgical technique used at Kysthospitalet ved Stavern is described.

The material, which cowered a 10 year period, consisted of 20 patients on whom a total of 23 operations were performed. Thirteen patients (15 operations) were examined by the author with simple, clinical methods.

During the observation period the range of contraction increased in 4 cases and decreased in 5.

The changed functional conditions of the transposed muscles did not appear to influence their functional capacity, as judged by observation of the patient while climbing stairs.

The postoperative improvements and undesired side effects (sequelae) of the operation are presented in detail. An observed postoperative decrease in genu (valgum) and of lumbar lordosis is emphasized.

The results obtained were comparable to those reported by other authors, for they were satisfactory in 94 %. In one case the operation gave no relief except elimination of a knee joint contracture of 10°.

In 2 cases the good results of operation were spoilt: in one case by a supracondylar femoral fracture and in the other by forced passive flexion during parturition. In the latter case extension was afterwards improved by reconstruction of the ruptured lig. patellae.

STUDIES OF ULNAR NERVE INJURIES BY MEANS OF A NEW SPECIAL ERGOMETER

by *Lennart Mannerfelt* (Borås, Sweden)

The difficulties in the way of grading objectively an injury to the ulnar nerve are obvious. Great interest lies in discovering whether regressive or progressive tendencies are taking place. Certain problems here must be solved as:

1. How does motor regeneration occur after an ideal suture to the ulnar nerve?
2. Which muscle or which groups of muscles regenerate as the first?
3. How does a certain contusion to the ulnar nerve infuence motor functions within the area?

Objective measurements are required to follow up such problems. Partial injuries must also be followed up and one must be able to evaluate which muscle groups are affected by paresis and which are not.

The need for a special ergometer to determine these questions has long been present. Certainly in some studies (*Lewey, Kuhn* and *Juditsky,* 1947 and *Newman* 1949) the question was taken up but since no sizable series has been presented, there is reason to believe that the method admitted of doubt.

For some years now the need for objective registration of ulnar nerve injuries in my work has clamoured for a solution. The orthodox "squeeze ergometer" has proved not delicate enough and can in no way make detailed distinctions for evaluating nerve injuries in the ulnar region. *Moberg* (1948) indicated a more correct method when he introduced his special ergometer to measure the "pinch grip". However, possibilities of evaluating questions of detail within the ulnar region were lacking since only the "pinch grip" was examined with his ergometer. As this special grip consists of a summation of the majority of the components involved in the thumbindex finger grip, it therefore follows that not only the ulnar nerve is concerned. In reality both the flexor pollicis longus and the flexor profundus to the index finger are engaged here and also extensor pollicis brevis together with the first dorsal interosseous muscle.

In order to cultivate a movement governed by the ulnar nerve it showed to be necessary to find out how the adductor pollicis workes. It now appears that this adductor works in two ways mainly. Where the thumb moves parallel with the volar surface down towards the top of the third metacarpal head, a purely ulnar adduction is found. A palmar adduction movement occurs where the thumb follows a path at right angles to its former path, i.e. from the abducted position at right angles towards the metacarpal plane II–V and completing its movement towards the volar aspect of the index finger.

In order to grade this last movement objectively a bridge was first built on which the thumb could glide at right angles towards the metacarpal plane II–V. Attached weights calculated the objectively measurable force. The bridge was clumsy and proved to be unsuitable for exact work, cf. Fig. 1.

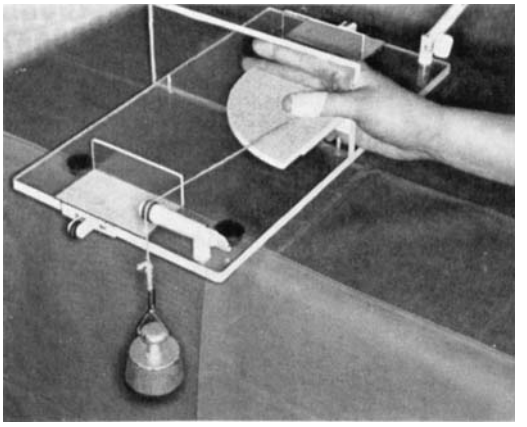


Fig. 1,

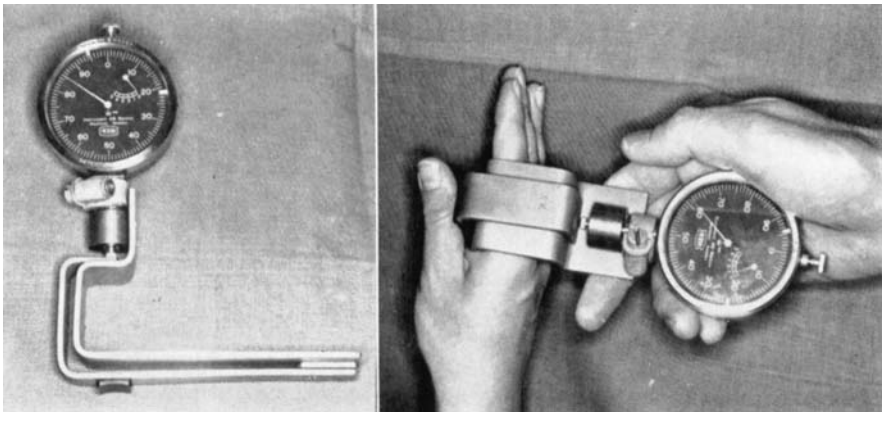


Fig. 2,

A simple and reliable method had to be evolved therefore, and with the ergometer now constructed I believe that my aim has been achieved. Briefly, the present ergometer consists of two steel springs which are pressed together. This pressure is projected onto a precision instrument (Metron Dial Indicator) on which each interval represents 1/100 mm. of movement.

This ergometer is not intended for individual exhibitions of strength but works as a precision instrument with great powers of discrimination.

By means of the ergometer the following muscles governed by the ulnar nerve can be measured and distinguished:

1. Adductor pollicis, cf. Fig. 2.
2. Abductor digiti quinti.
3. First dorsal interosseous muscle.
4. Other interosseous muscles.

(Furthermore, both the "pinch grip" and some of the hands other intrinsic functions can be measured as abductor pollicis brevis and opponens pollicis).

By means of the mentioned ergometer a fairly large normal series has now been measured in order to ascertain normal values. In addition a comprehensive investigation into ulnar nerve injuries is being carried out, both those operated on by nerve suture, and those not operated on. This last group consists of partial injuries not suitable for surgical intervention.

The ergometer has proved of great value. With the instrument we now have a method of demonstrating in an objective manner whether regressive or progressive tendencies exist in a certain nerve injury in the ulnar region. In questions of compensation cases the ergometer can without doubt be shown to be of use.

EXPERIMENTAL EVALUATION OF THE HYPOTHESIS OF LIGAMENTO-MUSCULAR PROTECTIVE REFLEXES

by *B. Stener* (Gothenburg, Sweden)

The hypothesis of ligamento-muscular protective reflexes put forward in the literature was tested on 49 decerebrate cats and 35 unanaesthetized subjects, using the medial collateral ligament of the knee joint.

In cat a method was developed for effecting a large increase in the ligament's tension, without appreciably damaging its innervation during the preparatory dissection. Three different methods were used for studying the effect on the motor side of increasing the tension in the ligament: myography, electromyography and monosynaptic testing. All muscles able to oppose an increase in tension in the ligament were tested. With none of the methods and in none of the muscles was it possible to detect any reflex motor effects in response to the increase in tension in the ligament, although control reflexes could be elicited. That the absence of reflex motor effects was not due to absence of afferent discharge could be shown by recording impulses from the medial and posterior articular nerves.

In man the ligament's tension was increased in a natural way by forcibly trying to abduct the tibia on the femur. The effect of increasing the tension in the ligament on the activity in muscles capable of opposing abduction at the joint was studied by electromyography. No reflex motor effects ascribable to stimulation of ligamentary receptors were observed.

Taken together the results in cat and man provide strong reasons to doubt the existence of a protective muscular reflex originating in tension receptors located in ligaments.

Detailed accounts of these experiments on cat and man have been published in Acta Physiologica Scandinavica, Vol. 48, Suppl. 166.

ELECTROMYOGRAPHY IN DIAGNOSIS OF LUMBAR ROOT COMPRESSION SYNDROME

by *Bertil Knutsson* (Lund, Sweden)

TRANSPOSITION OF THE TRACTUS ILIO-TIBIALIS TO THE PATELLA IN THE LATE STAGE OF POLIOMYELITIS

by *Erik B. Riska* (Helsingfors)

Material:

The treatment of paralysis of the quadriceps muscle and some deformities of the lower limb in residual poliomyelitis is reviewed on the basis of 56 follow-up cases of transposition of the tractus ilio-tibialis to the patella. The patients were operated on from 1943–1959 in the Ortopaedic Hospital of the Invalid Foundation of Finland.

With regard to age at the onset of the disease, the largest group (23 cases) is made up of the youngest patients, betwen six months and 3 years old. The intervening time between the onset of disease and an operation was less than 4 years in about half of the cases. The period of observation had an average duration of about 7 years; it was 11–12 years in the largest group (19 cases) of patients subjected to follow-up examinations.

Indications for operation:

Indications for operation were: paralysis of the quadriceps muscle with consequent limping and loss of stability causing knee buckling and falling, or hand-to-knee walking; fixed deformities of the lower extremities following contracture of the tractus ilio-tibialis with its allied structures (probably the greatest deforming factor in lower limb involvement in residual poliomyelitis; genu valgum, knee-flexion deformity and external torsion of the tibia, flexion and abduction contractures of the hip). Some of the patients had been forced to make prolonged use of braces or crutches.

Treatment:

In 41 cases the tractus ilio-tibialis was detached laterally in its axial direction, and severed distally from its attachment to the lateral condyle of the tibia, after which the tractus was rotated 180° on its axis and fastened to the patella. In the other 15 cases the tractus was entirely detached, that is, laerally as well as ventrally in its axial direction and distally from its attachment. It was transposed in its plane and fastened to the patella (motion picture shown). After operation, the extremity was immobilized for 3–4 weeks with the knee-joint at maximum extension and the hip joint in slight flexion. In most cases physiotherapy was commenced prior to operation with the correction of fixed deformities, and one week after operation with exercises of the tensor muscle; training of the knee-joint and walking exercises followed after termination of the period of immobilization.

Results:

Dividing the results by the clinical symptoms, we noted increased extension force of the knee-joint in 40 cases out of 56 (71.4 %), with higher stability of the knee-joint in 43 cases (76.8 %). Completely corrected or reduced faulty position was recorded in 21 cases out of 30 (70.0 %); in 15 cases out of 22 (68.1 %) the patient was able to discard his braces or cruches. 11 patients were unchanged. In seven of these cases certain errors in operating technique were responsible for the failure. In two cases the indications had been misjudged, and in two cases some other disease was to blame.

There were no cases of impairment in the present series, *i.e.*, no patient was compelled to resort to braces or crutches on account of the operation. No faulty position of the knee-joint had resulted from the operation, and faulty position established preoperatively had not increased in any case.

Conclusion:

In consideration of the present results and of the previous reports which give rather high percentages of impaired cases (*e.g.*, recurvatum of the knee, lateral dislocation of the patella, lateral instability of the knee) in treatment of quadriceps pareses by transposition of the hamstrings, this transposition of the tractus iliotibialis to the patella and utilization of the m. tensor fasciae latae (which is mostly spared by the paralysis) is thought to be a suitable and justified method of operation in the treatment of quadriceps pareses and certain deformities of the lower extremities caused by contracture of the tractus ilio-tibialis subsequent to poliomyelitis.

(This paper will later be published in a complete form).

MEASURING MUSCLE STRENGTH AS AN AID TO JUDGING THE RESULT OF TENDON TRANSPOSITION

by *A. Möllerud* and *A. Bentzen* (Oslo)

In measuring muscle strength before and after tendon transposition the aim was to judge the result objectively and thus plantar and dorsal flexion power of the foot was measured following tendon transpositions around the ankle joint. Since the majority of tendon transpositions are performed on children who on follow-up should normally have grown and become stronger, it was necessary to secure a normal series for purposes of comparison. This normal series was obtained by measuring strength in schoolchildren aged 10–14 years. Thus quite a good correlation is gained between body weight and strength, especially plantar flexion strength. On comparing the objectively measured improvement in strength after tendon transposition and the clinical assessment of the result, it will be found that the latter on the whole gives rather too favourable a picture of the result.

DISCUSSION:

H. Støren (Stavern, Norway):

I should like to thank Dr. Haug for the conscientious investigation he has made into our series of muscle transpositions of the thigh flexors in poliomyelitis. I should like to put forward a few supplementary remarks. It must be clearly realised that the results are dependent on:

1. The strength and vitality of the flexor muscles which are transposed. It occurs very often that the muscles which are at the disposal of poliomyelitis are not fully sound. They carry the consequences of paresis.

If the results are recorded as a total percentage, as was done although with reservations by Dr. Haug and earlier by Schwartzman and others, then this says nothing about the series one has had to deal with—and does not give a correct opinion on the effectiveness of the operative procedure chosen.

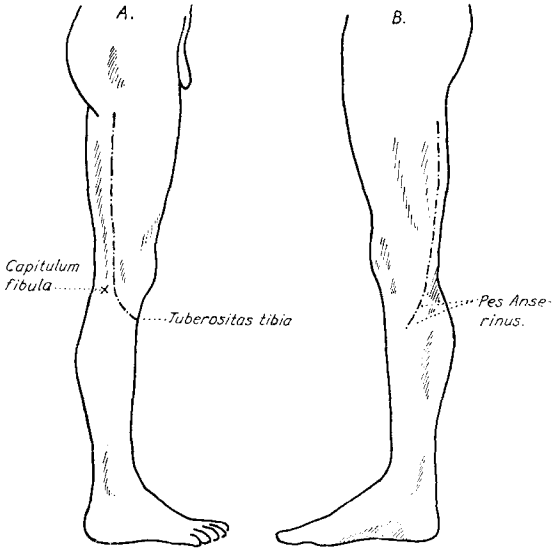


Fig. 1.

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.

The results must be recorded in groups in relation to the condition of the hamstrings employed.

2. The results are also dependent on the technique employed and the method of operation. The well known and obvious rules for muscle transpositions are:

1: that the innervation is not harmed.

2: that the muscles are given a correct course from origin to the fixation site.

3: that the fixation is trustworthy: intraossal during suitable tension.

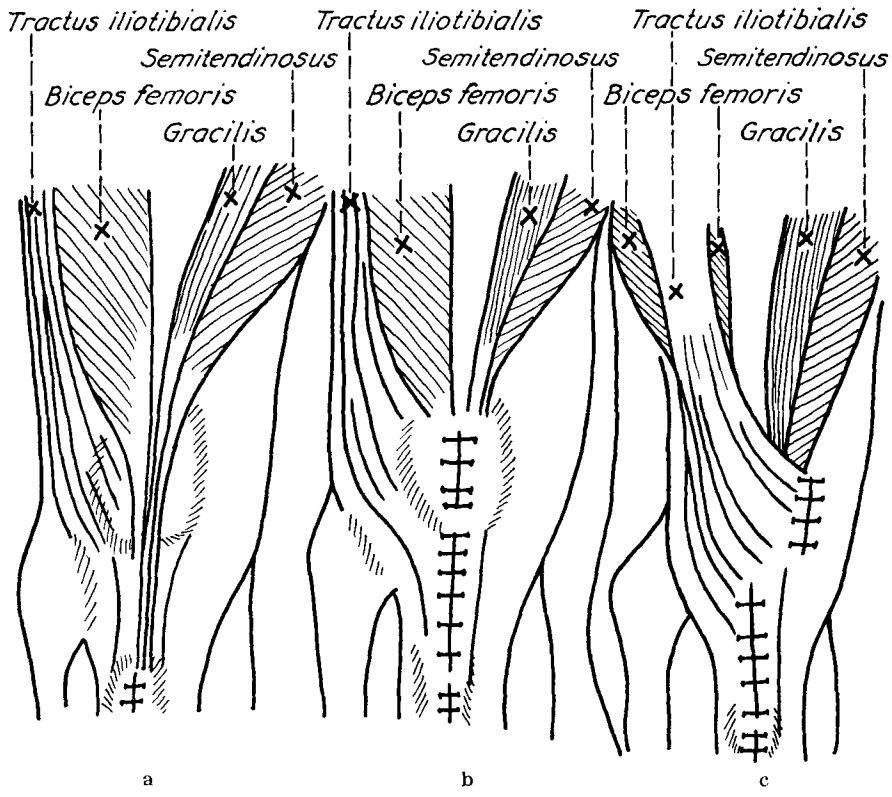
4: that the immobilisation is long enough. We take 8 weeks.

5: that there is muscle training of the hamstrings before and after transposition.

On operation I employ the 2 long incisions which are illustrated and which Bylow Hanssen used. These afford a good view of the muscles depressed and permit the fulfilment of the above-mentioned conditions better than any of the other incisions I know.

An important poin is that the lig. infrapatellare in poliomyelitis pareses is often slack and atrophic. The tendons of the medial thigh muscles must therefore also be secured to the tuberosity of the tibia as well as the patella—so that they are simultaneously embedded in the lig. infrapatellare. The biceps tendon is too short for this. It does not extend further than to the lower edge of the patella (fig. 2 a).

If the fascia lata is preserved—this is used so that the iliotibial tract is detached behind and rotated around its longitudinal axis and sutured above the remaining transposed muscles of the patella. It works then as a knee joint extensor and the operation works simultaneously against the poliomyelitic valgus position of the knee (fig. 2 a, b, c). Examples of this are to be seen in the material presented.



Figs. 2 a and b.

Fig. 2 a. Biceps embedded in the patella groove. Gracilis and semitendinosus in the patella, the infra-patellar lig., and tibial tub.—*Fig. 2 b.* Periosteum and the divided infrapatellar lig. sutured over.

Fig. 2 c.

Iliotibial tract turned 180° around its axis and sutured above the other muscle tendons.

S. Friberg (Stockholm):

Dr. Möllerud said that he had transplanted the tendon of the posterior tibial muscle in a number of cases. I presume that it was passed through the interosseous membrane in the cases under discussion.

At the Orthopaedic department of Karolinska Institut we have for many years been interested in the transplantation of tendons, and formerly we also transplanted the tendon of the posterior tibial muscle. For a couple of years in the beginning of the last decade one of my colleagues advocated transposition of the tendon of the posterior tibial muscle in pes equino-varus deformities. The results were not satisfactory. I have with time become more and more reluctant to transplant this tendon also for other indications. In contrast to a number of other foot tendons, it cannot

be transposed without considerable loss of strength and, as a rule, notable loss of stability of the foot.

O. Mogens Hansen (Copenhagen).

Erik Moberg (Gothenburg).

THE AXIS OF THE ANKLE JOINT AND ITS IMPORTANCE IN SUBTALAR ARTHRODESIS

by *Thomas Wyller* (Oslo)

The direction of the axis of the ankle joint is described somewhat variously in the literature but generally it is described as almost entirely transverse in relation to the sagittal plane of the normal foot.

Barnett, Napier and Hicks examined the axis of the ankle joint in greater detail. Barnett and Napier examined 152 cartilage-covered talus bones and found that the medial profile of the trochlea consists of an anterior arc with a small radius and a posterior arc with a large radius, while the lateral profile forms a single arc with a mean radius. (Fig. 1).

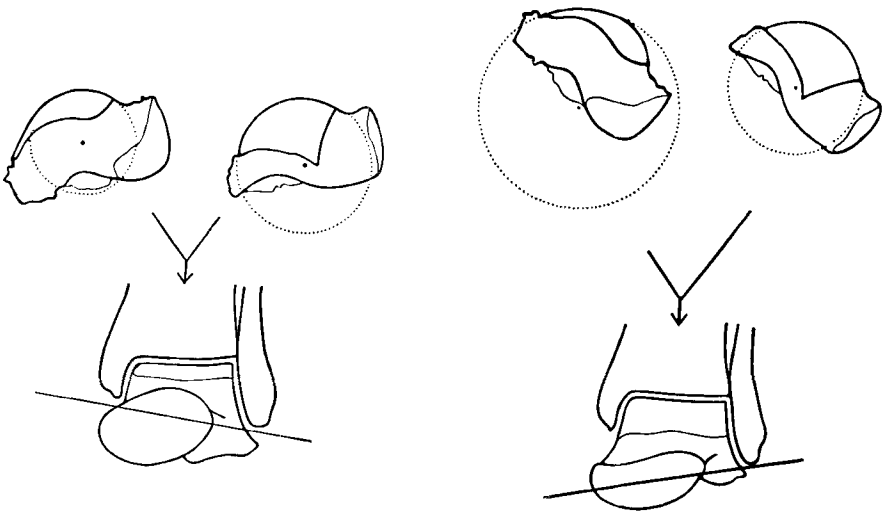


Fig. 1 A. *Fig. 1 B.*

Figs. 1 A and B.

The medial profile of the trochlea tali is composed of a ventral curve with a small radius and a dorsal curve with a large radius. The lateral profile consists of a single curve of medium sized radius. Movements of the foot dorsally for the O-position therefore occur about an axis that is higher medially than laterally (1 A), and plantar movements for assumption of the O-position occur about an axis that is lower medially than laterally (1 B). For clarity the lateral side of (the left) talus is given in mirror reflection (Barnett & Napier 1952. Reproduced from the Journal of Anatomy with kind permission of the editors and of the authors).

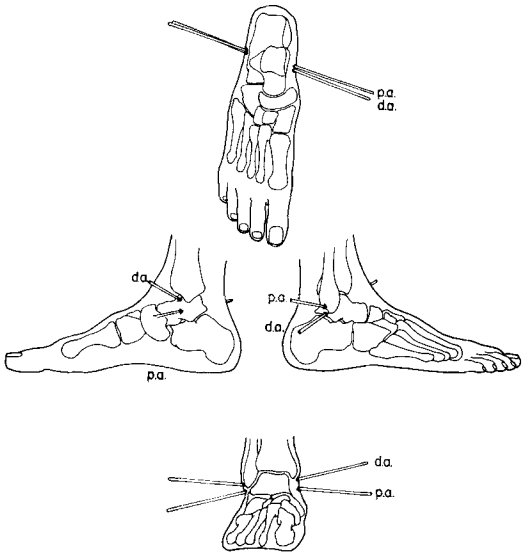


Fig. 2.
Axes of ankle joint. p.a. = axis of plantar movement for assumption of O-position. d.a. = axis of movement for dorsal movement for assumption of O-position. (Hicks 1953. Reproduced from the Journal of Anatomy with kind permission of the editors and the author).

In moving the foot dorsally to the O-position (both in the dorsal and plantar direction in this dorsal area of movement), it is the anterior part of the trochlea with the sharp medial arc which is in contact with the tibia. From this Barnett and Napier concluded that these movements must occur around an axis which is higher medially than laterally. Fig. 1 a. The reverse is the case with movements plantar of the O-position (both in the plantar and dorsal direction in this plantar area of movement): now it is the posterior part of the trochlea with the slack medial arc which is in contact with the tibia. These movements must therefore occur around an axis which is lower medially than laterally. Fig. 1 b.

The oblique position of both axes in relation to the horizontal plane varies amongst individuals.

The extent of the variation in breadth is not stated directly in Barnett and Napier's work, but from graphs it appears that the obliquity of the axis for the plantar area varied from 0° to 16°, and that the obliquity of the axis for the dorsal area in selected groups totalling 83 bones varied from 0° to 14°.

Hicks examined the movements in the ankle joint by means of 5 presumably normal preparations. The soft tissue of the preparations was preserved up to 4 cms above the ankle joint. The movements were produced by pulling on the tendons, both with and without weight-bearing by the foot.

Hicks also found 2 axes, one for the dorsal and another for the plantar area of movement. The axes had the same direction of inclination relative to the horizontal plane as Barnett and Napier had calculated. Moreover, Hicks found that both axes

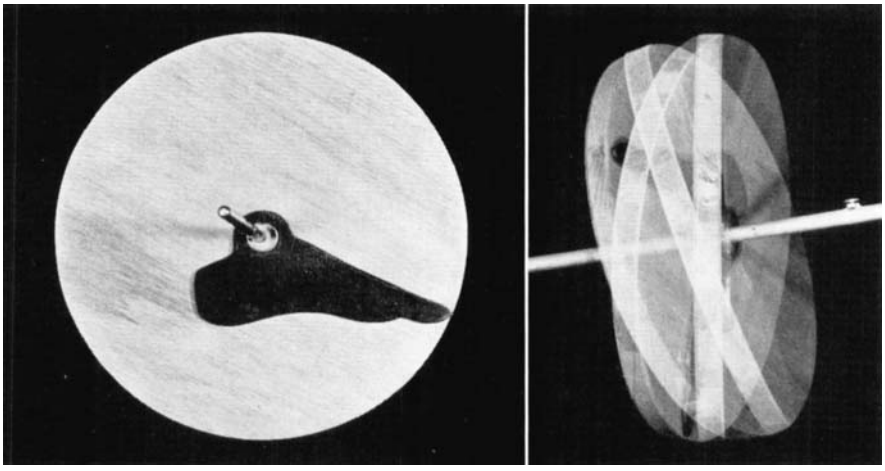


Fig. 3 A. *Fig. 3 B*

Figs. 3 A and B.
The sagittal plane of the foot may be regarded as a round disc with the ankle joint in the centre and the axis of the joint eccentric (3 A). On movement about its axis the disc will be thrown from one side to another like a poorly mounted wheel (3 B).

passed obliquely in relation to the frontal plane of the foot, since the medial end of both axes pointed somewhat ventrally. On Hicks' illustration (Fig. 2) I have measured the horizontal projection of the divergency of the axes from the frontal plane to 14° and 17°. (The frontal plane is thought to be at right angles to the longitudinal axis of the foot. On Fig. 2 the horizontal projection of the foot is shown in slight abduction, so the oblique position of the ankle axes appears larger still).

As clinical landmarks Hicks states that the axis of the dorsal area of movement passes from a point 1½ cms. in front of the tip of the medial malleolus to a point ½ cm. below the tip of the lateral malleolus, and that the axis of the plantar area passes from a point 1½ cms. in front of the tip of the medial malleolus and 1 cm. below it to a point ½ cm. above the tip of the lateral malleolus.

The fact that the ankle axis passes obliquely instead of at right angles to the sagittal plane of the foot means that the foot moves in the ankle joint like a badly mounted wheel. If we imagine the sagittal plane to be a round disc with the ankle joint as its centre and the ankle axis mounted obliquely the disc will wobble from side to side in its movements around the axis. Fig. 3. If we regard the tip of the foot we call this swerve abduction/adduction, if we regard the heel (represented by a cranio-caudal line of direction) we call this swerve valgus/varus. A model like that in Fig. 3 swerves regularly. The swerve of the foot becomes irregular because the ankle axis changes direction when the O-position is passed.

Normally the swerve of the ankle joint is compensated as required by opposing movements in the talo-tarsal joint, so that the swerve is difficult to detect. When subtalar arthrodesis has been performed, however, this compensation mechanism is repealed and the swerve comes to light. This means that the foot after performance

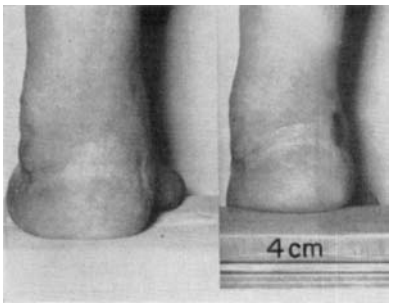


Fig. 4.
Man, aged 48. He had had poliomyelitis as a child and triple-arthrodesis as an adult. The slight support of 4 cms. under the heel made his gait so unsteady that he could not use this height of heel, which would have been desirable because of shortening of the leg.

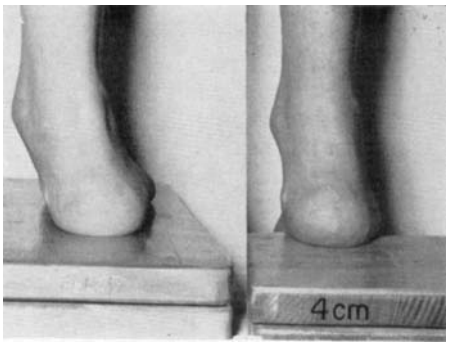


Fig. 5.
Girl, aged 12, poliomyelitis, arthrodesis a.m. Grice. The shortening of the leg made a 4 cms. heel desirable, so that the arthrodesis may be regarded as being in ideal position despite considerable valgus.

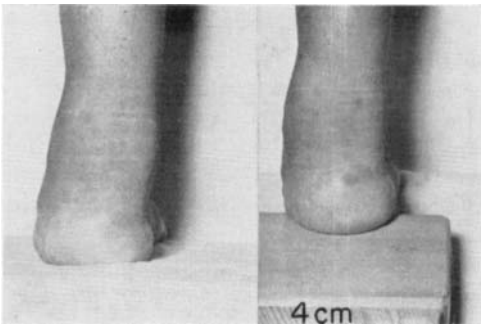
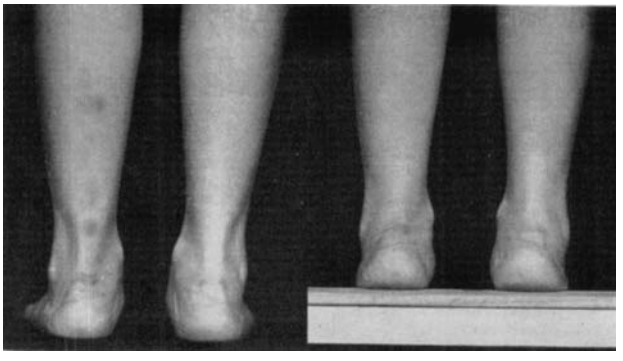


Fig. 6.
Girl, aged 13, poliomyelitis, arthrodesis a.m. Grice.

Fig. 7.
Girl, aged 10, bilateral idiopathic pes planovalgus, bilateral arthrodesis a.m. Grice.



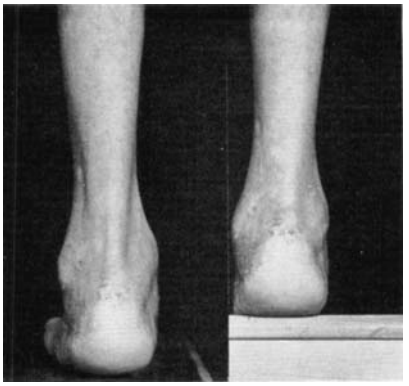


Fig. 8.
Man, aged 43, cavo-varus, triple-arthrodesis. No appreciable wobbling.

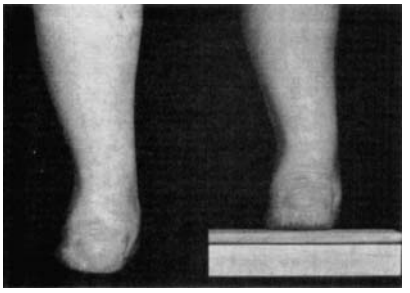


Fig. 9.
Woman, aged 48, calcaneus fracture, triple-arthrodesis.

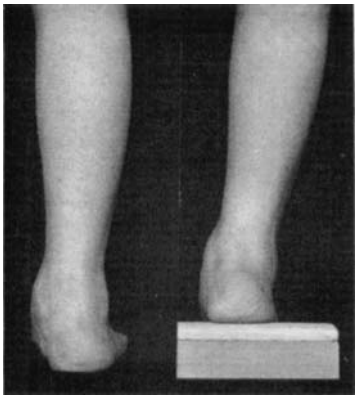


Fig. 10.
Boy, aged 11 years, pes valgus after division of tendon of anterior tibial muscle, arthrodesis a.m. Grice.

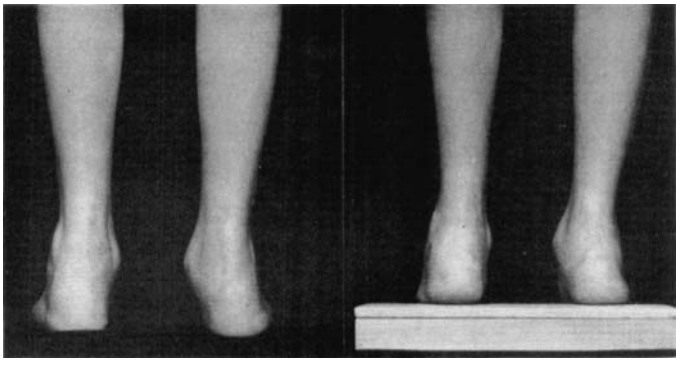


Fig. 11.
Girl, aged 13 years, Charcot-Marie Tooth's disease, bilateral arthrodesis.

of subtalar arthrodesis places itself in different degrees of varus or valgus according to the different degrees of height of the shoe's heel.

The extent of the swerve normally varies in breadth according to the individual. In a pathological series, which feet with subtalar arthrodesis certainly form, the variation must be assumed to be larger than normal. This must already be accepted for the reason that even if the axis passes normally in relation to the malleoli and the talus, then a malposition of the heel will produce and abnormal position between the axis and the median plane of the heel with a consequent abnormal swerve of the heel.

Figs. 4–11 show some examples of how 4 cms lift of the heel influences the valgus/varus position of the heel when subtalar arthrodesis is carried out. The individual variation is, as can be seen, considerable, from no swerve (Fig. 8) to considerable swerve in the varus direction (Fig. 5). None of the examples show swerve in the valgus direction nor can I remember seeing such a swerve at any time in plantar flexion. The swerve seems to be particularly prominent in patients who had polio as children. (Figs. 4, 5, 6).

Now it is the case that the varus position is endured much less easily than the valgus position, not least by polio patients.

The conclusion is therefore that in the adjustment of a subtalar arthrodesis on the operation table consideration must be given to the degree of plantar flexion which it is desirable for the patient to carry out but which yet excludes a varus position of the foot. In other words consideration must be given to the height of heel which the patient will require in his footwear after the operation, with a slight addition for walking down hills. The height of the heel may be determined by cosmetic wishes or by shortening of the extremity.

Allowance for the height of the heel is most simply achieved by undertaking the adjustment of the arthrodesis with the ankle joint in the pointed foot position which the desired heel height requires and not at right angles between leg and sole of foot.

With this procedure one does not need to know how large or small is the patient's swerve in the ankle joint. If the swerve is large the foot places itself in a deforming valgus position when walking barefoot (Fig. 5), but this must be said to be of minor importance in this connection. It is the price the patient must pay to walk comfortably and neatly with shoes on. If the swerve is small, the fact that the subtalar adjustment is undertaken with the ankle in the pointed foot position will not very much affect the position of the foot when walking barefoot. (Fig. 8). It may be accepted that this procedure is more reliable than, with the ankle at right angles, the haphazard adjustment of the arthrodesis to some degree of valgus position, in order to compensate for the unknown large swerve in the varus direction caused by the shoe heel.

Summary:

Barnett, Napier and Hicks showed that the axis of the ankle joint moves obliquely in relation to the sagittal plane of the foot. This means that the foot moves in the ankle joint like a poorly mounted wheel, it swerves from side to side. Normally the swerve is compensated for in the talotarsal joints, but when subtalar arthrodesis has been performed there is no compensation. The size and variability of the lateral swerve of the heel in a plantar flexion corresponding to a shoe heel of 4 cms is de-

monstrated. In all the cases demonstrated the heel swerves in the varus direction on such plantar flexion, if it does at all swerve.

Varus is endured less easily than valgus. The conclusion therefore is that in adjusting a subtalar arthrodesis on the operating table consideration must be given to the height of the heel the patient is to use (e.g. owing to shortening of the extremity). This is done by adjusting the subtalar arthrodesis with the ankle joint in the pointed foot position which the height of the heel requires, and not at right angles between leg and sole of foot.

DISCUSSION:

S. v. Rosen (Malmö, Sweden).

A NEW METHOD FOR ASSESSMENT OF THE STATIC AND DYNAMIC WEIGHT-BEARING OF THE FOOT (Preliminary report)

by *H. Wetzenstein* (Stockholm)

A new method has been developed for recording the dynamic and static weight-bearing of the foot in a shoe. The vertical component of the load is measured in the heel region. For this purpose a stiff spring-balance is used in which the deflection is registered by strain-gauges.

The resolution of the weight-bearing load which corresponds to the point of action of the load on the weight-bearing surface, migrates over this surface in a characteristic way during the weight-bearing phase of a step. Whether this migration is sufficiently significant to allow a demarcation of different weight-bearing types will be investigated in the continuing work.

It is also possible to make similar measurements even under the fore part of the foot's weight-bearing surface.

The purpose is to get a technically simple measuring apparatus for objective registration of the foot's weight-bearing on standing and walking in shoes.

HAS EPIPHYSEODESIS IN ONE END OF A LONG BONE A GROWTH-STIMULATING EFFECT ON THE OTHER END?

by *Henrik V. A. Heikel* (Björneborg, Finland)

Epiphyseodesis according to Phemister was performed on the proximal end of the right tibia in 9–22 day old rabbits. The growth was observed by means of repeated radiological checks and compared with the left tibia. Five rabbits could be observed during the entire period of growth. No or only insignificant stimulation of growth in the distal end of the right tibia could be observed.

DISCUSSION:

Göran Bauer (Malmö, Sweden), *G. Wiberg* (Lund, Sweden).

CARDIOPULMONARY FUNCTION STUDIES IN PATIENTS WITH SCOLIOSIS

(Preliminary report)

by *M. Foss Hauge* (Oslo)

At the Sophies Minde Orthopaedic Hospital a systematic study of cardiopulmonary function has been commenced amongst the patients on whom it is intended to operate for scoliosis. The tests are being carried out at the University Institute for Respiratory Physiology. The studies undertaken are: determination of vital capacity, maximal breathing capacity, CO_2-recovery time after a standardized exercise on a bicycle ergometer and the increase in pulmonary ventilation consequent to this test. All the studies were performed with Erikson-Scholander's apparatus.

32 have so far been examined pre-operatively. Cardio-pulmonary function varies strongly amongst these patients, but is generally very poor. 14 patients had a function of about ½ the normal, 2 had, moreover, an increase in pulmonary ventilation indicating the probable commencement of heart failure.

8 patients out of the 32 were examined post-operatively 9 months after osteofixation of the column (very often 14–15 vertebrae were fixed). In 3 of these cardiopulmonary function was improved, in 3 it was unchanged and in 2 of them it was diminished, but the difference in function before and after the operation was strikingly small in all patients. Amongst those operated on, however, the tests were undertaken immediately after they had been wearing an immobilising plaster corset for 9 months and their thorax had then scarcely regained its potential elasticity.

The research will be continued in the years ahead, and it is supposed that a representative series will be reviewed within a relatively short time.

DISCUSSION:

A. Langenskiöld (Helsingfors), *S. v. Rosen* (Malmö, Sweden).

ON DETERMINATION OF THE ANGLE OF ANTIVERSION OF THE FEMORAL NECK

by *Folke Tidström* (Linköping, Sweden)

DISCUSSION:

M. Foss Hauge (Oslo).

ON THE TREATMENT OF SEVERE CASES OF EPIPHYSEOLYSIS CAPITIS FEMORIS

by *Istvan Adorjan* (Copenhagen)

A survey is made of wedge osteotomies performed at O.H.K.I. dept., as a treatment for pronounced slipping of the upper femoral epiphysis, in order to contribute towards elucidating the problem of whether this method will be justified in the future, in spite of the increasing number of reports of poor results owing to necrosis of the epiphysis or joint cartilage.

Out of 18 wedge osteotomies over a 6 year period one third had excellent results

(6), one sixth were poor (3) and half of them were good (5) or fair (4). Total necrosis was not observed in this series. The partial necroses healed and were recorded as fairly good. Among the poor results was one case in which a pseudarthrosis arose, and 2 were due to necrosis of the joint cartilage.

It is emphasised that caput necrosis and necrosis of the joint cartilage may also arise in the spontaneous course of the disease.

Since no other treatment gives such perfect results as were found in the good group of wedge osteotomies, this method ought not to be abandoned summarily, according to our experience.

DISCUSSION:

T. Jerre (Västerås, Sweden), *N. Lindström* (Härnösand, Sweden).

BONE-BRIDGE FORMATION BETWEEN THE GREATER TROCHANTER AND THE FEMORAL HEAD—A NORMAL VARIATION OF THE PATTERN OF THE OSSIFICATION IN THE UPPER END OF THE FEMUR IN ADOLESCENSE

by *Poul Lütken* (Aalborg, Denmark)

The process of ossification of the upper end of the femur shows a peculiar pattern in a fairly large group of mammals. In this group, the ossification centres of the great trochanter and the caput femuris invade the upper ridge of the collum femoris from either side until they fuse, forming a bony bridge joining the great trochanter and the caput femoris together into a common epiphysis, while the proximal epiphyseal line towards the diaphysis remains open some months or years, to the end of the growth period.

This is illustrated by Fig. 1. The picture shows the upper end of the femur of a young elephant. The bony bridge between the great trochanter and the femoral head is seen clearly.

In earlier publications (thesis for the doctorate 1947, and a communication given at the International Anatomical Congress at Oxford 1950) I have described the development of the cartilage skeleton in vertebrates with special reference to the morphogenesis of skeletal epiphyses.

My investigations showed that the distribution of certain well-defined surface types in the cartilage skeleton fundamentally identical in mammals and man, also as regards the femur.

Fig. 2 shows a picture of a cardboard reconstruction of the right femur of a 25 mm. human foetus. The upper end is seen from the side of the great trochanter, with the femoral head behind. The upper ridge of the collum is seen. The border-line between the surface-types is marked, and it is seen that the great trochanter, the upper part of the collum, and the femoral head are in a common area.

From this finding I deduced that, also in man, the formation of a bony bridge along the upper ridge of the collum was to be expected as a variation of the process of ossification.

I was fortunate in finding such a femur in a collection of skeletons found in a medieval grave-yard in Jutland, used in the thirteenth to the sixteenth centuries and excavated in 1915 and the following years.

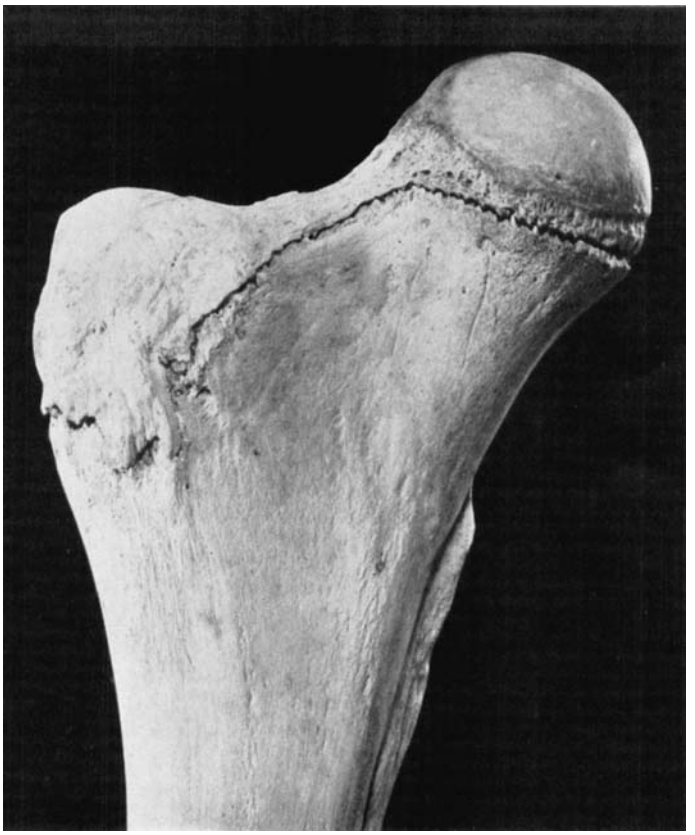


Fig. 1.

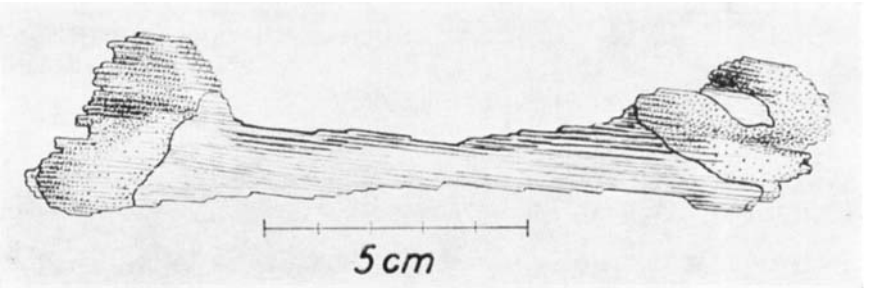


Fig. 2.

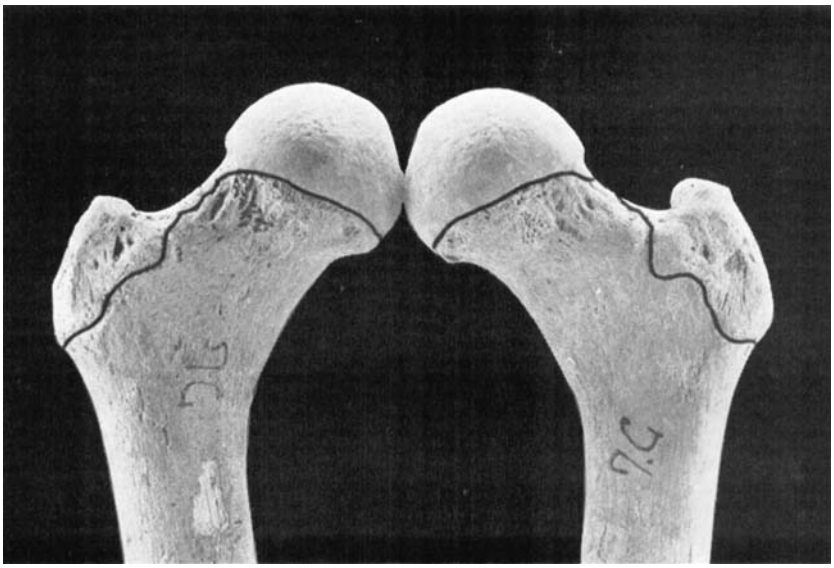


Fig. 3.

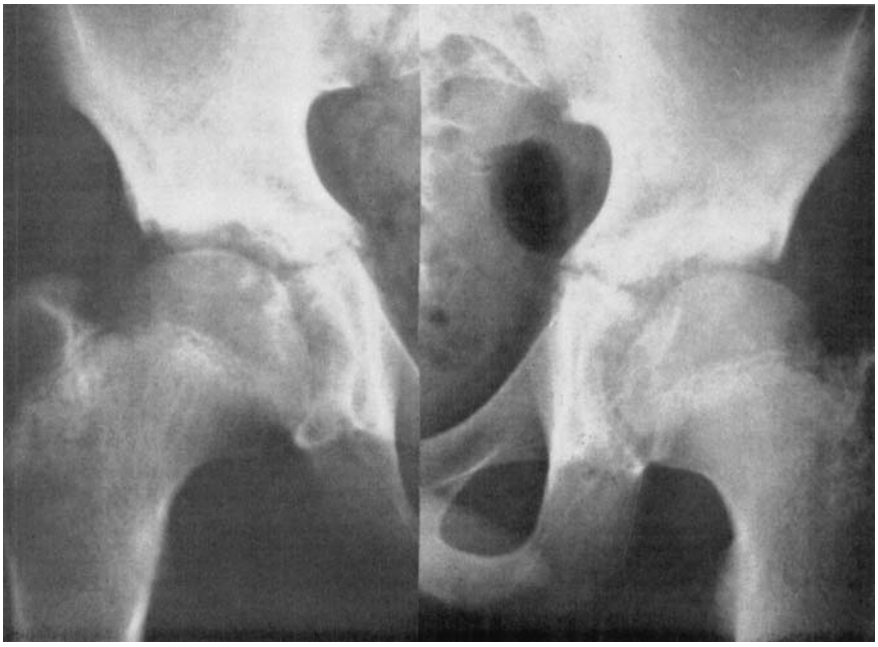


Fig. 4.

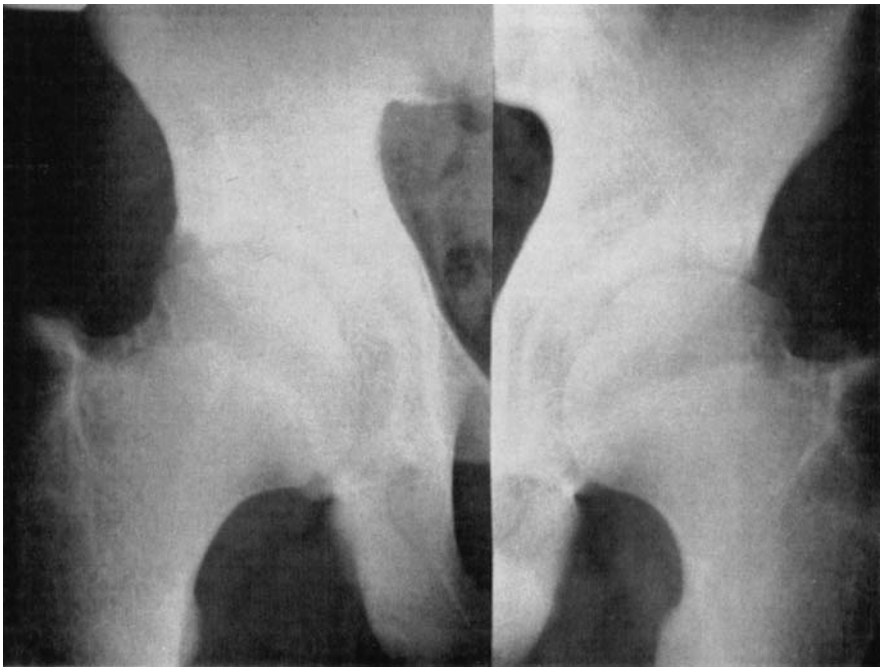


Fig. 5.

In Fig. 3 are seen the upper ends of both femurs of a young human individual. On the right femur, there is a narrow, but distinct bony bridge between the great trochanter and the femoral head, while on the left side no such bridge formation is found.

After these findings, the question of how rare this variation is, remained open—and whether it was possible to find it in X-rays.

In the last 10 years I have actually seen 3 cases of this bony bridge in X-rays of children from 11 to 13 years old.

Fig. 4 is an X-ray of a twelve-and-a-half-year-old boy. The bony bridge appears on the left side. Two years later (Fig. 5), the epiphyseal lines are nearly closed, but the bony bridge is now seen on both sides.

The next figure, number 6, is from a girl eleven-and-a-half years old, treated for congenital luxation of both hips and checked regularly since the reposition was done. The bony bridge is found on the left side. You see slight subluxation and coxa valga on both sides. Previous X-rays not shown of the same case showed no bony bridge.

In Fig. 7, the bony bridge is seen on the right side. This is from a girl eleven and a half years old, treated for congenital luxation of the right side and followed up since the reposition.

It is my opinion that the results of my research here presented show that the formation of a bony bridge between the great trochanter and the femoral head

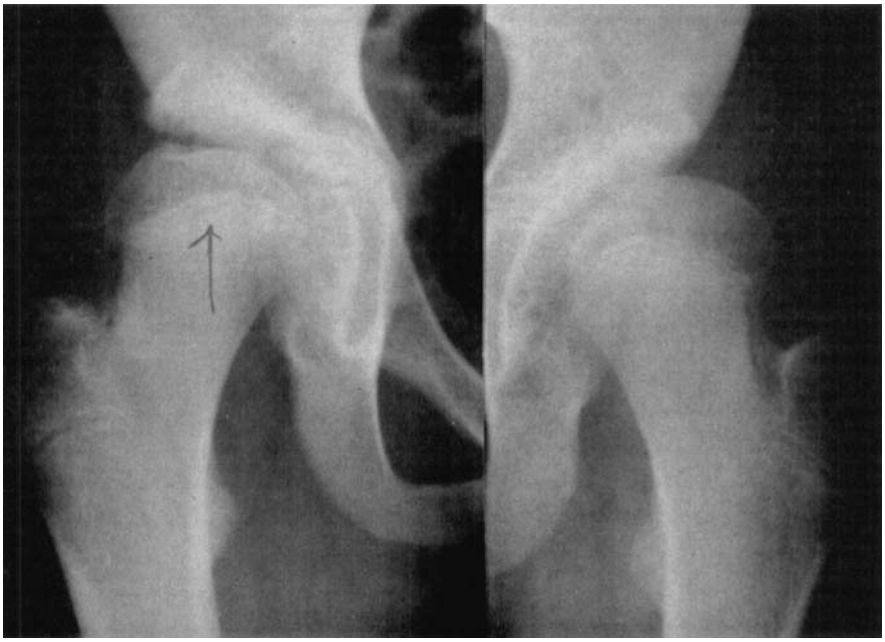


Fig. 6.

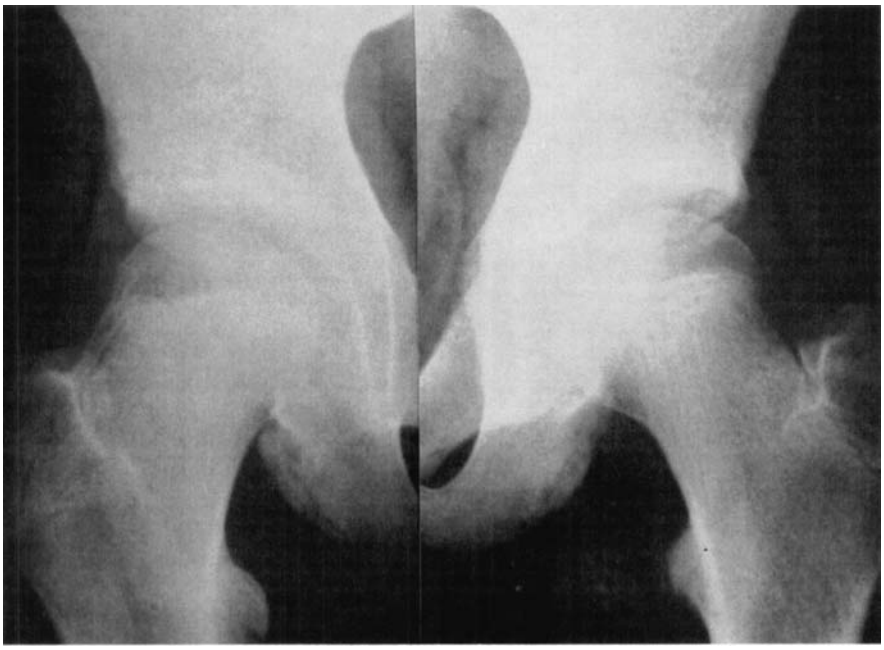


Fig. 7.

along the upper ridge of the collum is not the result of any pathological process, but a normal variation of the process of ossification.

These findings seem important in that they contribute to our understanding of the normal development of the upper end of the femur, and may influence our interpretation of pathological phenomena in this region.

INTERTROCHANTERIC OSTEOTOMY IN ARTHROSIS DEFORMANS COXAE

by *Lars Unander-Scharin* (Härnösand, Sweden)

Since 1955 in the orthopaedic clinic of Härnösand intertrochanteric osteotomy has been adapted to arthrosis deformans coxae. We began first with the method described by McMurray, i.e., osteotomy alone and plaster fixation for 3 months. 7 such operations were performed. We made the same observations as many others, namely, that after this type of osteotomy the mobility of the hip joint was considerably diminished and in addition the possibility of movement in the hip joint was hazarded. Treatment was very lengthy. The result was best compared with a less successful arthrodesis. Starting from this point therefore we changed to inner fixation of the osteotomy. First of all the plate introduced by London surgeon Kessel was employed and this was inserted into the trochanter region and then attached by screws to the femoral shaft, (Fig. 1). 20 cases were operated on: 10 men and 10 women. The average age at operation was 50–70 years. 11 patients had arthrosis in one hip joint and 9 in both. Out of these 9 with bilateral hip joint arthrosis 3 had trouble in one hip only and 6 in both. All were followed-up and the observation period was 1½–3 years. The results can be seen in Table 1.

TABLE 1

Cases operated on according to Kessel.

Subj.		*Complications*	
Free of pain	9	Pseudarthrosis (4 reop.)	8
Improved	7	Thrombosis	2
Unchanged	4		
	20		

Objectively it was found that mobility which primarily was between 60 and 90 degrees on the whole, remained unchanged and was almost normal. As Table 1 shows, 8 pseudarthroses were present from the osteotomy. None of these patients had fixation in plaster but were kept in bed for 6 weeks and afterwards allowed to put weight on the operated leg. After consideration of the high frequency of pseudarhtrosis another method of fixation was adopted, i.e., that described by McKee and Nissen (Fig. 2).

33 patients were operated on, 2 bilaterally. At the time of operation the patients were aged 50–70 years. The etiology of the arthrosis changes was in 3 cases subluxation, 3 trauma, 1 epiphysiolysis and 1 chondromatosis. 22 were unilateral cases and 11 bilateral. Previous operations were collum nailing in 1 case, curettage 1, subtrochanteric osteotomy 1, capsulectomy 1. 31 were followed-up. The observation period was 1–3 years. The results are shown in Table 2.

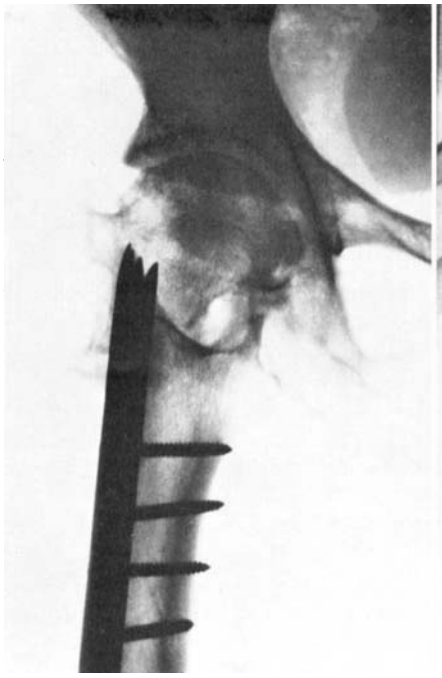


Fig. 1.

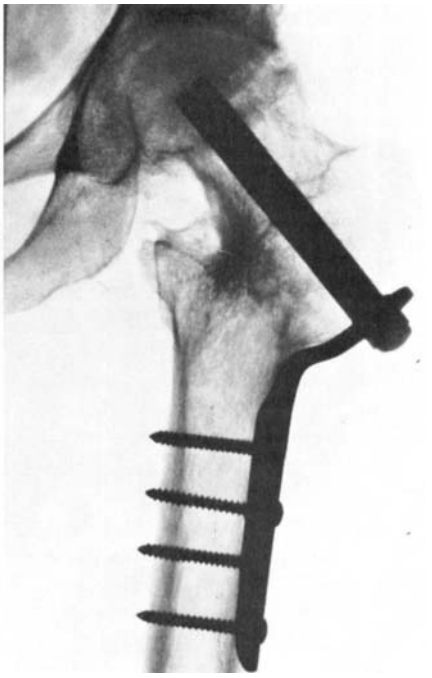


Fig. 2.

TABLE 2

Cases operated on according to McKee–Nissen.

Subj.		*Complications*	
Free of pain	21	Pseudarthrosis	5
Improved	3	Thrombosis	6
Unchanged	7	Subtrochanteric fracture	1
	31	Post-op. pneumonia	1

In this material also we could determine that the mobility of the hip joint had by and large been maintained, but yet was less in 10 cases, in one of which the mobility was only 10 degrees. This case was then operated on for arthrodesis. All pseudarthroses were re-operated on and healed.

Conclusions:

1. Intertrochanteric osteotomy with inner fixation gives freedom from pain, relatively unchanged mobility and stability to a high degree in coxarthrosis. How lasting the effect is cannot be judged from this material. Other published studies indicate that one can be quite optimistic on this point.

2. By means of inner fixation the patient avoids plaster and bed rest need not extend beyond 6 weeks, possibly this period can be reduced.

3. One may speak of a conservative effect on the hip joint in that the arthrosis process is arrested. Certain authors argue that regression occurs. One cannot go so far as this judging only from the present material.

4. In selection of patients those should be considered in whom the process has not advanced too far and where large destruction of bone substance has not occurred. Instead one should choose cases with early arthrosis and well preserved mobility.

FOURTEEN YEARS' EXPERIENCE WITH SMITH-PETERSEN'S ARTHROPLASTY

by *C. Semb, A. Jakobsen* and *H. K. Dahl* (Oslo)

In Ullevål hospital, dept. III, vitallium cup arthroplasty have formed the sole method since 1946 of treatment of hip joint arthroses. Adjusting the method to a certain extent we have also used it in residual conditions following arthritis, aseptic necrosis and pseudarthrosis, and lastly also in unsuccessful alloplasties. Up to May 1st, 1960, we have operated on a total of 650 hips according to the Smith-Petersen method, 437 in Ullevål hospital and 213 amongst professor Semb's private patients. The first 301 hips operated on were studied earlier and reviewed in A. Jakobsen's publication: "Vitallium mould arthroplasty".

We have all the time kept to firm indications for operation,—the patients must be in considerable distress, and we have attached special importance to the symptom complex pain, reduced mobility and instability. As we gradually accumulated experience, certain changes were made in operative technique. The following details are to be emphasised.

The capsule must be radically extirpated. The resection of the caput ought not to be too radical. If it is too radical, a short neck is the result, giving instability. Devitalised bone which must be removed is replaced by the transplantation of cancellous bone. Thus one avoids reducing the level of the caput. If the caput is necrotic and must be sacrificed, the trochanter must be transplanted to obtain a longer neck and better stability. We have abandoned resection of the whole or parts of the trochanter major.

In dislocations and dysplasias the acetabulum should be placed at the correct height, where the acetabulum is shallow it must be chiselled out radically; sufficient of the rear and lower edge must be removed and a smooth and oblique finish below the acetabulum should be aimed at. If one does not take sufficient from the rear lower edge, extension is not achieved. Use as large a cup as possible, this gives better mobility, the cup must rotate freely in relation to the caput and in relation to the acetabulum. In individual cases some form of shelf operation (acetabular roof plastics) will be necessary from the standpoint of stability. Raw bone surfaces on the collum and acetabular edge are covered with beeswax to prevent new bone formation. There should be postoperative prophylactic anticoagulation treatment from the 4th to the 5th day. Physiotherapy will be given postoperatively along the lines drawn up by Professor Smith-Petersen. Do not allow weight-bearing on the operated extremity for six months after the operation, preferably 1 year in cases of aseptic necrosis.

The first 301 hips operated on were re-examined in 1954, and since January 1st, 1960, the same series has again been examined. The minimum observation period for these patients is now 9 years, and the longest period of observation is 14 years, with an average observation period of 11.4 years.

During the observation period, apart from the one postoperative death, in all 33 patients passed away, but 3 of these were included in the last examination, when we were able to asses their condition before they died. Thus, 220 patients were available for follow-up, with a total of 268 operated hips. Up to the present, personally or by questionnaire and by X-ray of a new date, 182 patients with 221 operated hips have been followed-up.

The clinical results are assessed according to the same principle as was used in Arnt Jakobsen's publication.

The results of the series appear in the table below.

Our conclusion from the follow-up is that the patients who had a good result primarily maintain this, and our observation period is now so long that we believe we can say that the results are lasting. We therefore consider that there is every justification in continuing to use the same method, since in our hands it has produced such good results even in the long view.

TABLE

Operated	301 hips (250 patients)	
Followed-up 1960	221 hips (182 patients)	
Died postoperatively	1 patient (1)	
Died during observation time	33 patients (36)	
Mean observation time	11.4 years	
Clinical results:	1954	1960
Excellent	54	52
Good	89	86
Fair	52	57
Poor	26	26

DISCUSSION:

C. Hirsch (Upsala, Sweden), *C. Semb* (Oslo).

G. Wiberg (Lund, Sweden):

There is every reason to congratulate professor Semb on the excellent results which with his great experience he has achieved in cup plastics. It deserves to be pointed out, however, that in the treatment of arthrosis deformans of the hip joint other operative interventions may also be justified and that there are grounds for varying the operative type sometimes. Above all I would once again emphasise that arthrodesis for various younger patients who make great demands on their standing and walking capacity may be preferred to an arthroplasty.

PATHOLOGICAL FRACTURE OF THE FEMORAL NECK IN CHILDREN, A COMPLICATION OF HAEMATOGENOUS OSTEOMYELITIS

by *A. Doder* and *V. Psorn* (Serajevo, Jugoslavia)

The disease of acute haematogenous osteomyelitis is characterised in most European countries by a diminishing incidence and at the same time by less grave manifestations of the disease.

This is also happening i Jugoslavia.

It may well be attributed to both the general improvement in living standards and to the special medicinal advances based on the manufacture of a steadily increasing number of antibiotics.

But the change described in the incidence of the disease and its clinical features is certainly also a result of the increasing interest of recent decades in the special pathology of childhood. Nonetheless acute osteomyelitis in children is still a grave reality home in Jugoslavia, with the following etiologic and pathogenetic background: insufficient food and lack of personal hygiene is relatively common even in our days, especially in the country districts.

For these reasons skin abscesses and other pyogenous inflammations are general here.

We regard such localised inflammations—combined with repeated slight trauma—as the most important causes.

Infected scratches in children—who like to walk barelegged when it is warm—represent the typical focus of haematogenous osteomyelitis.

In spite of the favourable course and the improved prognosis one must continue to expect to meet a number of complications in acute osteomyelitis.

To these belongs the pathological fracture of the neck of the femur: it is true that it is rare but nevertheless it is important because it has such serious consequences.

During the last 5 year period, 1955 to 1960, 62 patients in the age group under 14 years were treated for acute haematogenous osteomyelitis of the femur at Sarajevo, in the surgical clinic.

According to the localisation of the inflammation one can divide the patients into the following groups—illustrated in Table 1.

TABLE 1

Proximal part of femur	36
Middle part of femur	17
Distal part of femur	9
All	62

36 children with osteomyelitis in the upper third of femur.

17 children with osteomyelitis in the middle third of femur.

9 children with osteomyelitis in the lower third of femur.

The incidence of disease in the two sexes and in the different age groups appears in Table 2.

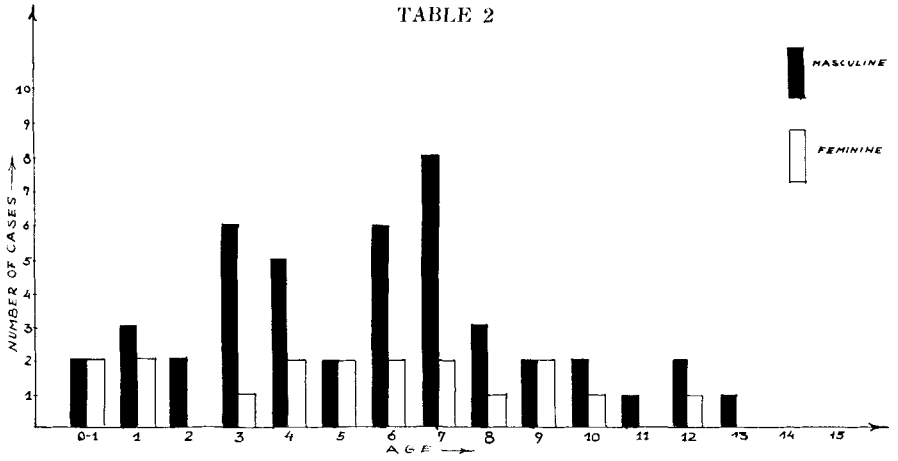
The figures show that the majority of the cases appear in boys in the age grup 3–7 years, which is not surprising, because these are most exposed to trauma and incur most frequently small infected wounds.

Of the 36 patients who had osteomyelitis in the upper end of the femur, 14—i.e., a good third of the cases— were found to have purulent joint affection.

In 8 cases the inflammation involved after a short time destruction of the neck of the femur culminating in fracture, i.e., in 22½ % of the patients in whom osteomyelitis was found localised to the proximal third of the femur.

The majority of these 8 patients, i.e., 5, represents advanced and partially neglected cases which had incurred their fractures before admission into hospital.

TABLE 2



In the three other cases the destructive process had not progressed so far and here more moderate degrees of dislocation were present.

Treatment was in all cases conservative in the acute stage; this included large dosages of antibiotics, immobilising plaster or zinc paste traction and suitable hygienic-dietietic regime to improve the general condition combined with the necessary relieving incisions.

The treatment results proved to be good in the three cases in which the therapy could be commenced at an early stage.

Then one could prevent the malformation and restrict the inflammatory changes before any irreparable bone destruction had occurred.

Thus fracture consolidation was achieved in a good position as will now be illustrated by X-ray pictures and photographs of one of these three patients: Photo 1 and X-ray Series 1.

In the other group of pathological fractures, comprising the 5 advanced cases, there are 3 patients who stand out because their results in spite of everything are satisfactory from the functional point of view. But a certain deformity could not be avoided in these cases.

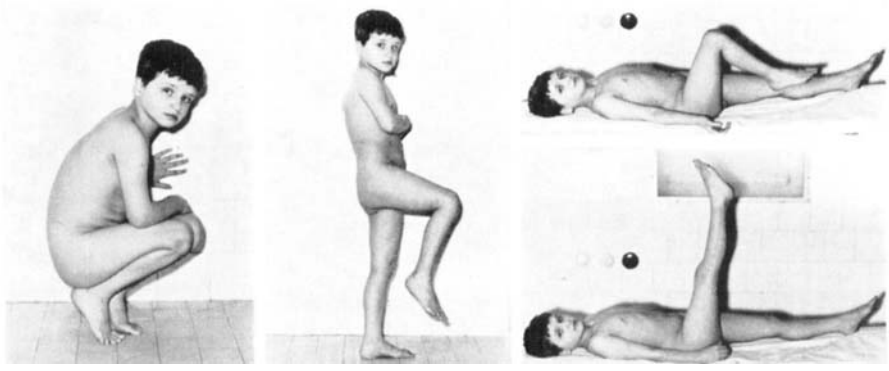


Photo 1.

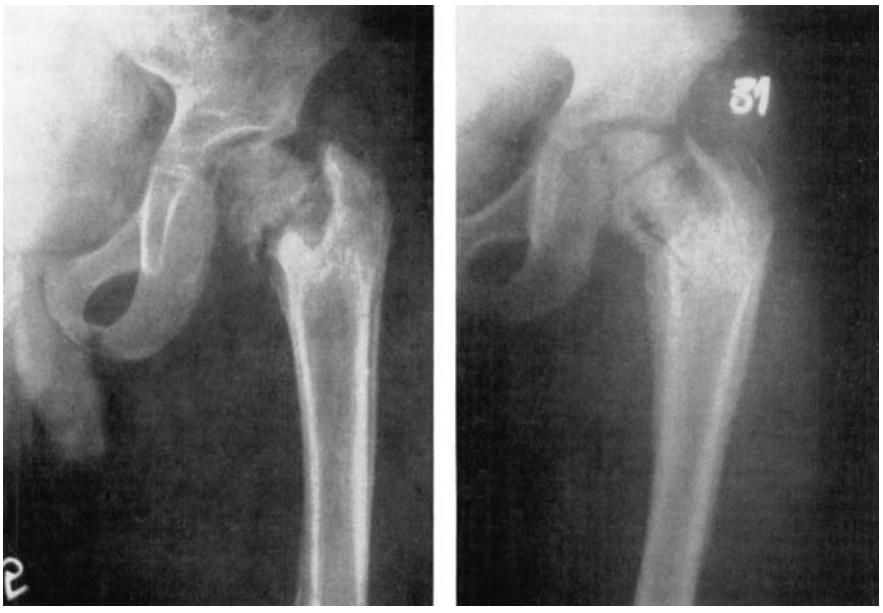
a.

b.

c.

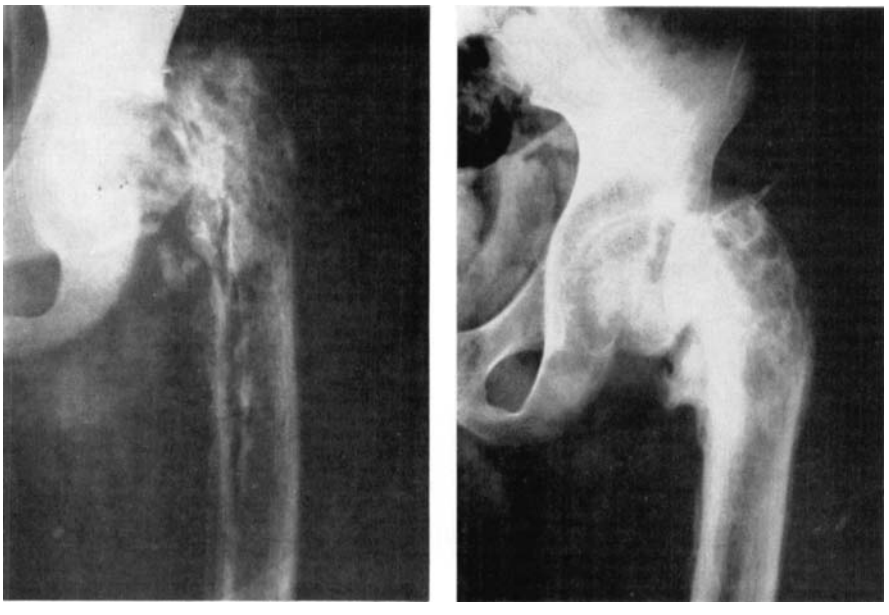
d.

X-ray series 1.



a. b.

X-ray series 2.



a. b.

X-ray series 3.

These X-ray pictures are representative of this group: X-ray series 2.

Finally the two remaining fractures will be discussed separately.

These had arisen owing to widespread bone destruction and are characterised by considerable dislocation.

The first case concerns a boy aged 13 who arrived in a poor general condition and with unusually severe local symptoms, at the following X-ray series shows: X-ray series 3.

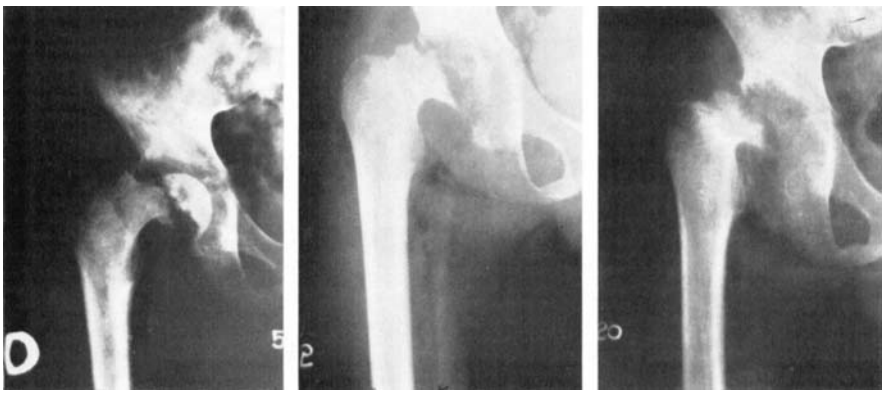
TABLE 3

1	Fracture with no dislocation	None	Good	Consolidation
2	Destruction of collum. Disloc.	None	Good	Consolidation
3	Marked destr. of collum. Slight disloc.	Incision	Good	Consolidation
4	Destruction of collum. Necrosis of caput. Disloc.	Incision	Fair	Consolidation
5	Destruction of collum. Disloc.	Incision	Fair	Sclerosis of coll. Consolidation
6	Destruction of collum. Disloc.	None		Consolidation in varus position
7	Widespread destr. Dislocation	Incision	Fair	Sclerosis. Consolidation in varus position
8	Destruction of collum. Necrosis of caput. Dislocation	Incision	Bad	Complete resorption of head, unstable hip joint

The pictures taken after 6 months treatment reveal that this pathological fracture has also consolidated,—although with obvious deformation of the hip joint and upper femur end,—with decisive reduction of function.

The last case represents the gravest picture of disease amongst our pathological fractures.

A boy aged 6 was only admitted after a history of 4 weeks, so that the osteomye-



a. b. c.

X-ray series 4.

litis had not been diagnosed and not been treated during the whole of that period. In spite of immobilising traction treatment and suitable antibiotic therapy the end result was complete collum resorption and destruction of the caput femoris, —as we now see from these X-ray pictures: X-ray series 4.

Table 3 comprises the results of treatment in the 8 cases of pathological fracture which makes up our series.

Discussion.

Our series comprises a relatively large number of cases of acute osteomyelitis in the upper end of femur, and should therefore present a representative picture of the collum neck fracture's incidence in this condition.

One may then say according to our investigations that where haematogenous osteomyelitis in children has first attacked the proximal third of the femur, there is every reason to be on guard against a development leading to pathological fracture of the collum neck.

The series shows indeed that this complication occurs frequently when one considers its incidence in relation to patient group which forms the basis of assessment.

Moreover, it is obvious that the pathological fracture of the neck of the femur arises with a higher incidence and in its gravest form in children who have received insufficient treatment.

On the other hand it appears that this complication can be avoided as a rule by early and suitable treatment—and where fracture cannot be avoided, that in any case functionally satisfactory end results can be secured.

In other words the task of our treatment is primarily prophylactic in nature by means of early diagnosis of the acute osteomyelitis in children. Furthermore immediate hospitalisation is required bearing in mind suitable antibiotic therapy combined with energetic efforts to improve the general condition. In this connection we would mention that we believe we derive great benefit from the bacteriological resistance condition as a basis for choosing the antibiotics.

In addition we have placed much weight on strengthening the child's ability to resist the disease through blood transfusions alongside the normal hygienic-dietetic rules.

If in spite of the treatment regime a pathological fracture of the collum neck occurs, then it has turned out that with strict supervision during traction treatment we can still prevent the gravest consequences of the above complication by avoiding complete destruction of the collum and caput.

With neglected cases, however, one cannot guard against the loss of the joint-nourishing part of the upper femur end, which involves lasting invalidisation of these small patients. Infirmity can only be partly offset by means of secondary surgical interventions like arthrodesis or arthroplasty or corrective osteotomies.

This operative treatment is not undertaken naturally until all acute signs of inflammation have disappeared, and the patient is fully recovered as far as the general health is concerned.

Then we usually send all children who are to undergo the above surgical treatment to the convalescence home on the Adriatic coast which is known for its mild and sunny climate.

In the acute stage we must give way to surgical treatment in the form of incision and drainage where it seems necessary.

We have not found any grounds for adopting such relieving osteotomy as normal treatment,—on the contrary it is only used in exceptional cases.

In addition it is natural to discuss undertaking puncture and evacuation of the hip joint where pyarthrosis is present,—possibly combined with intra-articular antibiotics.

Finally there is the question whether traction treatment should not be carried out as the normal method for every osteomyelitis which affects the joint, even in early cases, both to relieve subjective trouble and to prevent further traumatisation of the necrosis-threatened cartilage.

DISCUSSION:

G. Wiberg (Lund, Sweden), *C. Semb* (Oslo) and *H. Holmdahl* (Boden, Sweden).

ON THE UPTAKE OF RADIOACTIVE CALCIUM AND STRONTIUM IN THE SKELETON OF RATS

by *Hans Bohr* (Copenhagen)

THE BONEMETHABOLISM IN TIBIAL FRACTURES IN MEN

by *Bo Wendeberg* (Malmö, Sweden)

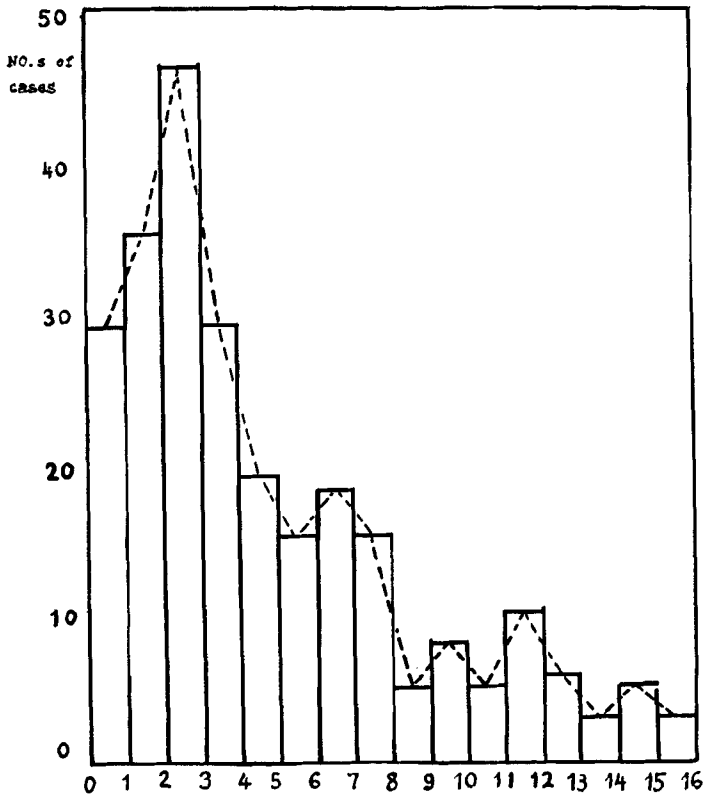
ON INEQUALITY IN LENGTH BETWEEN LOWER LIMBS AFTER POLIOMYELITIS WITH UNILATERAL INVOLVEMENT AQUIRED DURING THE GROWTH PERIOD

by *Ralf Lindholm* (Helsingfors)

Inequalitiy in length between the lower extremities is caused by various disease conditions (congenital malformation, infection, tumours and trauma). By retardation of the growth period poliomyelitis is the commonest cause of inequality in length of lower limbs. The specific origin of the growth disturbance in poliomyelitis is still unknown. The problem of therapy is likewise an incomplete chapter in orthopaedics. Skeletal operations, such as epiphyseodesis on the longer extremity, and which aim at correction of the inequality, are best served by an accurate prognosis of the final figures of the inequality so that the operation may be calibrated correctly in all respects. Retardation values following epiphyseodesis are obtained by tables drawn up by Green & Anderson amongst others. Anticipation of the size of the final inequality has always been an uncertain matter after poliomyelitis. A general view, also held by Steindler, has been that the difference in length would depend both on age at the onset of disease and on the extent of the pareses. Surprisingly enough, however, Stinchfield, Reidy & Barr, 1949, could find no correlation between age at initial disease (0–10 years) and the degree of inequality. They based their opinion on a clinical series comprising 166 patients, 64 with bilateral involvement.

This investigation was carried out in order to throw light on the size of the inequality in length and on the possibilities of prognostic evaluation. Only unilateral cases were chosen as the object of study so that as far as possible the variable influence of the other limb was eliminated in cases of bilateral involvement. The literature confirms that inequality in length in bilateral pareses remains less than in unilateral cases.

TABLE 1

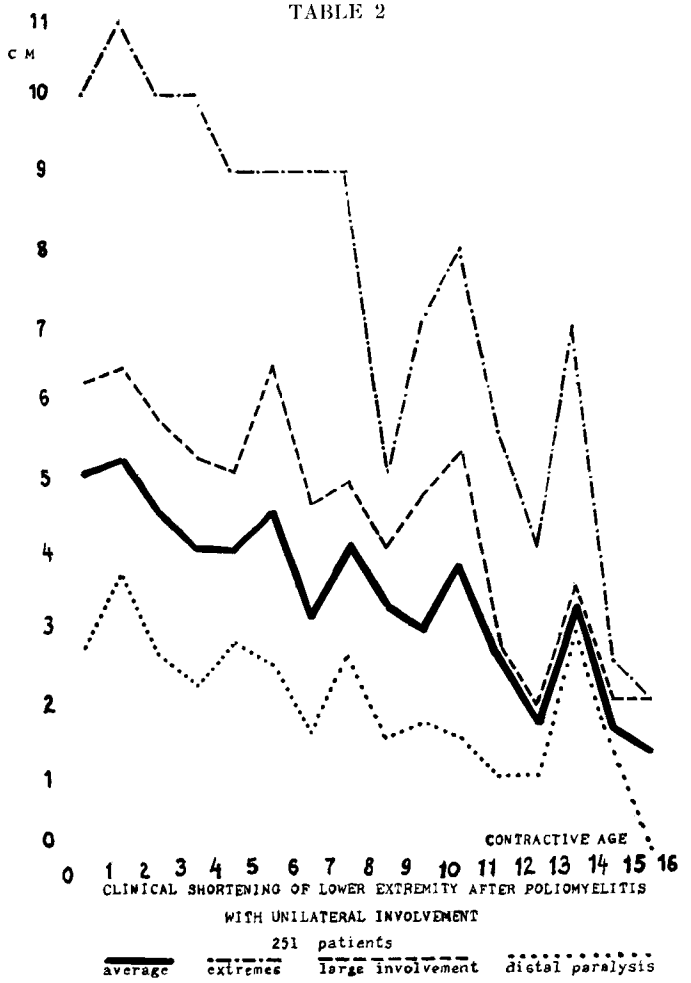


Distribution of cases by contractive age
251 patients.

The problems which were assumed to be capable of elucidation at first hand were: 1. The absolute extent of the true incongruence. 2. Its relation to the contractive age. 3. Its relation to the spread of the pareses and the degree of severity.

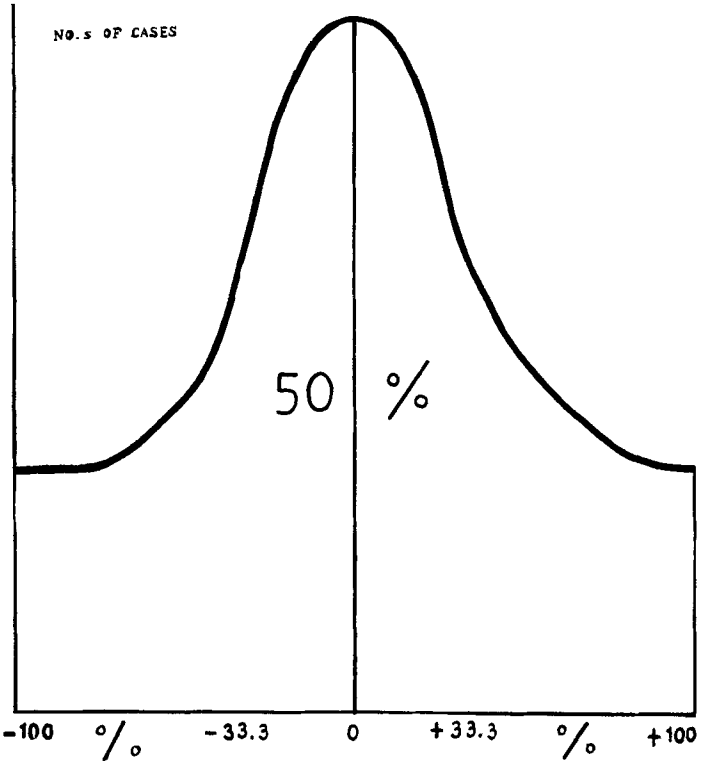
The *material* was made up of 251 cases of poliomyelitis in one lower limb acquired during the growth period from 0 to 16 years. The distribution of the cases according to contractive age appears in Table 1. The clinical shortening was observed in the affected limb after cessation of skeletal growth. By clinical shortening is meant the difference between the spine-malleolus measurements. The measurements in question do not give an exact value for the length of limb but indicate as well as the distance from the medial malleolus' tip to the cranial end of the caput femoris, also the distance from the latter point to the spine iliaca ventralis. Only cases with an otherwise intact skeleton were included. Therefore this excluded cases of osteotomy, congenital deformity, traumatisation etc. In this way sources of error were avoided such as the influence on the length of any other possible disturbances of epiphyseal growth.

TABLE 2



As regards degree of paresis the cases were grouped according to the following plan: 1. Cases with distal paresis = cases with only wrist and foot muscles affected in varying degree while knee and hip muscles remain intact. 2. Cases with extensive pareses = cases with all "main" muscle functions affected to a "marked" degree. By "main" functions is meant flexion extension, abduction and adduction in the hip, flexion and extension in the knee and also dorsal, plantar flexion, eversion and inversion in the foot. By involvement to a "marked" degree is meant that condition in which all "main" muscle functions are reduced to a value not above 3 (i.e., that the muscle strength is at its peak equivalent to the force of gravity in the direction of the movement but not beyond). Grouped in this way two distinctly separate types of case were constituted with the greatest possible difference. This was in order to demonstrate very clearly the possible relationship between the degree of paresis and the inequalitiy in length.

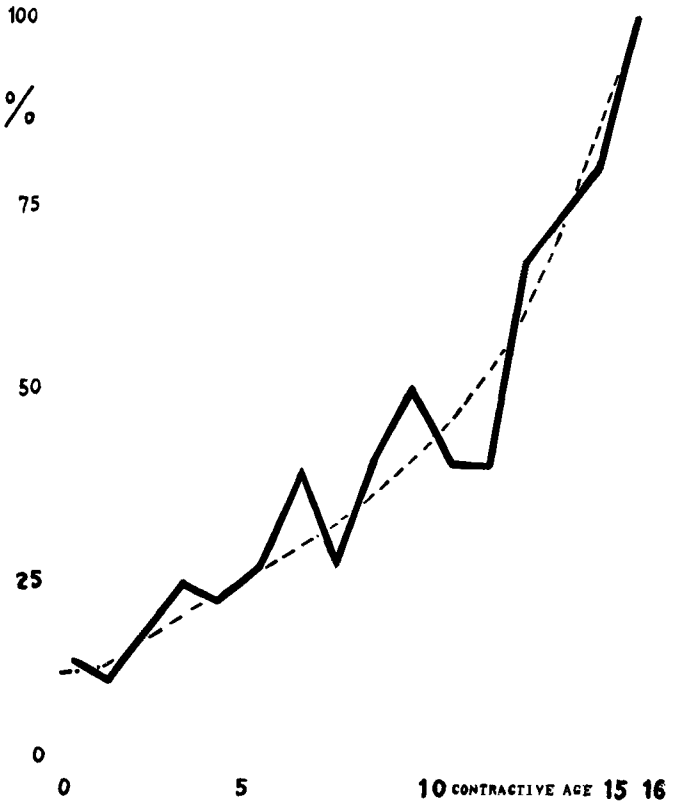
TABLE 3



FREQUENCY DISTRIBUTION IN RELATION TO
HIGHEST and LOWEST VALUE OF SHORTENING
IN EACH GROUP OF CONTRACTIVE AGE
251 cases

The arithmetical mean in cms of the inequality in length in all cases of the various age groups was calculated, and also, separately, that for the distal pareses and the extensive pareses. Furthermore the extreme values of shortening within each category were noted. In practice the low extreme values are represented by the value nought in each group, showing that independently of the degree of pareses and the contractive age, some case was present with non-existent inequality in length. The mean for the greatest and least amount of shortening proved to coincide quite well with the mean for all cases in the various age categories. The difference in the resultant length between the distal and the extensive pareses appears plainly in the diagram in Table 2. The falling curves show the tendency towards diminishing inequality as the age rises during the period at which poliomyelitis is incurred. The first group demonstrates an exception, when patients contracting the disease between 0 and 1 year of age exhibit a somewhat smaller average of inequality than the following group taken ill between 1 and 2 years of age. The number of cases probably lends the result a certain significance.

TABLE 4



The normal curve in Table 3 shows quite a good concentration around the middle value, but with a considerable number of cases near the maximal and minimal values of inequality. The curve is constructed on the basis of percentage departure from the average of maximal and minimal shortening per age group. About half of the cases are found within—33.3 % divergence from the average figure, which means for example, for the 35 cases contracting disease between 1 and 2 years of age with an inequality varying between 0 and 11 cms shortening, that about half had an inequality between 4 and 7 cms. This relationship indicates that a marked uncertainty regarding the prognosis is undoubtedly present if no other criterion except what is now recommended is employed.

The incidence of cases with negligible inequality (below 2 cms.) is graphically represented in Table 4 as a percentage relationship of the whole number, irrespective of the degree of paresis. The general tendency is plain: an increasing number of cases with negligible shortening as age increases on contraction of the disease. The risk of an inequality appearing with clinical importance seems for patients acquir-

ing unilateral poliomyelitis between 0 and 2 years of age to be thus about 90 %, to fall later, as age increases, to about 0 at 15 or 16 years of age. It should be noted that the diagrams refer without distinction to men and women so that prognosis conclusions in individual cases may only be drawn with reservations.

In conclusion it may be stated: 1. The size of the final inequality in length in the lower limbs following unilateral poliomyelitis during the years of growth is in indirect proportion to the age of the individual on contraction of the disease (possibly with the exception of group 0–1 years, which shows slightly less inequality than the above statement indicates). 2. Distal involvement of the lower limb with intact knee and hip muscles generally produces less inequality on average than widespread involvement of all main muscle functions (test value not above 3). 3. Forming prognoses on the basis of the diagrams included in this study should be made with reservations owing to a) the relatively large spread toward the extreme values and b) the absence of differentiation between the sexes. 4. The probability that the inequality will remain within negligible limits (under 2 cms.) is, however, great in cases of solely distal involvement (wrist and foot muscles) from the age of 6 and 7 upwards at the time of contraction of the disease. Much risk of considerable inequality is present with widespread pareses as late as 9–10 years of age on contraction of the disease. Inequality of clinical significance occurs still in isolated cases after contraction in the 12–13 age group. 5. The highest average value of inequality is found in the group taken ill at 1 to 2 years of age and consists of 6.3 cms. with widespread pareses and 3.7 cms. with distal involvement. The highest inequality values in individual cases of varying age when taken ill fluctuate from 11 to 2 cms. with a tendency to fall as the age group rises. A small number of cases with non-existent difference in length even with extensive pareses are to be seen in all groups at various ages of contracting the disease.

METAL PLATE WITHOUT SCREWS FOR FIXATION OF SHAFT FRACTURES OF THE FOREARM

by *Erik Moberg* (Gothenburg, Sweden)

It is not generally known that almost a third of the diaphysis fractures of the forearm in the radius or ulna end in pseudarthrosis. Large groups of statistics—even from the most recent times—reveal, however, how difficult these fractures are to heal.

Through previous studies, together with my collaborators, I was able to show that bony union can be obtained in almost every case, if rotatory movements at the fracture site can be prevented.

Earlier in our series this was effected by inserting into a slit made by a bone saw a self-locking, strong, cortical bone graft. The technique required for this, however, is not too easy, and especially when fractures of the two diaphyses simultaneously are present a large quantity of bone material must be used with the risks this brings to the donor site.

In a series, now amounting to 19 such shaft fractures, I have replaced the above self-locking bone graft with a self-locking steel plate, inserted in the same way as the bone transplant. Sometimes the metal plate may require to be fixed by a transverse piece of Kirschner wire. To make this locking possible the plate has a slit shown in the figure.

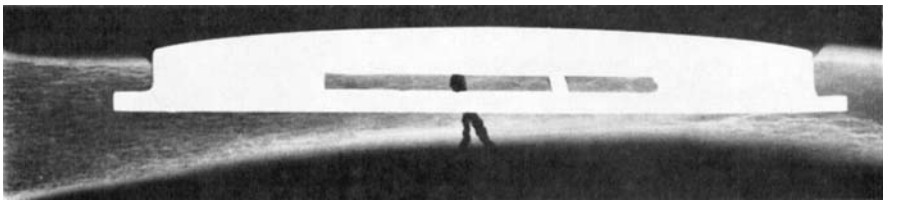


Fig. 1.
Metal plate inserted in position, locked by a piece of transverse Kirschner wire through the slit. Model fracture.

It has turned out that bony union was obtained in 18 out of 19 cases in this way, while in one case the plate was too short to give sufficient fixation. It had to be replaced in this case on re-operation by a cortical tibial graft. Amongst those treated in the way mentioned also cases of pseudarthrosis in diaphysis fractures are included.

The advantages of the method by comparison with other ways of metallic fixation of these fractures are:

1. The elbow joint and wrist joint are not included in the area of intervention.
2. No circular dissection with injury to the nutrition of the bone ends is necessary, only unilateral dissection.
3. The drawbacks always connected with screws are avoided, yet very stable fixation is achieved, hindering in particular deleterious rotation.
4. The operation becomes easier, although not easy, since exact work is required.

Naturally the surgery is completed by a rotation-preventing plaster, which must have a firm grip both around the metacarpal region of the hand and the distal part of the upper arm.

DISCUSSION:

M. Foss Hauge (Oslo), *C. Hirsch* (Upsala, Sweden), *L. Hult* (Umeå, Sweden), *G. Wiberg* (Lund, Sweden).

BONE TRANSPLANTATION WITH THIN TIBIA CORTICALIS AND SCREW FIXATION

by *Erin Madsen* (Sorö, Denmark)

I should like to present the results of a series of bone transplantations on the long bones employing a technique which was determined some years ago. We decided to use a thin tibia graft secured by means of vitallium screws. The tibia graft is thin, both because a lesser lesion is thus made on the tibia the marrow cavities not beeing opened, and because we think that the thin graft would heal more quickly. Using screw fixation one achieves a fixation of the fracture. After applying the tibia graft we place bone chips around the site of the lesion, taking the chips from the newly-formed bone tissue around the lesion. The tibia graft is about 4 mms. thick, about 16 mms. wide and quite long, e.g., in a tibia fracture about 14 cms. long. The graft is sawed away from the medial aspect of the tibia and from its anterior

border, in such a way that the marrow cavity is not opened. *The graft is put in a* vice, its corners are smoothed off, so that it does not project unnecessarily, and holes 4 mms. in diameter are drilled, i.e., large enough to prevent the vitallium screws biting into the graft. At 3.1 mm. drill is used when drilling into the bone. The graft is attached solidly to the bone and we believe this is important for perfect contact and good healing. If the fracture position is good, *no* resection of the fracture site is made, but a flat surface is made at the fracture site, so that the graft can fit closely to the bone throughout its length. If the fracture position is poor, the fracture is loosened, a little of the ends is resected, the latter are adjusted and after Beck's drilling reduction is performed and the fracture is fixed with the aid of the tibia graft on its shaped bed. Only as little of the bones as is necessary is taken for this purpose. Generally we can obtain sufficient chips from the newly-formed bone tissue and we have taken bone chips from the iliac crest only occasionally. With few exceptions unpadded plaster splints were used until clinical healing occurred. *Clinical healing* is the term used from the time that *the patient begins to support himself on the leg or to use the arm and can continue to do so without feeling pain or tenderness at the fracture site.*

In this way we *operated on 40 patients with 49 fractures.* The material was examined by Jörgen Stougaard, who published the results of the major part in Nordisk Medicin. The follow-up examination took place from 11 months up to 8 years after the operation. There was no fatality in the series. In one case, a tibia fracture, a slight infection arose in the wound 3 weeks after the operation. The infection disappeared and had no effect on the healing time, which was 3 months. There were no other complications.

Owing to lack of time I shall confine myself today to the discussion of the actual results of healing, since the *function* of the different extremities in the follow-up (those Stougaard has reported) was good in the great majority of patients and essentially depended on whether a lasting reduction in function had already arisen *before* the osteoplastic operation. Most of the cases were admitted to Sorö Hospital after primary treatment elsewhere. The cases which were primarily treated for the fracture at Sorö Hospital were given transplantation treatment quite early, since we aimed at carrying out bone transplantation at a relatively early stage, i.e., as soon as we obtained the diagnosis of delayed healing. We operated early to avoid diminishing the function of the extremity by having too long a period of plaster splinting. In a number of cases, in particular with the antebrachium, we employed bone transplantation as the primary treatment to ensure union of these fractures which often heal only with difficulty.

Survey.

Operated: 40 pts. with 49 fractures.
Healed: 39 pts. with 48 fractures.
Period of healing (average): $2^2/_3$ months.
No healing in 11 months: 1 ulna.

As stated above, 40 pts. with 49 fractures were operated on, of whom 39 pts. with 48 fractures healed, with an average healing period of $2^2/_3$ months. The one who did not heal, had an antebrachium fracture where the ulna was not healed 11 months after the operation.

I should like to begin by discussing this case which up to now has been the only failure of our method. It concerns an antebrachium fracture in a 16 year old girl: she was operated on 10 months after an osteosynthesis which gave no healing. The fracture ends had to be resected owing to the poor position. After the bone transplantation the radius quickly united, but the ulna is still not completely healed. A technical error was committed in this operation a screw being introduced in the fracture line and so prevented healing. The screw was removed some months after operation. When removing the screw it was found that the fracture was firm. A slight tenderness persisted, however, at the fracture site and on the X-ray a fine line can be seen corresponding to the fracture line. The case must therefore be recorded as "not healed", even if the fracture feels firm.

Tibia: 19 cases.

Healing period: 1½–2 months: 6 pts. (18, *20*, *39*, 46, 53, 62) (*3*, *4*, 4, 4, 7, 7 mths. before op.).

Healing period: 2½–3 months: 6 pts. (23, 32, 34, 35, *37*, *64* yrs.,) (2, 3, 5, 6, *6*, *27* months before op.).

Healing period: 3½–4 months: 4 pts. (19, 25, 30, 41 yrs.) (6, 8, 8, 12 months before op.).

Healing period: 5 months: 3 pts. (17, 18, *19* yrs.) (4, *24*, 41 months before op.).

Resection underlined.

The majority of the transplantations were performed on the tibia following crus fractures. From the survey it will be seen that 6 cases healed in 1½–2 months—6 in 2½–3 months—4 in 3½–4 months and 3 cases in the course of 5 months. *Age plays no part in the healing;* the three who took the longest time to heal were also the 3 youngest. This only confirms the general experience that the healing time of fractures is the same in young and old adults.

Radius and Ulna: 14 cases.

Healing period: 1½–2 months: 11 cases: 3 ulna, 5 radius, 3 ulna + radius cases. age: 20–40 years: 7 cases. 40–60 years: 4 cases.
Period before operation: ¼–1 month: 4 cases. 1½–7 months: 7 cases.
Resection: 3 cases.

Healing period: 2½ months: 1 case: ulna, 39 yrs. old, 13 mths. before op. — resect.

Healing period: 6 months: 1 case: ulna + radius, 27 yrs. ½ mth. before op. — resect.

Non-healed for 11 months: 1 case: ulna + radius, radius healed in 3 mths. Age: 16 yrs. Period before operation: 10 mths. + resection.

The patients numbered 14 with a total of 19 fractures. It will be seen that *healing occurred in 1½–2 mths. in 11 of the 14 patients.* In one, healing occurred in 2½ mths., in one other in 6 mths., and finally there is the one who did not achieve healing and whom I gave an account of, and who was the only one of all those operated on, who was a child with open epiphysis lines.

Diverse bones: 7 cases.

Humerus: 2 cases, healing period 2½ and 5 mths., aged 58 and 73 years, 4 and 2 mths. before operation.

Femur: 2 cases, healed after 3¼ and 3 mths., aged 23 and 68. 3 and 5 mths. before operation.

Clavicula: 1 case, healing period 2¾ mths., age: 38 yrs. 10 mths. before operation.

Metacarp. III, IV, V: 1 case, healing period 1¾ mths., age: 21 yrs., 3 mths. before operation.

Metacarp. II, III, IV: 1 case, healing period 2 mths., age: 21 yrs., 21 mths., before operation.

Resection in all these cases.

For the other bones we have some scattered cases, 2 on the humerus united in 2½–5 mths., 2 on the femur both united in 3 mths., 1 clavicula united in 2 mths., and also 2 hands, each with 3 metacarpal fractures, which all united in about 2 months. Here as before it will be seen that the long period before the operation did not play any decisive part in the healing time after operation. In one case with metacarpal fractures 21 months passed before operation. On the femur we see again that the young and the old heal in the same time. In the femur we employed simultaneously with the bone graft a very solid vitallium plate in a plane at right angles to the plane of the graft and did *not* use plaster bandage after the operation.

Finally I should like to point out that when different methods of transplantation are compared, I do not believe that it is sufficient to discuss corticalis versus spongiosa or versus bone chips etc., but one must take into consideration that the dimensions of the grafts, accurate adjustment, method of fixation and other technical details play an equally decisive part in the healing results as the kind of material.

FIXATION OF THE TIBIO-FIBULAR SYNDESMOSIS BY MEANS OF CERCLAGE THROUGH DRILLED HOLES

by *Lars Mårtenson* (Gothenburg, Sweden)

The study is intended to be published in Acta Orthopaedica. Here is merely a short summary.

Everyone knows of the obvious difficulties involved in maintaining a satisfactory reduction position which has been obtained by closed reduction in ankle joint fractures. Therefore, interest in active operative treatment of fractures in the ankle joint region is constantly increasing.

If one possesses this active approach, however, it is necessary constantly to take into consideration two elementary factors:

1. To insert as little and from the point of view of tissue irritation as harmless osteosynthesis material as possible.

2. To judge the quality and appearance of the skin covering primarily with consideration of the nutritional injuries presumed to arise on trauma.

At the Surgical Extremity Clinic in Gothenburg from which this study has proceeded we have adopted a markedly active approach to the treatment of these injuries.

After the operative method itself is demonstrated, a surgical material of in all 60 cases is reported covering the period from the 15th, October 1959, to 30th, April, 1960. Statistical information on the following questions is given in table form:

a) age at accident,
b) age distribution during the months most prone to accidents,
c) cause of accident,
d) incidence of triple fractures,
e) importance of the skin problem.

Included also is inforamtion on average period of care; period before weight-bearing on foot; late problems of primary treatment when the patient has not yet been discharged.

DISCUSSION:

L. Hagelstam (Helsingfors), *Hans Dahl* (Oslo).

G. Wiberg (Lund, Sweden):

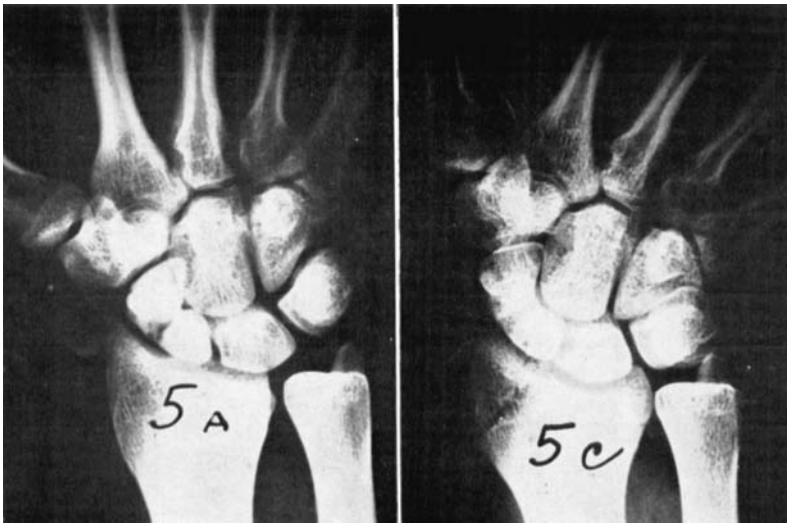
As is well known, syndesmosis injuries combined with fracture lead in a large number of cases to late arthrosis deformans changes within the talocrural joint and even if these changes are many times of slight nature such a foot betrays symptoms many times. Even with the very simple fractures to the lateral malleolus alone the consequence may be lasting with limitation of e.g., the possibilities of sport. Since we know from experience that the risk of deformans changes becomes less, if an intra-articular fracture is accurately reduced, it seems a justified procedure in these fractures to undertake an operative correction and perhaps to a larger extent than has hitherto been the case. During the last 2 years we have taken the step at the orthopaedic clinic in Lund of operating also on these fibula fractures and so one finds that the distal fibula fragment lies about 5° outward-rotated and a few millimeters upward-displaced, which is sufficient to create incongruency between the fibula and the lateral talus articular surface. It is of course much too early to express an opinion on the effect, since the deformans changes discussed earlier do not occur until after 10–15 years and research in the future must therefore reveal if our argument is correct.

PSEUDARTHROSIS OF THE CARPAL NAVICULAR BONE OF THE HAND TREATED BY INFORATIO ACCORDING TO BECK

by *Jørgen Ernst* and *Henrik Hamburger* (Copenhagen)

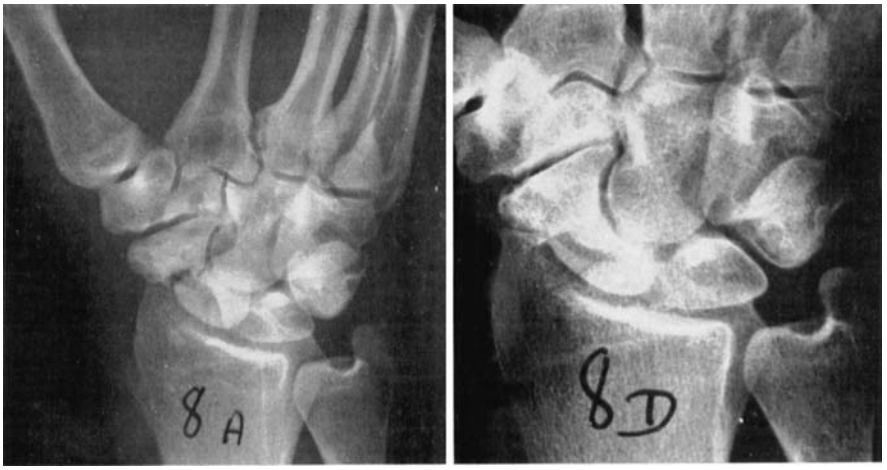
In the surgical department of Copenhagen's Military Hospital, 86 patients were treated during a 5 year period from 1955–1960 for fracture of the navicular bone of the hand. 51 of these 86 patients were designated as fresh—i.e., recognised less than 4 weeks after trauma—and 35 were designated as inveterate—i.e., not recognised until 4 weeks after trauma—19 of these within the first half year, 8 in the second six months and 8 between 1–4 years following trauma.

Out of the 51 fresh cases 48 were successful using plaster bandage alone, while in 3 pseudoarthrosis arose.



a b

Fig. 1.
Patient no. 5, before and after Beck drilling.



a b

Fig. 2.
Patient no. 8, before and after Beck drilling.

4 of the 35 inveterate cases were sent home on military grounds and therefore were not fully treated. 21 patients were treated exclusively with plaster bandage and on follow-up examination it proved that 15 had union and 6 non-union. Of the remaining 10, one patient on whom we shall report later, was treated by X-ray. The

GROUP

Beck drilling in 3 patients, whose fracture was recognised immediately (i.e., within

Pt. no.	No. of mths. in plaster before op.	X-ray fdgs. at op.	No. mths. in plaster after op.	Follow-up no. mths. after end of trmt.	Subjective
3	5	sclerosis + cyst	3	18	slight pain with hard work
4	8	sclerosis + cyst	2	18	no complaint
7	4 mths. and afterwards 4 mths. — treatmt.	sclerosis	4	3	moderate trouble, with hard work

GROUP

Beck drilling in 9 patients, whose fracture was in veterate (i.e. more than 4

No. of Pts.	Previous visited doctor	First X-ray	Fracture recognised no. of mths. after trauma	X-ray fdgs. on confirmations of diagnosis	No. of mths plaster before op.	No. of mths. after op.
1	at once (+ treat. before for 2 mths.)	at once	6	sclerosis + cyst	8	2
2	at once	nothing abnormal	20	sclerosis + cyst	3	2
5	at once	X-ray	8	sclerosis + cyst	0	4
6	no		10	cyst + fracture	2	2
8	no		24	sclerosis + cyst	0	5
9	no		48	cyst + fracture	0	3
15	no		24	sclerosis	2	3
10	no		12	cyst	3	about 2
11	at once, old trauma unknown	old pseud-arthrosis	?	cyst + fracture	2	about 2

1

4 weeks) and in whom no success was achieved with the routine plaster bandage.

Tendernes in thse »Snuff-box«	Mobility	X-ray findings	Work	Total result
0	4/5	Union	+	Fine
0	4/5	Union	+	Fine
(+)	2/3	Partial effacement of fracture line	+	Improved

2

weeks old) when they came for treatment at Copenhagen's Military Hospital.

Follow-up no. of mths. after end of treat-ment	Subjectively	Ten-derness in the »Snuff-box«	Mobi-lity	X-ray findings	Work	Total result
25	no trouble	0	4/5	Union	+	Fine
20	no trouble	0	4/5	Union	+	Fine
13	no trouble	0	4/5	Union	+	Fine
2	no trouble	(+)	2/3	Union	+	Fine
1	no trouble	(+)	2/3	Union		Fine
3	no trouble	0	2/3	Partial effacement of fracture line	+	Improved
3	no trouble	(+)	4/5	Union	Will begin now	Fine
24	is at mental hospital, – treament was interrupted			Not united	+	Unchanged
—	Treatment interrupted owing to home posting			Not united	+	Unchanged

remaining 9 and the 3 non-united patients from the group of fresh cases were surgically treated and the present study therefore concerns these 12 patients operated on and the patient treated by X-ray.

Group 3. X-ray treatment of pseudoarthrosis of the navicular bone.

An ensign aged 25, who first sought treatment 12 months after trauma. On X-ray examination pseudarthrosis was found with irregularly sclerosed fracture lines. He was treated with a total of 375 r. and has now been examined 4 years after conclusion of treatment. Subjectively, minimal pain is reported when working hard and objectively, a mobility amounting to $^2/_3$ that of the healthy hand was found.

Hand grip, 75 against 120.

On X-ray examination a nearthrosis can now be seen with smoother, good-looking articular surfaces and no sign of secondary arthrosis—thus recalling the result following a Bentzon operation.

As the tables show, certain osseous union arose in 8 of the 12 patients. Mobility in the wrist joint was almost normal especially in the case of those observed over a long period.

In 2 patients the fracture union is designated as partial, but both these patients are working and it seems to them that the hand improved after operaion. They were both only observed for 3 months after the conclusion of treatment, so further improvement is still possible.

In 2 patients no union occurred. In respect of both of these patients it may be said that the length of after treatment is uncertain and was only carried out by us for about 2 months. They were sent home and the department had no opportunity therefore to direct the after-treatment itself.

Finally as already stated one patient was X-ray-treated. It was before Beck drilling commenced and the thought behind the X-ray treatment aimed at achieving something along the lines of what is achieved with Bentzon's procedure. The smooth-edged nearthrosis and the functionally good result indicate success.

The treatment of fractures of the navicular bone of the hand, recognised at an early stage, is a rewarding task, as our total series will show.

48 out of 51 fresh fractures healed with plaster bandage alone and 30 patients healed after only 2 months in plaster: 17 had plaster bandage for 3–6 months and only 1 remained in plaster for more than 6 months.

In applying the plaster it is important not only to lock the movements of the thumb and wrist but also the rotatory movements of the forearm. With this in mind Düben recommends his boxing glove plaster bandage which extends to all the finger tips. In the last year we have applied the plaster to the middle of the upper arm and believe that we can see a quicker union—particularly in the inveterate cases—than earlier, where we applied the plaster to the elbow according to Böhler. Our series does not permit a review of this difference, however, since we only gradually transferred to the longer plaster bandage. When, however, the treatment of fractures of the navicular bone presents such a great problem that at any rate 8 different methods of operation are described, the problem well known to surgeons is held responsible, i.e., that many fractures are not recognised in the earlier stages —partly because many fractures cannot be seen on X-ray pictures taken just after

trauma—partly because many cases are regarded by both doctor and patient as a simple sprain which will heal spontaneously. Of our 35 patients with inveterate fractures 11 were X-rayed immediately with negative results. If the fracture for one reason or another is not recognised until a late stage, the X-ray will show a quite manifest pseudarthrosis with sclerosed fracture lines and cystic rarefaction. Conservative treatment may be tried but will take often six months or a whole year and many authors therefore quickly adopt operation.

Amongst the published methods of operation it must be mentioned that P. G. K. Bentzon together with Randlöv-Madsen in 1944 announced his method which by means of fascia plastics between the fracture fragments transforms the pseudoarthrosis to a nearthrosis. In 1954 Perey announced 15 cases of follow-ups—14 of which had restarted work—10 without subjective trouble, while 4 had trouble.

The intra-osseous method of bone graft originally announced by Adams and Leonhard in 1928 has many advocators. Out of 20 patients Berben has 13 especially good, 4 good and 3 poor. A. Hoff has 44 united out of 49, Murray 96 out of 100, Palmer and Widen 28 out of 28, Stewart 3 out of 5 and Scaglietti and Perrazini 10 out of 10.

The Matti operation, consisting of scraping out the bone and the introduction of spongious bone transplant has been used by Hueck and Bauer, who obtained union in 4 out of 7, by Fehr, who obtained union in 3 out of 6 and by Russe, who states 80–90 % union.

Geisendorfer's metal wire osteosynthesis, discovered by means of a case in which a drill wire broke, resulted in union for Geisendorfer in 16 out of 21 and for Lindvall in 5 out of 6, while a screw osteosynthesis used by McLaughlin showed no union in 5 inveterate cases, only union when used in fresh cases.

Different authors have removed either parts of the bone, (Aleman 1937 and Palmer 1942) or the whole bone, e.g., Badgley and Hayes or removed the styloid process of the radius (Smith and Friedman, Badgley and Hayes, Decouex and finally Hoff)—in the case of the latter as a supplement to the bone graft operation.

Exstirpation of fracture fragments of the navicular bone or of the whole of the navicular bone shows poor results and can be assumed to have been abandoned.

Finally inforatio according to Beck is reported as a surgical procedure. The method has not won so many supporters as for example the bone graft method, indeed Palmer wrote even in 1942, that Beck drilling must be discouraged since he is afraid that in cases of cyst formation in the bone it can bring about the collapse of the whole bone. On the Danish side the method has been employed in 10 cases by Kj. Andersen and F. Therkelsen. They obtained union in 4 cases. The best results are from Soto-Hall and Haldeman, who obtained union in 5 out of 6. In addition Schnek obtained union in 1 out of 3 and Stewart in 1 out of 2, while Aleman had no union in any of his 6 patients operated on.

Summary and conclusion:

In a series consisting of 51 fresh and 35 inveterate cases of fracture of the navicular bone of the hand, inforatio according to Beck was undertaken in 12 patients.

In 8 there was certain osseous union, in 2 partial effacement of the fracture line and in 2 no union occurred, as their after-treatment was broken off through home posting.

One patient was treated by X-ray and the result achieved with a smooth nearthrosis recalls somewhat that achieved by a Bentzon operation.

Even if Beck drilling thus cannot show such good results as the bone graft method, it can still,—especially in view of the method's lack of risk—be characterised as a useful method for the treatment of pseudarthrosis of the navicular bone.

ARTHROGRYPOSIS MULTIPLEX CONGENITA

by *Ole M. Hansen* (Copenhagen)

A survey is made of the results of the muscle biopsies, taken from patients with arthrogryposis multiplex congenita. The findings resemble most the final stage of a myogenous disease.

Afterwards an embryologic survey is made of the formation of the musculature and of the extremities.

If the histological changes, the clinical picture, the time conditions are compared with experience from experimental teratology, one comes to the conclusion that arthrogryposis multiplex congenita may be due to an exogenous effect on the foetus about the 7th foetal week. It cannot, however, be excluded that the disease in some cases may be genetically determined, even if several cases are described in the literature, in which one of identical twins has arthrogryposis, while the other does not have it.

DISCUSSION:

G. Wiberg (Lund, Sweden), *L. Hult* (Umeå, Sweden) and *C. Hirsch* (Upsala, Sweden).

TOMOGRAPHY STUDIES ON THE INTRAARTICULAR FRACTURE OF THE POSTERIOR PROCESS OF THE TIBIA

by *Lars Mårtenson* and *Ulla Lagerquist* (Gothenburg, Sweden)

The paper is considered to be a preliminary report.

During study by the clinic for ankle joint fractures the problem arose whether wider knowledge of the fracture through the posterior process of the tibia with the following dislocation of articular surface bearing elements could be gained by utilising tomographic radiology more systematically.

Tomographic examination was able to demonstrate particularly well such intra-articular posterior process fractures as those in which articular surface bearing fragments are displaced from the joint surface by compression, leaving behind unevenness and impressions.

After such an examination it is therefore possible at the operative reconstruction of the ankle joint to come to grips directly with the dislocations within the articular surface since these have been determined exactly in the above way.

Tomography studies on the fracture of the posterior process of the tibia have therefore been continued as routine and the result of the investigations will be published in Acta Radiologica.

PROPHYLACTICAL TREATMENT OF THROMBOSIS IN ORTHOPAEDIC SURGERY

by *Kåre Lavik* and *Rolf Duus* (Oslo)

GRIP RECONSTRUCTION OF THE HAND WITH TRANSFER OF SMALL NEUROVASCULAR ISLAND FLAPS

by *Erik Moberg* (Gothenburg, Sweden)

By means of previous studies I have been able to show that the functional value of a hand grip is fundamentally due to the fact that the surfaces which contact each other in the grip possess normal and full sensibility, called tactile gnosis. Here one must clearly differentiate between this qualitiy of sensibility and the lower degrees of sensibility, which can be determined by the customary examinations with cotton-wool and pinprick. These examinations have, as regards the hand, no value from a practical point of view. For with these methods one cannot differentiate between paresthesia and tactile gnosis.

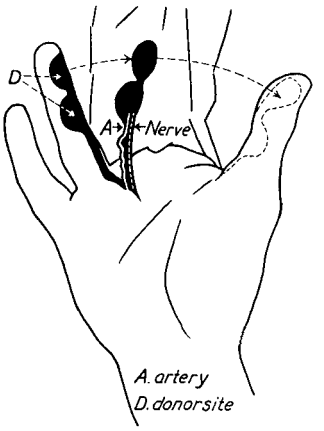


Fig. 1,
Transfer of sensibility-carrying skin, hanging on nerve and artery, from ring finger to a thumb without useful sensibility. The index and long finger are covered.

When a grip has to be reconstructed one of the most important procedures is to supply the gripping surfaces with normal sensation, if such is lacking. For this purpose I began as early as ten years ago to transfer to such surfaces small "islands" of suitable skin still in contact with good nerve and artery supply. The practical results have been striking.

Starting from complicated reconstruction cases demonstrating the principle the use of the technique was shown in a series of increasingly more simple cases. As an example of the latter may be mentioned the simple use of dorsal skin with normal sensory function brought over to the volar surface in finger amputation and the covering of thumb and finger pulps with skin from more proximal dissected free with nerves and vessels; the skin cover quite simple could be stretched 1 to 2 cms. in a distal direction and afterwards with this lengthening could be sutured into place again, giving cover with sensibility to the gripping surface.

The principle has many adaptations in everyday surgery, especially in the treatment of various forms of acute hand injuries. Every square centimetre of skin with its normal sensibility retained ought to be saved here for later reconstruction.

LUXATIO COXAE CONGENITA. DIAGNOSIS AND TREATMENT IN NEWBORNS

by *Ingulf Medbo* (Ålesund, Norway)

Over a three year period a consistent clinical examination for hip joint dysplasia was carried out on 3,242 newborns in a district in which the incidence of dysplasia seemed uncommonly high.

Whereever it was thought, depending on clinical examination, that pathological hip joints were present, X-ray examination was also undertaken. In all, 50 children with probable hip joint dysplasia at birth were found.

Treatment was performed with Frejka's cushion splint. In individual cases a short period of immobilisation in a plaster cast was also prescribed.

Clinical and X-ray control of all patients was adopted in the treatment period.

Clinically and radiologically normal hips were achieved in 49 of the 50 patients. In the remaining patient slight subluxation was present in one hip when the examination was concluded. The cause of the failure in treatment of this patient is specially discussed.

The experience believed to have been acquired on the basis of this material may be summed up as follows:

1. In the neonatal stage clinical examination of the hip joints is superior to the X-ray. It is not until the epiphysis is visible on the X-ray that this method of diagnosis reveals something more than the clinical examination.

2. For the great majority of patients in this age group Frejka's cushion splint gives satisfactory immobilisation in a favourable position. It seems to trouble the patient but little. It is easy for the mother to adjust and the treatment can be given outside the hospital.

3. When treatment of a hip joint dysplasia is commenced in the newborn stage, in the great majority of cases normal hip joints will be achieved before the child begins normally to put weight on the lower extremities. The treatment can therefore be performed during a period in which the physical and mental development of the child is affected to the least possible extent.

OUR FURTHER EXPERIENCE IN THE TREATMENT OF CONGENITAL HIP JOINT DISLOCATION IN NEWBORNS

by *Sophus von Rosen* (Malmö, Sweden)

At N.O.F.'s Congress in Lund-Malmö two years ago, I brought up the following questions for discussion:

1. What is the cause of congenital hip joint dislocation?
2. Is the dislocation always present at birth?
3. Can the dislocation always be diagnosed immediately after birth?
4. How long is the treatment required?

Today I shall begin with *questions two and three* and answer them simultaneously against the background of our continued experience. This experience is based on 39 cases of congenital hip joint dislocation out of 24,000 newborns. This is an incidence of 0.17 %. In all but one case the diagnosis was made during the first or second day after birth. The case which spoils our statistical perfection is that of a girl born in Malmö while the mother was spending the summer in the town. The girl had cramp

the first day after birth and was transferred to the Children's Hospital. As a result of this the hip joints were not examined according to routine. The dislocation was discovered when the girl began to walk and then limped with the one leg. This case excepted, the questions whether the dislocation is already present at birth and whether the diagnosis can already be made at this time may be answered in the affirmative.

Question no. 4: How long is the period of treatment required?

The answer to this question remains as before, up to three months. In some cases the fixation period was shortened to as little as 6 weeks. Redislocation did not occur in any case and hitherto we have had no case showing Perthes-like changes or subluxation.

I shall deal especially with the question about the cause of congenital hip joint dislocation.

Our fine treatment results have persuaded us more and more to doubt that the cause of the dislocation is a congenital dysplasia of the hip joint. The constantly repeated observation that the reduced hip joints, are felt to be quite stable as soon as a few weeks have passed, even earlier, if they are reduced and fixed in the reduced position during the first days after birth,—this observation also argues against the above theory.

At the X-ray examination of a dislocation case in September, 1959, my radiological colleague Lars Andrén made a very interesting observation. He found a looseness present not only in the hip joint but also in the pelvic joints. On picture taken in Lauenstein's position with the legs apart and pressed against the midline of the body the difference in distance between the proximal ends of the femoral diaphyses was 10 mm. The difference in symphysis width was 3 mm. on the respective pictures. Similar observations were made later in 5 cases of dislocation, while 70 normal cases only showed a difference in symphysis width of 1½ mm. at the most.

Could the cause of the congenital hip joint dislocation be a primary looseness of the hip joints and to what could such a looseness in turn be attributed? It is a logical step, as regards the looseness in the symphysis joints, to make a comparison with the relaxation in the pelvic joints of the pregnant woman, which occurs in connexion with delivery. It is hardly to be doubted that this is conditioned by hormones.

In newborns it is known through *Diczfalusy*'s research that oestriol is present in the urine during the first week of life. *Deblieck* and *Schwers* have also shown in their research that the urine from girls contains more oestriol than that from boys. Would it be possible that the newborns with congenital hip joint dislocation diverge in these respects from normal newborns? In collaboration with the Women's Clinic in Malmö hormone analyses are now made in our new dislocation cases. By good fortune it has turned out that just when this problem arose, it became technically possible for us to carry out these hormone analyses.

The preliminary results of these investigations revealed that the amount of conjugated oestriol excreted was about the same as in the control group, but the amounts of oestrone and oestradiol-17 β were definitely larger.

I shall not now give an account of this research in detail. It will be reported in another context. If the progress it seems to promise is maintained, then congenital hip joint dislocation will in future be more of an endocrinal than an orthopaedic disease. The task of the orthopaedic surgeon will merely be confined to seeing that the relaxed hip joints are fixed in the reduced position until they are stabilised. It

already appears to me to be a serious sin of omission if every possibility is not examined of discovering these cases immediately after birth and of starting treatment at once.

DISCUSSION:

M. Felländer (Stockholm) and *A. Langenskiöld* (Helsingfors).

THE POSITION OF ORTHOPAEDICS IN MODERN MEDICIN

by *Göran Bauer* (Malmö, Sweden)

(Abstract).

Like in other countries and other areas of medicine, Swedish Orthopaedics is drastically shifting its emphasis from "cold" orthopaedics practiced in isolated institutions to embrace metabolic skeletal disease and fracture surgery practiced in close co-operation with other specialities. Examples of dwindling diseases are tuberculosis, and sequlae to poliomyelitis, osteitis, club foot and congenital dislocation of the hip. Examples of increasingly severe problems are osteoarthrosis and various traumatic conditions.

The changing pattern of disease is an effect of political, social, demographic and medical factors. The challenge of this situation can be accepted by orthopaedic surgeons only if they are willing to change presently accepted standards for training in orthopaedics. (Published in Svenska Läkartidningen, 57: 2684, 1960).

DISCUSSION:

Erik Moberg (Gothenburg, Sweden):

We should be grateful to Docent Bauer for bringing forward the problem for discussion. Trauma is without doubt here to stay. It will be one of the great disease groups of the future by the side of psychiatry, circulation disturbance and perhaps dermatology. *Someone* must treat it.

The tasks of orthopaedics have diminished, for tuberculosis has almost been eliminated, poliomyelitis is strongly on the decline and the suppurative conditions are considerably reduced in number. Apart from trauma new problems have arisen. Laine and Vainio in Finland have shown that every third patient with chronic polyarthritis can be aided more through surgery than in any other way. Hand surgery is far from being as well practised as one could desire with our present knowledge. We do not possess today surgeons who are capable of accomplishing these tasks, but we can train them. Today I shall only speak about trauma. We have to include quantitative factors, geographical factors and finally the question of personal ability.

As far as the quantitative factors are concerned, a committee has been set up to inquire into the organisation of traumatology in England. From one of the leading members I know that one of fundamental tasks of this committee is to recommend to the small hospitals that they should cease to take care of accident cases. In our countries a good department of traumatological surgery of the extremities, with fractures, cannot be organised with fewer staff than six doctors, which corresponds

to approximately 100 beds. Smaller departments cannot maintain a service for 24 hours a day with adequate quality—even so the burden is heavy. Bauer's statement "it is not the surgeons who will swallow up the fractures, but it is the fractures which will swallow up the surgeons," is absolutely correct. One of three of our operations is acute.

The geographical factors are completely different in different parts of our countries. To have the same organisation in the great cities—around Copenhagen and Stockholm—as in north Sweden and Norway is out of the question. Different solutions must be adopted for different areas.

In the end personal ability remains a decisive factor. One must realise clearly that the time is past when one learnt fracture surgery by studying for some years at a clinic for general surgery. Whereever one's training is obtained—and this applies to general surgeons, orthopaedic surgeons and plastic surgeons to an equal extent—a supplementary training, by no means insignificant, will become necessary for whoever shall tend the fractures which we admit today. The skin problems dominate here as never before. If they cannot be solved then one is not capable either of being responsible for the care of the fractures. The skin problems must be solved at once yet nowhere do plastic surgeons wait up at night for the stream of accident cases which rolls in. Trauma must be lived with, as it were, if a surgeon is to be capable of tending these cases.

The field is so large and the problems are so many that a treatment which is adequate can be scarcely imagined without collaboration from all the departments concerned. It is certainly very desirable that the orthopaedic surgeons should make in all sincerity and effectiveness a vastly greater effort than they have done previously. A train is standing at the station. It will be leaving because it has an urgent task. Who will travel with it?