lengthening the short limb 5 in. (12.5 cm.)—2 in. (5 cm.) above and 3 in. (7.5 cm.) below the knee-joint—shortening the normal tibia by 2 in., and compensating for the remaining inch by pelvic tilting. The greatest gains in length have been 3½ in. (8.75 cm.) in the femur (one case) and 4½ in. in the tibia (two cases).

Experience with the recent cases has not differed very much from that previously reported, except that the complication of secondary fracture, not encountered before, has happened twice without, however, any loss of length already gained, but with a delay of three months in each case before final recovery. It is possible, too, that in a case not included in this series a paresis of some of the muscles supplied by the anterior tibial nerve which occurred immediately after the operation, before distraction started, was due to direct transfixion of a nerve branch by one of the distracting Kirschner wires. No tourniquet was used. This complication should be avoidable by placing these wires well forward through the crest of the tibia.

The average lengthening in the whole series is 2½ in. (6.25 cm.) in the tibia and 1¾ in. (4.4 cm.) in the femur.

### Conclusion

Gains in length in both tibia and femur up to 2 in. are possible without any complication, transient or permanent. Beyond that, transient complications occur, and must be weighed against the desire to gain more length. With the technique described no difficulty has been found in maintaining femoral alignment, and little in maintaining tibial alignment.

The choice between leg-lengthening and leg-shortening is not an easy one to make. It may be pointed out, however, that the difficulties described do not arise suddenly and can often be anticipated. The distraction stages of the operation may be stopped at any time, before any temporary or permanent harm is done, and the operation of shortening the opposite limb still be carried out.

### Summary

The indications for and against leg equalization are summarized, and the choice of operative procedures is discussed.

The operative technique and the management of distraction in leg-lengthening are described.

The possible complications of leg-lengthening are discussed.

The results in 101 personal cases are presented.

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The Food and Agriculture Organization (F.A.O.) and the Government of Peru have signed an agreement to improve nutrition and bring about more adequate diets in Peru by providing a nutrition consultant who will help to plan and organize dietary surveys and biological work in nutrition; by providing four fellowships to technicians already working in the field of nutrition; and by the purchase and transport of equipment and supplies for the animal experiment laboratory at Lima. The present agreement is the twenty-first which F.A.O. has made, and Guatemala, Costa Rica, Uruguay, Ecuador, Honduras, Colombia, and Haiti are already included.

# BONE-SHORTENING FOR INEQUALITY OF LEG LENGTHS*

BY

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In considering the treatment of inequality of leg lengths we must first decide what degree of inequality calls for surgical measures. Up to ¾ in. (2 cm.), a person of average stature can ignore the discrepancy; up to 1½ in. (3.75 cm.) the inequality can be readily dealt with by a lift of one heel and a dropping of the other. As a rule surgery need not be considered until a discrepancy of over 1½ in. has occurred or is anticipated. Warren White (1947) wisely stressed the unimportance of a slight discrepancy in length: a limp is usually due to the muscle weakness, and he reports a shortening of 2 in. (5 cm.) with no limp. In his opinion the hazards of the compensatory scoliosis have also been overemphasized. Two further points need to be stressed: first, where a patient has to wear a calliper the elimination of a surgical boot alone does not warrant surgery, and, secondly, all cases need to be carefully documented as regards bone lengths, preferably by accurate radiographic recording.

### Risks of Bone-lengthening

The inequality can be corrected by leg-lengthening or leg-shortening; the former is the ideal treatment, and the latter can have an appeal only to the extent that bone-lengthening is regarded as over-ambitious and carrying too great risks. What are these risks? Deformity and sepsis when the bone fragments are not under complete control, delayed union and late fractures, paralyses, vascular trouble with oedema, stiff joints, and weakened muscles are some of those which seem to occur in most series of any size. That this is the present opinion in America is indicated by the following extracts from recent literature. Abbott and Saunders (1939), who have done so much to popularize bone-lengthening, wrote in 1939: "We emphasize that the procedure of bone-lengthening is, and in all probability always will be, a major operation, with the possibility of serious complications." This is a grave warning when applied to a purely elective procedure. Barr (1948) wrote of these procedures: "The operation of femoral lengthening was therefore soon abandoned"; and later, referring to lower-leg lengthening, "It is safe to say that the operation, once reasonably popular, is now rarely done." These remarks may apply more to America than this country, but even the surgeons who favour this form of treatment will admit that serious risks are run, the procedure is lengthy, and convalescence is often protracted—a minimum of six months seems to be required.

Most cases of inequality of leg length result from anterior poliomyelitis, and the weakened muscles cannot be assisted by the additional stretching entailed by leg lengthening. On the other hand, the well-muscled limb with shortening from congenital or other causes unconnected with paralysis, is less suitable for leg-lengthening, allowing of little elongation and being rather more prone to all complications.

*Read to the Section of Orthopaedics at the Annual Meeting of the British Medical Association, Liverpool, 1950.

As a consequence of these risks, many surgeons have turned to surgical shortening as a wiser procedure; but they at once come under criticism for two reasons: (1) the patient's loss of height, and (2) the fact that the elective surgery is performed on the normal leg of a patient already afflicted with a considerable disability in his other leg. Loss of height is humiliating in the true sense of the word—which means bringing one nearer to the ground. To the tall it means little, but to those short in stature it may mean a great deal, and it is certainly of more importance to a man than to a woman. With due regard to all the claims made for leg-lengthening, it would seem, however, that one should practise bone-shortening in all but a small group of patients who either are unwilling or can ill afford to sacrifice any fraction of their height.

### Epiphysiodesis

Bone-shortening is usually accomplished by epiphysial arrest during the growth period or by surgical bone-shortening—at any age, but preferably after growth has ceased. Epiphysial arrest can be accomplished by epiphysiodesis—a procedure introduced by Phemister (1933) and of established value—or mechanical retardation of metaphysial growth by staples—a procedure introduced by Blount in recent years and still in an experimental stage. The preliminary report by Blount and Clarke (1949) was very impressive, and an important new method of leg-shortening seems to be available to surgeons; results are but slowly accumulated in such a field, and further reports are awaited with keen interest.

It is very important to estimate accurately the effect of epiphysiodesis. The calculation of expected growth and expected discrepancy in leg length is the basis of the method advocated by Wilson and Thompson (1939), while Warren White (1947) uses a simple estimation that the distal epiphysis of the femur will contribute $\frac{3}{8}$ in. (1 cm.) per annum and the upper tibial epiphysis $\frac{1}{4}$ in. (0.6 cm.) per annum up to the age of 17 in boys and 16 in girls. Growth varies so greatly with each individual that the simpler method is as likely to give good results as any. Errors are usually on the side of insufficient correction; hence it is rarely advisable to delay epiphysiodesis beyond 11 years in a girl or 12½ in a boy.

A good result may be claimed if the final leg lengths differ by less than $\frac{3}{4}$ in. (2 cm.) (Straub, Thompson, and Wilson, 1945) and if the shorter leg is the same or reversed. Reported series rarely contain more than one case of over-shortening. This is not only on account of delay in operating but also, as mentioned by Warren White, because little correction occurs in the first year, the stimulation to metaphysial growth being only just counterbalanced by the destruction of the epiphysial plate; and other near-by epiphyses may be stimulated by hyperaemia.

Mention must be made of deformities occurring in limbs on which epiphysiodesis has been performed. While Warren White reports only one case in a large series covering 12 years, Straub, Thompson, and Wilson record a series of 103 operations in which 20.7% developed bony deformity, 10.1% of the latter being severe enough to warrant surgical correction; and Regan and Chatterton (1946) report a series of 36 cases with four (11%) severe deformities. Both groups of authors attribute the deformity to faulty technique resulting in partial failure to close the epiphysial line, and Regan and Chatterton combine repetition of the epiphysiodesis locally with correction of the developed deformity.

Phemister described his procedure thus: "A piece of cortex 3 cm. by 1–1.5 cm. wide is excised, crossing the cartilaginous disk and including 1 cm. of the epiphysis. The sides of the cartilaginous disk anterior and posterior to this are chiselled out to a depth of approximately 1 cm. and the transplant is reinserted with its ends reversed." Most surgeons have modified the operation in the direction of greater thoroughness, and it is certain that the stressing of this point alone will reduce this serious deformity rate to a negligible minimum. The procedure advocated by Wilson and Thompson would appear from their subsequent report (Straub, Thompson, and Wilson, 1945) to be insufficient when applied by the various surgeons doing this procedure at any one clinic.

A more thorough operation (Figs. 1 and 2) is accomplished by removing a block of bone containing a great deal more than the cortex. The full depth of the epiphysial plate will accommodate a narrow spoon or curette, with which to remove the cartilaginous seam and make adequate contact between the approach on the two sides. The use of diathermy completes the destruction of the growing cartilage cells throughout the operative fields. The result is so large an area across which fusion must rapidly occur that the remaining two triangles of epiphysial cartilage are suppressed, and even should they function for a while they would from their very central and symmetrical locations produce no deformity. Epiphysiodesis should be evident radiologically within three months (Figs. 3 and 4).

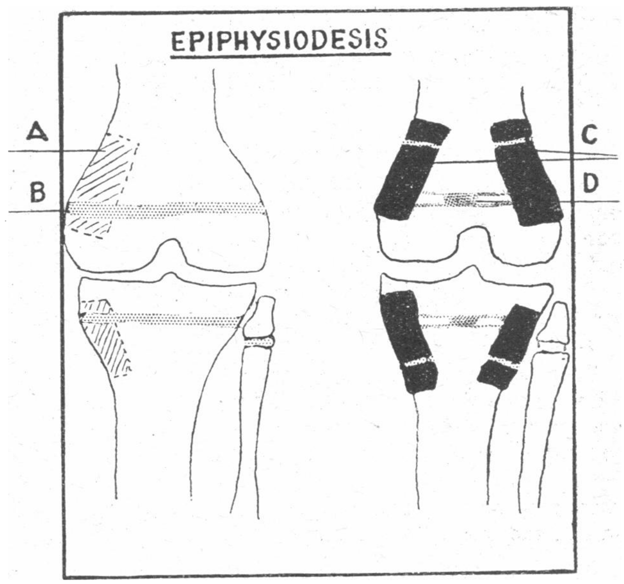



FIG. 1.

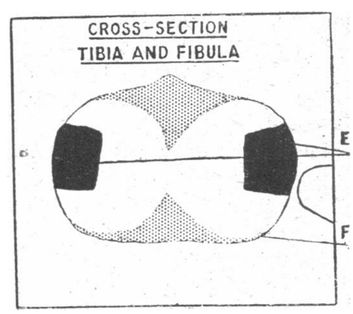
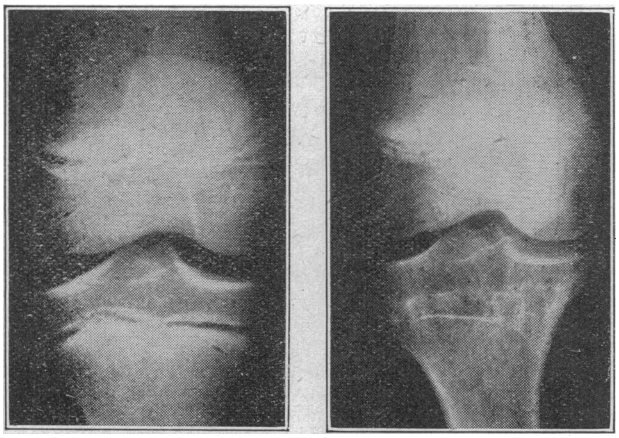



FIG. 2.

FIGS. 1 AND 2.—Diagrammatic representation of operation of epiphysiodesis, with extensive removal of epiphysial plate to avoid all risk of deformity. A, Bone block for removal. B, Epiphysial line. C, Blocks of bone reversed and replaced. D, Removal of epiphysial cartilage from side to side; triangles remain anteriorly and posteriorly. E, Blocks of bone reversed and replaced. F, Remaining triangle of epiphysial cartilage.

Epiphysiodesis can be performed only during the period of active epiphysial growth, but surgical bone-shortening can be done at any age, though it is better delayed until growth has finished. If bone-shortening is carried out during the period of growth, allowance must be made for the fact that the operation itself causes stimulation of growth because of the resulting hyperaemia of the bone. The shortening required will therefore be rather more than that suggested by pre-operation measurements. For any surgeon who practises epiphysial arrest the logical procedure when faced with a patient in an older age group is surely to perform surgical bone-shortening. The outcome is the same whether the loss of stature results immediately or is designed to occur over a period of years.

The procedure of surgical bone-shortening is very much older than leg-lengthening and, according to Wilson and Thompson (1939), Sayre in 1863 advocated fracturing the femur and allowing the fragments to overlap to the required amount, but Standler attributes the first operation of leg-shortening to Rizzoli.



FIGS. 3 AND 4.—Good radiological evidence of closure of epiphysial line three months after operation.

Femoral shortening has commonly been performed, and a number of cases are reported in support of Hey Groves's (1931) contention that the femur might be shortened by 25% of its length—4 in. (10·cm.)—with "perfect impunity."

A search of the literature reveals various methods, but a straightforward lateral overlap as advocated by Warren White in 1920 with transfixing screws seems to commend itself because of its very simplicity and freedom from the risk of technical complications, which occasionally occur with the use of such refinements as step cuts or long oblique cuts. With straightforward lateral overlap and transfixing screws the immobilization is excellent, the alignment certain, and the muscular damage minimal, as the operation can be performed through a short exposure. This method of femoral shortening is illustrated in the following case.

### Case 1

A girl aged 11 had within a few days of her birth suffered from a haemorrhagic condition leading to the disorganization of her knee and gangrene of a number of her toes. Various operations had been performed on her knee, leaving her at the age of 11½ with an ankylosis of the knee, a closed upper tibial epiphysis, and 4-in. shortening of the leg. The shortening was largely below the knee, but the lower leg was normally muscled—a deterrent even to those who support bone-lengthening. It was decided to equalize the leg lengths by femoral shortening and to equalize future growth by suppression of the upper tibial epiphysis—both these operations to be performed on the normal leg. Her height at the time was 4 ft. 10 in. (147.3 cm.), and at 13½ years she measured 4 ft. 10½ in. (148.6 cm.), her mother's height being 5 ft. 3 in. (160 cm.). In this case, 4-in. shortening was effected through a 5-in. (12.5-cm.) muscle incision, 2 in. (5 cm.) of bone being removed and an overlap of 2½ in. (6.3 cm.) allowed owing to the obliquity of the saw cuts (Fig. 5). Although we were operating on 8 in. (20 cm.) of femur, the muscle incision was no longer than 5 in., the full exposure of the two pieces of femoral shaft being delayed until overlapping was being effected. This procedure proved simple, and there was not much shock. No form of external immobilization was used.

Hey Groves (1931) wrote that "it is remarkable how the slack of 4 in. of muscle is taken up within a few months and the full muscular power of the leg regained." This proved to be the case in this girl. Convalescence was complicated by the performance of an upper tibial epiphysiodesis (Fig. 4) seven weeks after the femoral shortening, so that one is not able to quote a date on which she succeeded in straight leg-lifting—a landmark in the recovery of strength in the quadriceps muscle. The joint movements and muscular control were quite unimpaired after a lapse of five months.

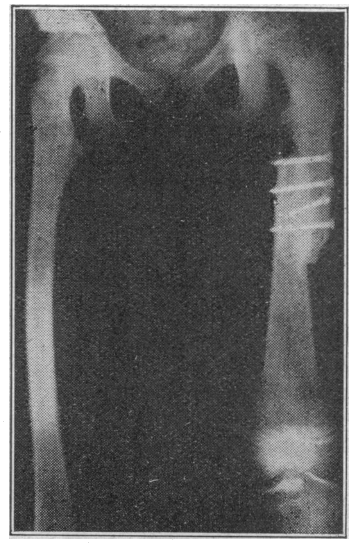


FIG. 5.—Case 1. Showing 4 in. (10 cm.) of shortening by resection of 2 in. (5 cm.) of bone, 2½ in. (6.3 cm.) overlap, and transfixing screws.

The features of this case are: (*a*) the presence of an ankylosed knee on the short leg, allowing of the whole 4 in. being taken from the femur, although both femur and tibia contributed to the shortening; (*b*) the well-muscled short leg, making leg-lengthening a greater hazard than in the more usual case with paralysis; (*c*) the simplicity of the procedure, with minimal risk of complications and a quick result.

Another technique of femoral shortening which can be recommended is illustrated in Case 2. Femoral shortening should be practised high in the shaft, and the use of a Blount plate gives good fixation after such an operation.

### Case 2

The patient, a woman with severe Still's disease, had a stiff knee on the short leg, allowing of the shortening being effected entirely in the femur. A corrective osteotomy was required on the long leg as well as 4 in. of shortening, and both procedures were performed in the femur just below the great trochanter; fixation was effected by a Blount plate. Leg equalization was done in this case without immobilization of joints—a very necessary precaution in a case of Still's disease. The patient was walking again within two months of the operation.

Surgical bone-shortening can also be performed in the tibia either by resection transversely and plating, or by resecting obliquely and using screws transversely placed to fix the bone ends.

### Summary of Conclusions

Where an inequality of leg length of over 1½ in. is present or is to be anticipated one may arrive at the following conclusions.

1. Bone-shortening is the preferable approach to all cases with the exception of the few who are unwilling or who can ill afford to sacrifice any height.

2. Some surgeons seem far more willing to practise leg-shortening by epiphysiodesis than to attack an older patient by surgical bone-shortening, logically the equivalent operation for an older age group.

3. A very thorough technique is required in epiphysiodesis to avoid deformities, and a more extensive operation than that advocated by Phemister is therefore described.

4. Epiphysiodesis is often performed at too late an age for the desired results to be obtained.

5. Surgical bone-shortening is a safe procedure, and certain and quick in its results—considerable attributes in purely elective surgery.

6. Surgical bone-shortening is preferable in the femur, and two methods are advocated: (*a*) straightforward lateral overlap with transfixing screws; and (*b*) excision of a segment below the lesser trochanter and fixation with a Blount plate.

7. Two further examples of a 4-in. femoral shortening with full return of knee movement and control within three to five months are reported.

In spite of the more challenging nature of leg-lengthening, an attempt has been made to demonstrate that leg-shortening has more to recommend it. Its adoption as the wiser procedure is advocated in most cases presenting with leg inequality sufficient to warrant surgery yet too old for treatment solely by epiphysial arrest.

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The New York Academy of Sciences, the fourth oldest scientific society in the United States—it was founded under a different name in 1817—recently elected a number of new foreign honorary life members, bringing the total of scientists so honoured in its 134 years of existence to 66. Among this latest addition to the roll were several medical men: Professor C. H. Best, of Toronto, co-worker of Banting in the first preparation of insulin and an authority on metabolism; Dr. J. B. Collip, well known for his work on the parathyroids and mineral metabolism; Sir Frank Burnet, of Melbourne, the great authority on virus diseases; and Professor Bernardo Houssay, of Buenos Aires, 1947 Nobel prize-winner in medicine and biology, who has worked on a wide front in endocrinology, and particularly on the pituitary in diabetes and on experimental hypertension. The other scientists were Professor W. T. Astbury, of Leeds (biophysicist), Professor Harold Jeffreys, of Cambridge (geophysicist and astronomer), Professor N. V. Sidgwick, of Oxford (organic chemist), Professor H. R. Kruyt, a Dutch physical chemist, Dr. Eduardo Cruz-Coke, a Chilean biochemist, and Professor J. Runnstrom, of Sweden, who has spent many years studying fertilization and early embryonic development in sea-urchin eggs.

# SIX BLOOD-GROUP ANTIBODIES IN THE SERUM OF A TRANSFUSED PATIENT

BY

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The purpose of this note is to call attention to another instance of the formation of multiple blood-group antibodies after transfusion. The recipient was suffering from an undiagnosed collagen disease. The name "collagen disease" is conveniently used in the United States to denote a group of diseases, such as periarteritis nodosa and lupus erythematosus, which are of unknown aetiology but have certain common characteristics.

Sera containing multiple antibodies have twice before been reported. One of the donors was suffering from lupus erythematosus (Callender and Race, 1946) and the other from "osteosclerosis and extramedullary haematopoiesis" (Collins, Sanger, Allen, and Race, 1950).

### Case History

The patient, a 30-year-old negro, was admitted to the Veterans Administration Hospital, Richmond, Va., on December 12, 1949, complaining of nausea, vomiting, and severe abdominal pain of about 12 days' duration. His illness began six years previously, and consisted then of migratory polyarthritis and serous pericarditis. A year later he was discharged from the Services, and at that time his skin and lips showed increased pigmentation. He had at one time suffered from exfoliative dermatitis subsequent to sulphonamide therapy. Ten months before admission he was in hospital for an undiagnosed condition which manifested itself by attacks of arthritis, angioneurotic oedema, endocrine dysfunctions, and gastro-intestinal irritability.

During the last few months he developed symmetrical, scaly, dry, pigmented lesions over the deltoid and infraclavicular regions.

It has not been possible to discover whether the patient was transfused during either of his stays in hospital: on neither occasion was he in a Richmond hospital.

Shortly after admission the patient was given three blood transfusions in one week (Table I) because of a severe hypochromic normocytic anaemia. Five days after the third transfusion he was noticed to be severely jaundiced, and his urine was blood-stained. Approximately six weeks

TABLE I.—*Transfusions of Patient*

| No. | Date | Group of Donor | Reactions |
|---|---|---|---|
| 1 | Dec. 23, 1949 | B, Rh+ | |
| 2 | ,, 28 | B, Rh+ | |
| 3 | ,, 30 | B, Rh+ | |
| | Jan. 5, 1950 | | Severe haemolytic reaction |
| 4 | Feb. 28 | B, cDe/cde, S−* | No reactions |
| 5 | March 8 | B, cDe/cde, N, S− | |
| 6 | ,, 24 | B, cde/cde, S− | |
| 7 | ,, 29 | B, cDe/cde, N, S− | |
| 8 | May 10 | B, cde/cde, N, S− | |
| 9 | ,, 10 | O, cde/cde, N, S− | |
| 10 | ,, 18 | O, cde/cde, N, S− | |
| 11 | ,, 18 | O, cde/cde, N, S− | |

* The absence of S was presumed from the compatible cross-match; no other anti-S serum was then available in Virginia.