
CLINICAL ARTICLE

Simultaneous joint fusion and limb lengthening for knee deformities in children: a one-stage procedure

The Kampala experience

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Abstract

Background:

Delay in the treatment of septic or tuberculous arthritis of the knee often results in a painful and stiff joint, mainly in a position of flexion. Often limb shortening is also present. A clinical study was undertaken to see what the long-term results of a one-stage procedure is, whereby an external fixator is used to achieve fusion of the knee and limb equalisation simultaneously by means of distraction of the callus at the arthrodesis site.

Method:

Seven children, with a mean age of 13.5 years at presentation, were included in this study. Four children had septic arthritis and three had tuberculosis. All children had the same procedure. The deformity was corrected and an Orthofix device applied. After seven days, distraction of the arthrodesis site was started and continued until the desired length was obtained. Screw replacement was necessary in five cases due to pin-track infection.

Results:

A stable, painless, well-aligned limb was obtained in all the patients and they were able to walk unsupported. Complete correction of limb length discrepancy was obtained in five patients and partial correction in the remaining two cases.

Conclusion:

Knee arthrodesis is a suitable option for managing severe deformities in children and young adults as it results in a stable and painless limb and eliminates the use of walking aids. In cases where leg length discrepancy is also present, the fusion can be achieved simultaneously with the equalisation process. Our experience has shown that this is a worthwhile clinical procedure which can result in a marked improvement in the quality of the life of these children.

Introduction

In developing countries, orthopaedic surgeons frequently assess patients whose disability is caused by untreated or improperly managed pyogenic or tuberculous bone and joint infection.¹ In children, the delay in treatment of septic arthritis and osteomyelitis may result, on the one hand, in painful deformed and stiff joints frequently associated with contractures and, on the other hand, it can lead to spontaneous ankylosis, usually in an unacceptable position.^{2,4}

In the knee, the end result of untreated or badly managed infections is usually unacceptable and also accompanied by limb shortening. In these cases, the therapeutic approach should be to fuse the joint and address the leg discrepancy at the same time. We suggest that both be achieved simultaneously. Firstly the arthrodesis of the joint is addressed, followed by correction of the leg discrepancy. A single or double osteotomy of the femur and/or tibia may be necessary.

By using an external fixator, fusion of the joint takes place while the leg is lengthened.

The concept of distraction of callus at the arthrodesis site is very well known.⁵

Materials and methods

This study includes seven patients who were treated at the Comprehensive Rehabilitation Services in Uganda (CoRSU) between January 2002 and June 2007. There were four males and three females, with an average age of 13.5 years. The youngest was eight and the oldest 17 years at the time of operation.

In the first group, four patients had a history of pyogenic arthritis of the knee. One patient also had a history of

osteomyelitis of the distal third of the ipsilateral humerus, while another patient presented with an open sequestrum of the ipsilateral tibia. In the second group all three patients had tuberculosis of the knee joint. *Table 1* shows the relevant data of the patients enrolled in this study.

At the time of the first assessment, all the patients were unable to walk unsupported, and used a long stick to move around. The affected knee had a fixed flexion contracture; in five patients it was more than 95°, while in the remaining two it was between 30° and 50°. A varus deformity of 30° was noted in one patient, while external rotation of the leg was present in two patients. Although all had some shortening of the affected limb, it was difficult to quantify this pre-operatively because of the fixed position of the joint.

Before surgery a full blood count and an ESR were done. Standard X-rays of the limbs were taken. As part of the operation, a biopsy of all patients was taken.

The surgical procedure was the same for all the patients. A pneumatic tourniquet was routinely used and the operation time averaged 55 minutes. A curvilinear transverse incision was used. This allows good exposure of the joint.

The arthrodesis was carried out in a standard way, chiselling out an adequate wedge-shaped bone block, with its base anteriorly placed, and trimming the femoral and tibial ends in such a way as to obtain a normal axial alignment without excessive tension on the neurovascular bundle. The cartilage of the patella was removed and it was used as an anterior bone graft. The arthrodesis was then stabilised by the use of an external fixator (Orthofix lengthener), placed anteriorly. Four screws were routinely used, bridging the joint, in the decided position (10° of flexion, 5° of valgus and 5° of external rotation).

Table I: Patient data

| No. | Initials of patient | Age/sex (years) | Side | Cause | Flexion contracture at presentation (degrees) | Lengthening in cm | Fixator applied for number of days | BHI | Complications | Notes |
|-----|---------------------|-----------------|------|------------------|---|-------------------|------------------------------------|-----|-------------------------------------|---|
| 1 | TH*** | 13 F | R | Septic arthritis | 50 | 13 | 297 | 23 | Screws loosening | |
| 2 | NS | 14 F | R | Septic arthritis | 110 | 5.5 | 176 | 32 | Sudek's atrophy | Skin biopsy to rule out neurofibromatosis |
| 3 | BA* | 8 M | R | Septic arthritis | 95 | 6 | 326 | 54 | Screws loosening | Over-lengthening of 1.5 cm |
| 4 | NB | 16 F | R | TB | 100 | 15 | 440 | 30 | | |
| 5 | AK** | 17 M | L | TB | 90 | 4 | 217 | 54 | Screw loosening, with osteomyelitis | Percutaneous ATL Sequestrectomy |
| 6 | KJ | 17 M | L | Septic arthritis | 110 | 3.5 | 112 | 32 | | |
| 7 | TR*** | 11 M | R | TB | 30 | 6 | 200 | 33 | Screws loosening, drop foot | Percutaneous ATL |

ATL: Achilles Tendon Lengthening, BHI: Bone Healing Index. Obtained by dividing the number of days with fixator by the centimetres of lengthening, *: a sequestrectomy was performed before the procedure, **: an open biopsy was carried out before the procedure, ***: There was associated external rotation of the leg (70–80°)

No compression was applied. Only in the oldest patient of the series were six screws used. No image intensifier was available for screw positioning. Simple closure in layers was carried out and no drainage was used. X-rays were taken immediately after the surgery so that any adjustment could be carried out as deemed necessary.

Measurement of the limb discrepancy was performed with the patient in the standing position, usually during the second or third day after surgery using wooden blocks and checking the position of the superior iliac spinae. Only in the cases where limb discrepancy exceeded 2.5 cm, lengthening was started a week after surgery by distraction through the callus of the arthrodesis at a rate of 1 mm per day. Seven patients qualified for the lengthening procedure. In the postoperative phase, patients were admitted to a rehabilitation centre where the lengthening process continued under supervision. A radiograph was taken during the postoperative period to ensure that the screws were well positioned and that the bone segments were well aligned. Blood supply of the foot was monitored carefully in the early postoperative phase. Four to five weeks after the start of the lengthening process another X-ray was taken. In cases where complications were suspected, radiographs were taken more often. Before removing the fixator, corticalisation of the regenerated area had to be present on X-ray films in order to avoid fractures of this area.

All the patients were contacted and reviewed. The mean follow-up time was 41.5 months, with a minimum of 16 and a maximum of 68 months.

Results

All patients went on to bony fusion. Disuse atrophy was present in all the cases. According to the radiological classification by Kerri and Martini in 1985,⁶ the three cases of tuberculosis of the joint were classified as stage 4. The ipsilateral hip joint was unaffected in all the patients in our series. One patient had laxity of the ipsilateral ankle joint with radiographic signs of early joint degeneration; there was enlargement of the whole limb with enlarged veins visible. Biopsy did not reveal signs of neurofibromatosis.

Two patients had had previous surgery for the treatment of osteomyelitis and one patient had an open biopsy of the knee. All patients received some form of local treatment and all had multiple scars around the knee joint, as a result of cut wounds by traditional bone-setters. There were signs of active infection in two patients. One had TB arthritis with four open sinuses around the joint. This patient had a gibbus in the lumbar spine as a result of collapse and fusion of vertebral bodies of L3 and L3. The second one presented with tibial sequestrum of the knee. Another two patients, with TB arthritis, presented with wide scars around the knee.

In the postoperative phase, all patients used axillary crutches. Weight-bearing was allowed when it was comfortable for the patient. All of them experienced an important subjective improvement just a few days after the operation as the fixator allows partial weight-bearing in the immediate postoperative period.

In one case it was necessary to change the fixator and adjust the arthrodesis to mild flexion to restore good blood supply to the extremity. The Orthofix lengthener was then applied again three days later to obtain the desired position. There was need for revision of the implant in four patients following failure due to septic loosening of the screws. Minor pin-tract infections were treated with antibiotics per os and pin care. The three patients with tuberculosis of the joint were given a six-month multi-drug treatment according to the Ugandan TB protocol of that time. One patient developed Sudek's atrophy of the ipsilateral foot. Two patients needed a percutaneous lengthening of the Achilles tendon. One patient got osteomyelitis of a screw hole after removal of the ring fixator and had to have simple curettage.

One patient had to wear a drop-foot splint due to overstretching of the common peroneal nerve. No fractures of the regenerated bone occurred.

All the patients had a sound arthrodesis of the knee. However, correction of the leg-length discrepancy was incomplete in two of them. In one of them the patient did not return for follow-up at the right time, and in the other lengthening had to be stopped due to the onset of equinus of the ankle. No supporting devices were applied after the removal of the fixator. *Table 1* also shows data concerning the postoperative period of each patient, including the amount of bone lengthening as well as the bone healing index.

During the follow-up, the alignment of the knee was clinically good and there was no complaint of pain. All were able to walk unsupported, even for long distances and the limb was rated as stable by all patients. Leg equalisation was obtained in five patients; a shoe-raise of 1.5 cm was necessary. Poor compliance in the postoperative phase led to incomplete correction of the limb discrepancy in one patient, whereas in the other, distraction had to be stopped because of the onset of deformities in the adjacent joints. Common radiographic findings were good alignment of the arthrodesis and sound bone regeneration. In one case the lengthening seems to have been achieved through the growth plates of the tibia and femur according to a process of chondrodiatasis (*Figure 1 a-f, Figure 2 a-i*).

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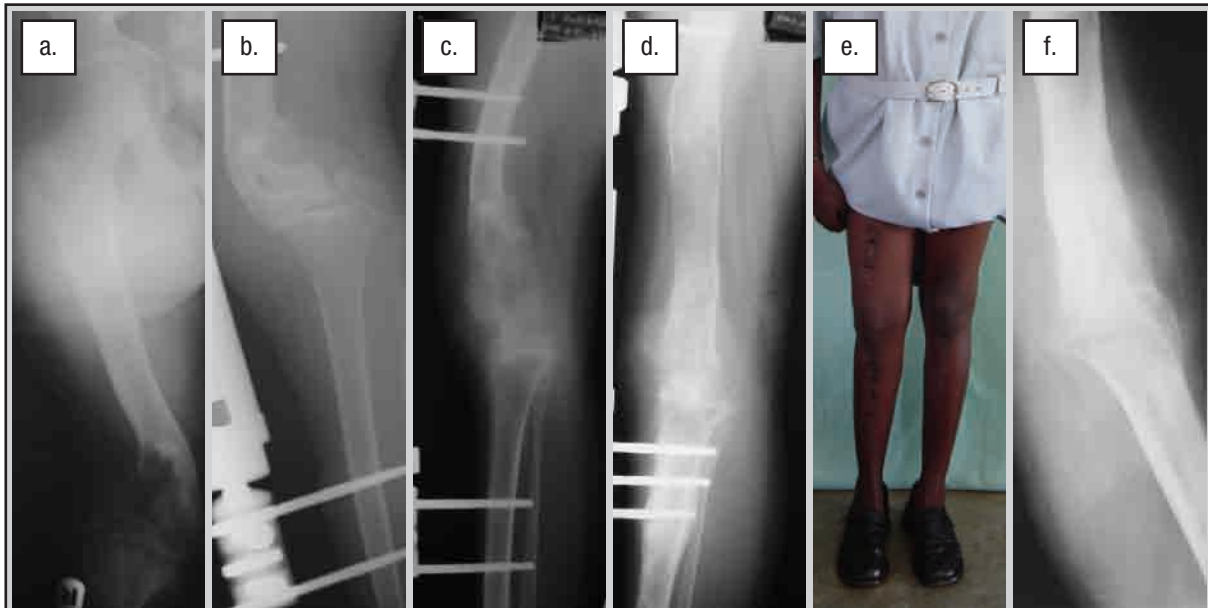


Figure 1: Septic arthritis of the knee

- a. A radiograph taken at the time of our assessment showing loss of the lateral femoral condyle, disruption of the knee joint and shortening of the femur. Clinically the knee was in fixed flexion and the leg was externally rotated.
- b. Implant of external fixator and correction of the axis
- c. Distraction osteogenesis two months after surgery
- d. A radiograph taken 10 months after the initial procedure, just before the removal of the fixator. Loosening of screws demanded earlier revision of the implant. A sound arthrodesis and 13 cm of lengthening bone were simultaneously obtained.
- e-f: Clinical and radiographic controls taken 20 months after the initial procedure. The patient was able to walk unsupported, even for long distances. The limb was stable and painless with a good alignment, and leg length was restored.

Discussion

Knee arthrodesis is especially useful for young adults, because they are in need of painless and weight-bearing limbs for many years to come. A functional limb, even when fused, can give them the ability to walk independently. For children with proximal focal femoral deficiency⁷ or in cases of resection surgery for malignancies around the knee, arthrodesis of the knee is still considered by many to be a valid option.⁷ In older patients, it can be a salvage procedure after a failed total knee replacement, post-traumatic deformities and pain, uncontrollable infections with joint destruction or neuropathic joint disease.⁸ Moreover, in cases of joints severely damaged by septic or TB-specific arthritis, arthrodesis enables the patient to have a stable, painless and well-aligned limb.

At CoRSU, patients were advised to undergo joint fusion when there was a history of septic or TB-specific arthritis, pain, deformity in different planes, established ankylosis in a poor functional position, and/or marked destruction of the knee joint.

While planning an arthrodesis, several factors should be considered. One of these is leg length discrepancy, which could be present at initial presentation or which could follow as a consequence of the procedure itself. In children the eventual length discrepancy is related to the age of the patient at the onset of the disease, including damage of the growth plates. Maintaining length is an important issue in this type of surgery and in order to avoid excessive limb length discrepancy, there are different techniques such as bone grafts, bone lengthening after a solid union is achieved, simultaneous lengthening through a nearby osteotomy site, or reducing the growth rate of the opposite limb.

The current view is that compression has to be applied in order to have union, by using external fixators, plates, nails, crossed screws or pins, supported by POP. Technically speaking, knee arthrodesis can be achieved by external and internal means of fixation. An important element is the application of firm compression of the bony surfaces until solid union is obtained.⁹ This type of intervention mainly requires good apposition of the surfaces and firm stability.

Our experience, however, suggests that leg equalisation and simultaneous knee fusion can be obtained through progressive callotasis at the site of the arthrodesis. In the current literature, no reports have been found describing the use of this method due to arthritis or osteomyelitis in children and young adolescents. De Pablos *et al*¹⁰ reported on a case of a 14-year-old boy with a congenital deformity of one limb where lengthening was obtained equally at the site of arthrodesis and at the tibial epiphyseal plate. Said *et al*¹¹ reports on two cases where the technique of resection-shortening-distraction was employed for malignant bone tumours. In one case, fusion was obtained first, followed by lengthening later on during two different procedures. In the other case, however, lengthening was obtained through the arthrodesis site using an Ilizarov frame. Distraction only started three weeks after the excision of the tumour.

Recently, Tomak *et al*¹² reported on a case of fusion of the knee and lengthening of the limb through the arthrodesis site in a 47-year-old woman with a flexion deformity following a thermal injury.

The two groups of patients eligible for knee fusion at CoRSU were distinguished by their postoperative limb discrepancy. The first group included patients for whom, at the time of surgery, good limb alignment could be obtained without resection of a big piece of bone. Although there might be slight shortening of the limb, this is acceptable if it is in the range of 1 to 2.5 cm. In these cases, only a shoe-raise is needed. The second group included patients with a limb discrepancy of more than 2.5 cm. Especially in young children who sometimes have damaged growth plates, which would cause a further difference in limb length at the end of their growing period, the axial correction should be combined with an equalisation of the limb length. This can

be done through progressive distraction of the callus using an external fixator. The arthrodesis can be obtained together with limb equalisation, resulting in stable, well-aligned, pain-free, weight-bearing limbs.

The external fixator provides stability, does not require internal means of fixation, is always accessible for external manipulations, facilitates wound care and allows early mobilisation of the patient. Furthermore, it is considered a good choice in the presence of a history of infection. The Orthofix lengthener has proven to be mechanically reliable for this procedure. When available, hydroxyapatite-coated screws should be used in order to decrease the risk of aseptic loosening, specifically of the screws.

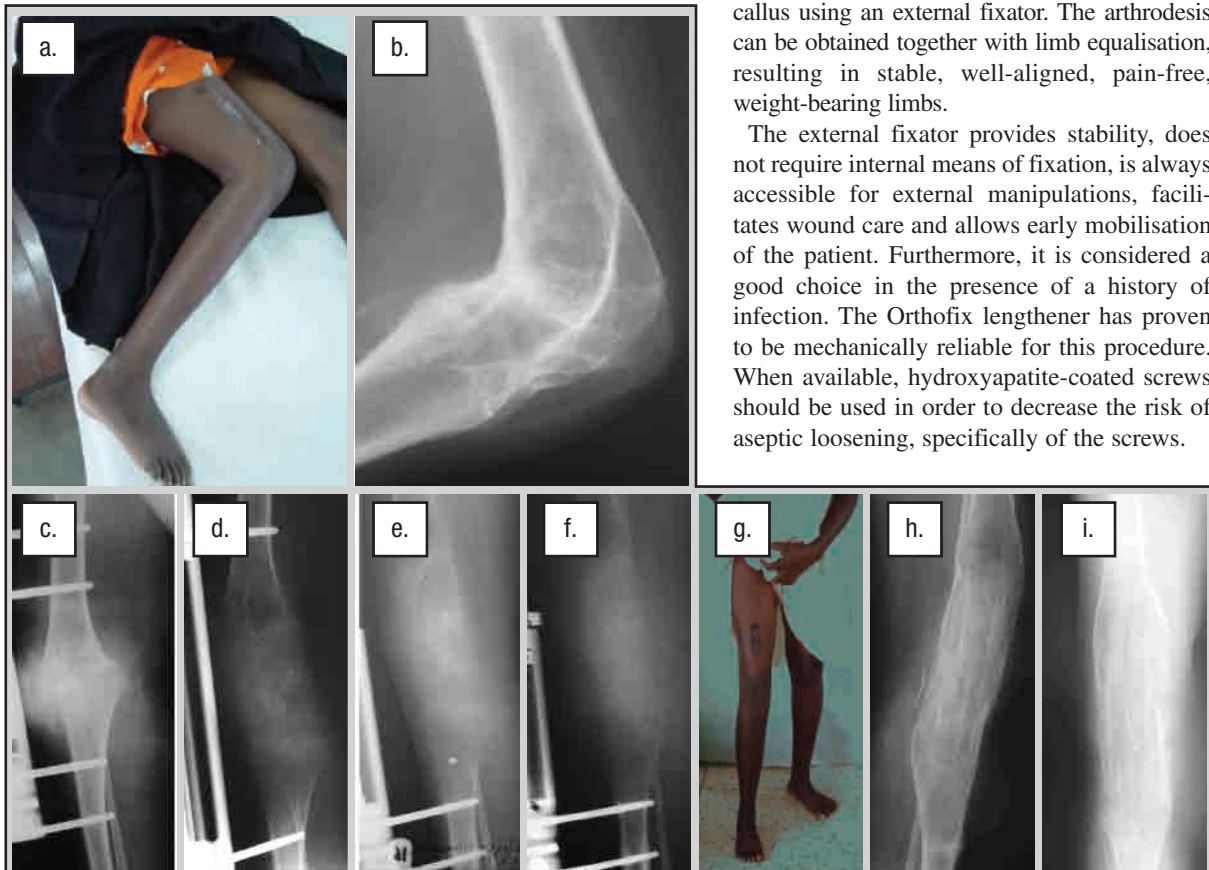


Figure 2

a-b: Result of tuberculosis of the knee joint. The patient at presentation: spontaneous arthrodesis in flexion can be noted.

c-f: Progressive distraction osteogenesis: at four months after surgery (d); at six months (e); and at eight months (f). The end result was a lengthening of 15 cm.

g-i: Clinical and radiographic pictures taken 18 months after the initial procedure. There is a sound arthrodesis, good alignment, and leg equalisation has been achieved. The patient was able to walk without support and the limb was painless and stable.

Iatrogenic fractures can occur at the site of the pins, especially in slender and fragile bones that are encountered in children who have been bedridden for a long time. The use of the appropriate screw size may lessen the risk of these fractures.¹³ In addition fractures can complicate deep pin-tract infections. The screws should be replaced when there are clinical and/or radiographic signs of loosening to avoid instability of the implant and axial deviation.

When comparing radiographs taken at the end of the procedure with those of other patients who underwent bone lengthening at corticotomy level, no apparent difference in the formation and maturation of bone can be seen. The rate of growth is similar, the bone healing index remains within normal range, and the texture of the new bone shows similar features.

Conclusion

Post-infection knee deformities in children may require arthrodesis of the joint in order to obtain a stable and painless limb. When the deformity is combined with an important limb discrepancy, the current trend is to achieve knee fusion first and address the limb discrepancy later.

In cases where limb discrepancy is more than 2.5 cm after surgery for the arthrodesis of the knee, simultaneous knee fusion and correction of length discrepancy can be achieved by using an Orthofix lengthener. This procedure is carried out by callotasis at the arthrodesis site and requires only one surgical procedure.

The authors state that no benefits of any form have been received from a commercial party related directly or indirectly to the subject of this article. Furthermore they state that all the subjects enrolled in this study have given informed consent and that the ethical committee of their institution approved the study.

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