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ORIGINAL STUDY

Surgical management of rickets-like bone deformities (knock-knee and bow-leg) in children in sub-Saharan Africa

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Rickets-like deformities of the lower limb (knock-knee or bow-leg) are very frequent in sub-Saharan Africa. A prospective study was carried out over a period of 5 years. Forty-eight children were treated surgically for rickets-like deformities. The surgical technique was guided growth using a tension-band plate (eight plate). One patient was lost to follow-up. The technique failed in two cases (absence of correction in one case and hypercorrection in one case). Five patients are still under follow-up with progressive correction and were excluded from the study. A full correction was achieved in 40 patients (73 knees). There were 33 bilateral and 7 unilateral deformities. The deformities were knock-knees in 20 cases, bowlegs in 18 cases and there were 2 windswept deformities Good correction was obtained after a mean time of 11.4 months for genu varum and after a mean time of 12.4 months. The two windswept deformities were corrected after 8 and 9 months respectively. The guided growth technique using eight plate is effective as well in Africa. The needed material is not expensive if a two-hole tubular plate is used with two 3.5 screws.

Keywords : rickets ; rickets-like bone deformities ; guided growth ; eight plate.

INTRODUCTION

Knock knees (genu valgum) and bowlegs (genu varum) are frequent in sub-Saharan Africa. Nutritional rickets is the usual cause and is one of the most frequent childhood diseases in many developing countries *(5)*. The main cause of rickets is vitamin D deficiency, although rickets in Sub-Saharan Africa, India and Bangladesh may be due to calcium deficiency without vitamin D deficiency *(8)*. When the deformity is not clearly due to active rickets with vitamin D deficiency, it can be called "rickets-like" bone deformity.

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Physiological genu varum is present between 0 and 2 years while physiological genu valgum is present between 2 and 6 years with a maximum angulation at 3 years. When the axial deformity does not correspond to the physiological age range or when it is very severe, rickets or Blount disease have to be suspected. Radiograph can be helpful to show rickets signs or Blount disease.

A very efficient surgery to correct pathological genu varum or valgum in children is guided growth technique. This consists of temporary hemi-epiphysiodesis by tension-band plate *(4)*. By using eight plates, the effect of epiphysiodesis is reversible. The material is not expensive as 1/3 tubular plate can be used and can be used many times. The surgical approach is minimally invasive.

The aim of this study is to report the result of this technique in a developing country.

PATIENTS AND METHODS

This is a prospective study over a 5 years period (October 2012 to September 2017), conducted at the Saint Jean de Dieu Hospital in Tanguiéta, level 4-hospital, based in Northern Benin. The surgeries were performed in collaboration with a team of surgeon of "Chain of Hope Belgium". Were included into the study, all children suffering from uni- or bilateral axial knee deformity and treated by guided growth. The exclusion criteria were: combined surgery (guided growth and osteotomy).

Surgery: All patients preoperatively received a standard radiograph of both knees to exclude epiphysiodesis and to diagnose rickets or Blount disease. Radiographic changes of active rickets are visible at the growth plate. There is expansion of the cartilaginous growth plate (the lucent gap between metaphysis and epiphysis expands) and there is delayed mineralization *(11)*. Severity of rickets can be graded according to Thacher's criteria *(11)*. To exclude Blount disease, the metaphyseal-diaphyseal angle of the proximal aspect of the tibia was used. In case of rickets-like deformity, no sign of active rickets nor Blount disease was observed. Standing full-length radiography of the lower limbs were not accessible in this developing-country hospital. The deformity magnitude was clinically evaluated by the intercondylar distance for bowlegs and by the intermalleolar distance for knock-knees.

The surgery was performed under rachi-anesthesia without use of a tourniquet. First a K-wire was inserted horizontally into the growth plate under C-arm control and a longitudinal mini-open approach (3 to 4 cm) was performed centered on the wire. A true eight plate was used in 9 cases with cannulated screws. In all the other cases, a 2 hole-1/3-tubular plate was used with cortical 3.5-screws. The length of the screws was more than 20mm (between 20 and 40mm). One of the two screws was inserted into the epiphysis and the other one into the metaphysis without damaging the growth plate. In all cases, two plates were used, one for the distal femur and one for the proximal tibia (at the medial side for knock knee and at the lateral side for bowleg). In the postoperative period, the children were allowed to walk as soon as possible. No physiotherapy was prescribed.

A close clinical follow-up (every 3 months) was performed to control the correction. The evaluation was clinical with goniometric measure of the tibiofemoral angle and with measure with a ruler of the intercondylar distance (for genu varum) and the intermalleolar distance (for genu valgum). The tibiofemoral angle was measured according to the method described by Arazi et al. *(2)* with a goniometer. The children were in standing position with patella pointing forward. Either both knees or both ankles were just touching each other. The first line was the line from anterior superior iliac spine to the midpoint of patella. The second line was the line from midpoint of ankle (midpoint between the medial mallelolus and lateral malleolus) and midpoint of patella. The tibiofemoral angle was positive for varus knee alignment and negative for valgus knee alignment.

Full correction of the deformities was obtained when the intercondylar distance or intermalleolar distance was less than 4 cm and when the tibio-femoral angle was between -6 to 0 degrees. The plates were removed when the correction was achieved.

RESULTS

During the study period, 48 children were operated by guided growth.

One patient was lost to follow-up and 5 patients were still under follow-up with non-achieved correction (progressive correction).

Two patients had failure of the technique. One patient with bilateral bowlegs had no effect of guided growth after one year. In this patient, the plates were removed and bilateral tibial osteotomy was performed. One another patient initially with knock-knees presented later than foreseen follow-up with bowlegs. The plates were removed but he kept slight bowlegs.

In our series 40 children obtained good result. A complete deformity correction was obtained and the plates have been removed. The mean age of these 40 children at the time of surgery was 5.1 years with extremes ranging from 3 to 15 years. There were 31 boys and 9 girls (sex ratio M/F was 3.4). The deformity was bilateral in 33 patients and unilateral in 7 cases (73 knees in total). The deformities were knock-knees in 20 cases (Figure 4), bowlegs in 18 cases (Figures 1 and 2) and there were 2 windswept deformities (associating unilateral genu varum and contralateral genu valgum ; Figure 3). The mean intercondylar distance of the children with genu varum was 11.9cm (SD 4.6cm; range, 6 to 24 cm). The mean intermalleolar distance in genu valgum was 16.7cm (SD 7.8cm; range 8 to 32 cm) (Table I).

Etiologies are summarized in Table II. There were mainly rickets-like bone deformities, probably due to calcium deficiency. A familial context of knee

Figure 1. — Evolution of a genu varum in a 3-year-old girl after guide growth. Left : before correction, middle : 9 months postoperatively, right : 15 months postoperatively.

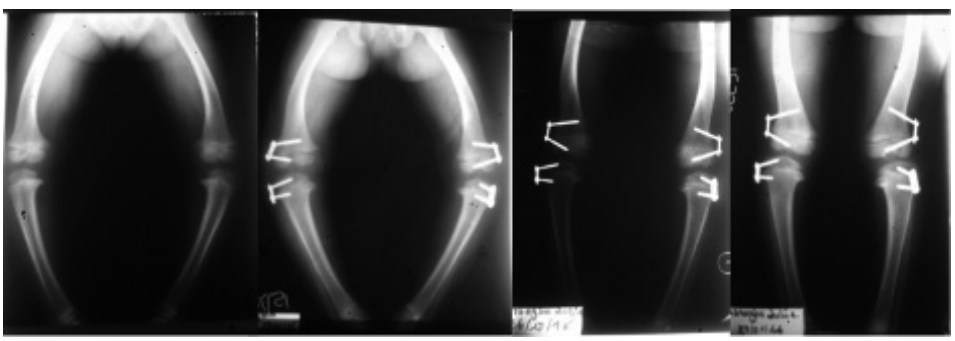

Figure 2. — Same patient than Figure 1. Radiographic evolution before correction, at 9 months postoperatively, at 12 months and 15 months.

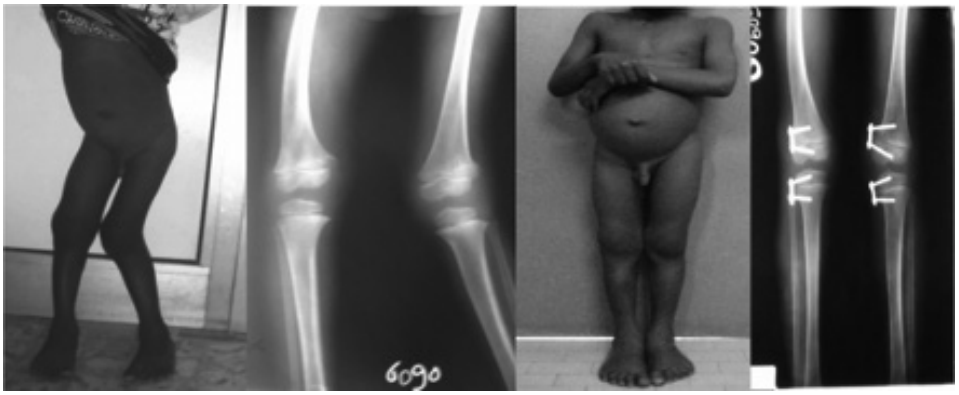

Figure 3. — 6-year-old boy with windswept deformity (right genu varum and left genu valgum). Left : preoperative picture and preoperative radiograph. Right : Result 8 months postoperatively : picture and radiograph.

Figure 4. — 14-year-old boy with bilateral asymmetrical knock-knees. Left : preoperative picture and preoperative radiograph. Right : Result 9 months postoperatively : picture and radiograph.

Table I. — Characteristic of the knee deformities (40 patients).

Side	Genu valgum	Genu varum	Windswept	Total
Unilateral left	4	1	0	5
Unilateral right	1	1	0	2
Bilateral symmetrical	12	12	2	26
Bilateral asymmetrical (right side more affected)	0	2	0	2
Bilateral asymmetrical (left side more affected)	3	2	0	5
Total	20	18	2	40

deformities was found in 25 cases. There were two cases of Blount disease and 6 cases of active rickets.

Per-operative complications were encountered in 2 cases. In two cases a drill bit broke and it was necessary to enlarge the approach to remove the drill bit. Postoperative complications were encountered in 2 cases and were transitory knee stiffness.

Full correction of the deformity was obtained after a mean time of 11.4 months (SD 4.4months, range, 6 to 21 months) for genu varum and after a mean time of 12.4 months (SD 5.7 months, range 6 to 24 months) for genu valgum. The two windswept deformities were corrected after 8 and 9 months respectively. One patient operated for a severe

Table II. — Different etiologies.

Etiology	Number of cases (percentage)
Active rickets	6 (15%)
Blount disease	2 (5%)
Rickets-like disease	28 (70%)
Osteo-chondro-dysplasia	3 (7.5%)
Incomplete post-infectious epiphysiodesis	1 (2.5%)

genu valgum (more than 40° tibiofemoral angle) achieved full axis correction but kept bilateral patellar instability that needed secondary surgical correction. Another patient operated for severe genu varum had persisting medial tibial torsion that also needed surgical correction by osteotomy.

All the eight plates were removed when full correction was obtained (less than 4cm intercondylar or intermalleolar distance and tibiofemoral angle between -6 and 0 degrees). All the 40 patients were examined 6 and 12 months after plate removal, 13 patients after 18 months and only 4 after 24 months. After 6 months, no recurrence was observed. After 12 months, 4 cases of minor recurrence were observed with intercondylar or intermalleolar distance less than 8 cm. At 18 and 24 months, no more recurrence was observed.

DISCUSSION

Rickets is a childhood disorder of bone mineralization at the growth plate. The failure of endochondral ossification leads to the development of bone deformities and a reduced growth *(7,8)*. Children may be disabled if the bone deformities are severe. There are 2 peaks of prevalence of rickets in Africa and Asia: at 3-5 years of age, and in adolescence *(7)*.

The main cause of rickets is vitamin D deficiency, although rickets in Sub-Saharan Africa, India and Bangladesh may be due to calcium deficiency without vitamin D deficiency *(8)*. In India, Aggarwal reported the role of low dietary calcium intakes in the pathogenesis of rickets in toddlers and children, in whom sunlight exposure however was not limited *(1)*. In a survey of children living in a poor rural area of Gambia (with a low calcium diet), Jones found a prevalence of 3.3% of rickets-like bone deformities in a population of children less than 18 years *(5)*. Diagnosis in this survey was based on clinical signs by a trained staff. Jones showed that the majority of these children with rickets-like deformity did not have active rickets. The prevalence was greater in males and in children less than 5 years. Knock-knees were more frequent (58%), than bowlegs (31%) or windswept deformity (9%) *(5)*. These results are very similar to our study population. In Nigeria, Thacher found a prevalence of 1.2% of radiographic rickets and 5.4% of vitamin D deficiency *(10)*. In Malawi (Africa), Braithwaite found that rickets is not due to vitamin D deficiency but to dietary calcium deficiency leading to elevated PTH resulting in increased losses of phosphate from the bone and glomerular filtrate *(3)*. In our series, the bone deformity was probably due to the same mechanism.

Another cause of bowlegs in Africa is Blount disease *(3)*. The cause remains unclear. Previously overweight or starting to walk early were suggested as risk factor, but in the study of Braithwaite, these risk factors were not found *(3)*.

Temporary hemi-epiphysiodesis can be performed using staples, percutaneous transphyseal screws, or a tension band plate. These techniques function by tethering one side of a growing physis, thereby allowing differential growth (guided growth technique). Guided growth surgery with temporary hemi-epiphysiodesis is the mainstay of treatment for lower extremity angular deformity in skeletally immature children *(6)*. Once the deformity is corrected, the hardware has to me removed to allow the tethered physis to continue to grow *(6)*.

The eight-plate was historically designed to avoid the complications experienced with staples *(9,12)*. Another theoretical benefit is less compression of the physis *(9)*. By comparison with the percutaneous transphyseal screw, eight plate has the advantage that it does not damage the growth plate and does not compromise the growth after plate removal. One disadvantage of the technique is the need of fluoroscopy to insert screws. Mini-open (3 to 4 cm long) approach is needed. The plate is placed

extraperiosteally, without physeal injury. Khadim did not find any differences in the results by using eight plate or H-plate *(6)*.

If the true eight plate is not available in Africa, a long 1/3 tubular plate can be used and cut every two holes. Classical 3.5 or 4.5 cortical screws can be used. The length of the screws is not important but the screws have to be long enough to ensure primary stability (more than 2cm). After removal, the plate and the screws can be sterilized and used again in another patients in developing countries.

Undercorrection may be a problem if the remaining growth is not enough to completely correct the deformity. Overcorrection is a common risk with guided growth. A close follow-up is mandatory because overcorrection will occur if the tension band plate is left after correction. If it is not sure that the patient is able to assure the close follow-up, the guided growth technique should be avoided because the risk of overcorrection is too important.

Prior to surgical intervention, supplementation with calcium should be considered for children with rickets-like disease as recommended by Braithwaite *(3)*.

CONCLUSION

Tension band plate technique for rickets-like deformities of lower limb is very efficient in children as well in sub-Saharan Africa. A close follow-up is needed, because of the risk of overcorrection. Non-expensive material as 1/3 tubular plate can be used.

Compliance with ethical standards

The authors declare no conflict of interest. No funding was received for this study. This study does not concern experimental research involving humans or animals. All the patients included were informed and gave their consent.

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