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Original Article

COMPARATIVE STUDY BETWEEN EXTERNAL FIXATION WITH MONO-LATERAL EXTERNAL FIXATOR AND INTERNAL FIXATION OF CORRECTIVE OSTEOTOMY OF KNEE DEFORMITY IN CHILDREN.

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Abstract

Background: *knee deformity is one of the most common presentations in pediatric orthopaedic clinic. It could be pathological or normal as a result of skeletal maturation. The gold standard for treating knee deformity is osteotomy. Normalization of the mechanical axis helps distribution of stress of body weight on all knee compartments and ligaments so prevent early development of knee osteoarthritis.* ***Patients:*** *It is a prospective study of 56 patients with knee deformity .genu varus having metaphyseal-diaphyseal angle greater than 11, genu valgus with a greater than 15-degree tibio-femoral angle, full extension range of motion and flexion greater than 100, exclusion of genu recuravatum, and limb length discrepancy. The patients' ages range from 10 to 18 years.* ***Methods:*** *Each patient assessed clinically for knee range of motion and pain as well as their radiological deformity correction and union. A nine-month follow-up period.* ***Results:*** *The results of patients operated by external fixation by monolateral external fixator were as follows: The deformity in all the 28 patients had been corrected. Mild pain was experienced in 16 cases (57.14%), moderate pain was experienced in 8 cases (28.57%) and severe pain was experienced in 4 cases (14.28%). The duration of union (in months) had a mean value of 2.23. Pin tract infection occurred in 14 patients (50%), 2 patient had superficial infection at the osteotomy site (8.33%) and no infection was encountered in 12 patients (41.67%). The results of patients operated by internal fixation were as follows: The duration of union in all the 28 patients was about 3.5 months. The pain score after union was mild in 14 cases (50%) and moderate in 14 cases (50%) patients. ROM of knee was >90 degree in 14 cases (50%) and >100 degree in 14 cases (50%). Wound infection occurred in 4 cases (14.29%) and no infection occurred in 24 cases (85.71%).*

Keywords: *External fixation, Corrective osteotomy, Knee deformity.*

1. Introduction

The mechanical axis of the lower extremity is a straight line that passes through the middle of the knee joint and runs from the centre of the femoral head to the centre of the ankle. The mechanical axis deviation is the mechanical axis's horizontal offset from the knee joint's centre, measured in millimetres [1]. It is generally known that normal physiological development includes the knee angle changing from a varus alignment in the baby to a valgus alignment in early childhood [2]. The clinical approach of measuring knee angle is popular since it is noninvasive, simple, accurate, and repeatable. The radiological approach is another way to evaluate the tibiofemoral angle. Radiographs of the lower limbs taken in a plane are used for measurements [3]. The purpose of therapy is to normalise the mechanical axis,

rectify lower extremity malalignment, and maybe postpone or prevent osteoarthritis from developing [4]. The gold standard for correcting angular deformities is corrective osteotomy, but this major surgical procedure has a number of drawbacks, including operative site morbidity, postoperative pain, and prolonged therapy that necessitates internal or external fixation and restricted weight bearing. Mono-lateral external fixator with osteotomy can perform its correctional function without subjecting the patient to the risks of major surgery [5]. The aim of the study is to compare the results of using internal fixation by plating versus external fixation by mono-lateral external fixator in corrective osteotomy of knee deformity of skeletally immature children and the advantages and drawbacks of each method of fixation.

2. Patients and Methods

2.1. *Patients*

It is a prospective study of 56 patients. Inclusion criteria are: Patients aged (10-18) years old with. **1)** Genu-valgum with a greater than 15-degree tibio-femoral angle. **2)** Genu-varum with a metaphyseal-diaphyseal angle more than 11 degrees. **3)** Flexion of more than 100 degrees. Exclusion criteria are: **a)** Genu-recurvatum. **b)** Dysplasia. **c)** Limb length discrepancy.

2.2. *Methods*

Each kid underwent clinical evaluations to see whether the deformity is corrected, pain, and range of motion, as well as radiological evaluations to determine whether the union had advanced. Antero-posterior and lateral images of the knee and ankle joints were used for the radiological assessment of union and deformity correction, and antero-posterior views of both hips were used to rule out any issues at the level of the hip joint that would hinder data collection. A planning X-ray was taken to assess the extent of the deformity and the degree of postoperative correction. Other investigations may include laboratory investigations such as Parathyroid hormone, serum Calcium, Vitamin D, serum phosphate and kidney function test to exclude conditions that may cause the deformity and prevent recurrence if left untreated.

2.3. *Surgical technique*

The image intensifier can show the ipsilateral hip, knee, and ankle joints since the patient is lying supine on a radiolucent table.

2.4. *Genu-varum*

Using a C-arm and a 4.5 mm drill bit to make transverse or short oblique osteotomy. To allow for correction of the deformity following osteotomy of the tibia, a fibular osteotomy is carried out at the intersection of the middle and distal thirds of the fibula.

2.5. *External fixation*

A C-arm is utilised during the procedure to help with the percutaneous implantation of two schanz screws on the medial side of the proximal tibia. Skin incision about 1 to 2 cm long is done 1 cm distal to the Tibial tuberosity. Tibial osteotomy is started using a 4.5 mm drill bit under the C-arm's guidance. An osteotome is used to perform osteotomy (can be done by schanz itself) followed by placement of the distal 2 schanz via the same clamp then the rod is introduced to connect the proximal clamps with the distal clamps, fig. (1)

Figure (1) Placement of the proximal 2 schanz through same clamp and making osteotomy using the 4.5 drill bit.

2.6. *Internal fixation*

Fibular osteotomy is performed as in external fixation. Medial proximal Tibial

incision is done followed by dome-shaped osteotomy then fixation by T-plate is done.

2.7. *Genu-valgum*

2.8. *External fixation*

Placement of the distal 2 Schanz is done parallel to the distal Femoral physis through 2 separate incisions using the same clamp then performing osteotomy through small skin incision (about 2 cm) followed by placement of the proximal 2 Schanz in the proximal segment of Femoral shaft through the same clamp, fig. (2).

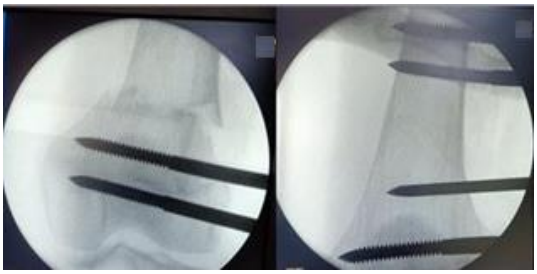

Figure (2) Distal femoral osteotomy is done using a Schanz screw.

2.9. *Internal fixation*

The Adductor Magnus muscle runs parallel to the line of the medial distal femoral incision. The vascular bundle that travels through this region is protected by the Adductor tubercle and posterior line of the Adductor Magnus tendon. Following wedge osteotomy, T-plate is used to fixation. We assess intraoperative correction of the deformity using the wire diathermy method under the guidance of the C-arm, the wire pass from center of the head of the femur and midline of the ankle should bisect mid or slightly medial to center of the knee joint.

2.10. *Post-operative follow-up*

The patients follow-up was as follows: After 2 weeks the stitches were removed. Follow up X-ray was done after 1, 2 and 3, 4 months before external fixator removal, Then 6, 9 months. The follow up is the same in internal fixation. Plate removal may be done within one year, but it is another operative session with the same complication which considered as an advantage of external fixation compared to internal fixation as external fixation doesn't require another operative session for the removal of external fixator.

2.11. *Outcome parameters*

The deformity is fixed to coincide with the mechanical axis of the knee, pain, range of motion, and radiological union.

2.12. *Case presentation*

2.12.1. Case 1

A male aged twelve year with right Genu-varum. Osteotomy and fixation by external fixator, figs. (3-7).

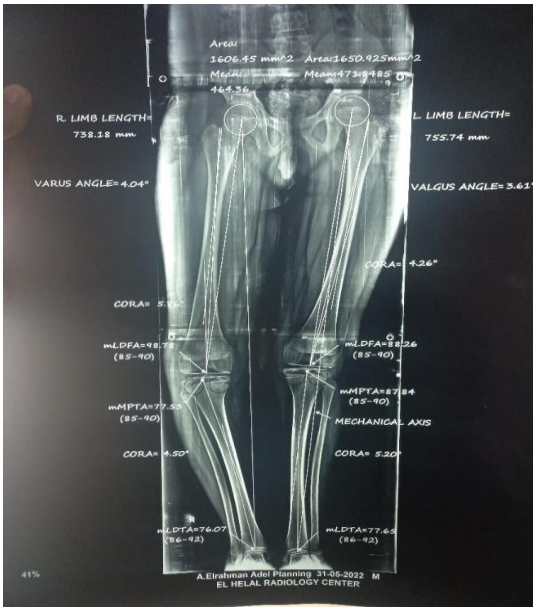

Figure (3): X-ray used in preoperative planning.

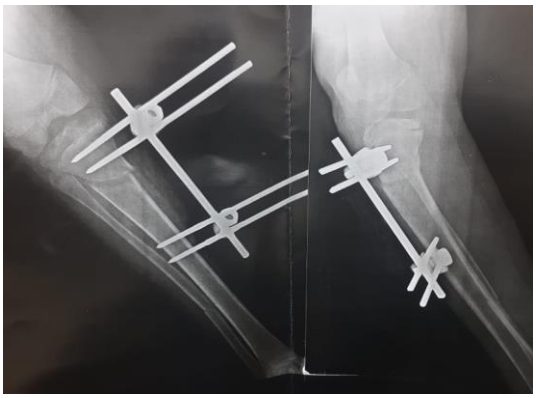

Figure (4) Post-operative x-ray

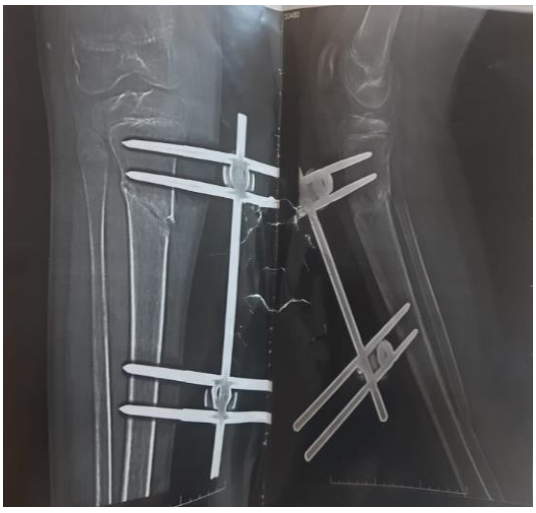

Figure (5): Two months after operation

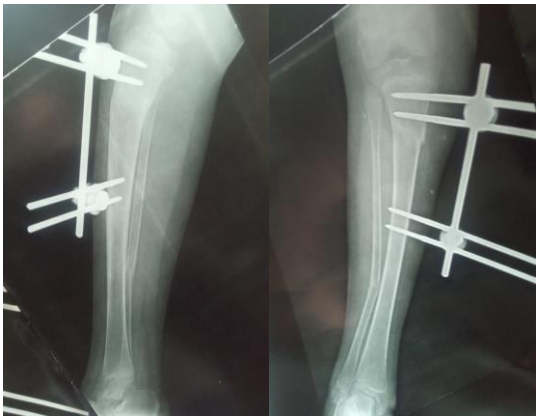

Figure (6): After operation X-ray after 3 months.

Figure (7) Post-operative X-ray after 4 months Immediately after the external fixator has been eliminated.

2.12.2. Case 2

An osteotomy and medial locked T-plate weres used to address a right-sided genu-valgum in a patient who was 18 years old, figs. (8-12).

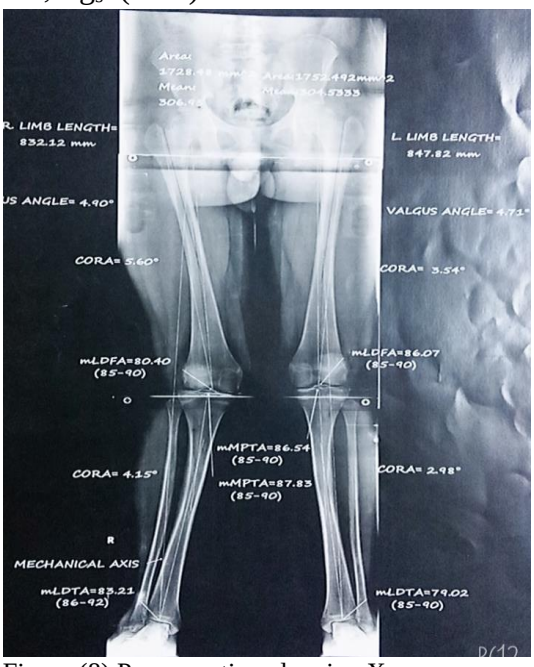

Figure (8) Pre-operative planning X-ray.

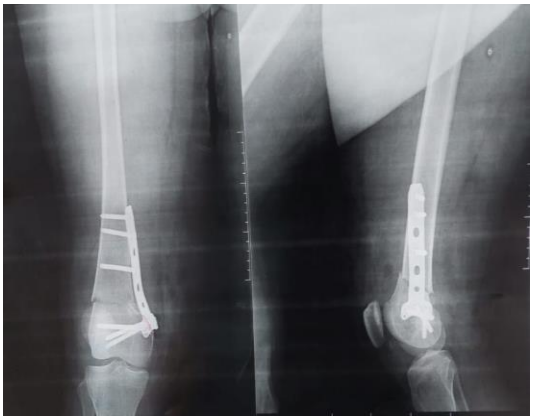

Figure (9) Post-operative film.

Figure (10) Three months after operation

Figure (11) Post-operative film after 4 months.

Figure (12) Clinically 6 month post operative

2.12.3. Case 3

17 years old female case with bilateral Genu-varum. The left-sided deformity was corrected by internal fixation, figs. (13-15).

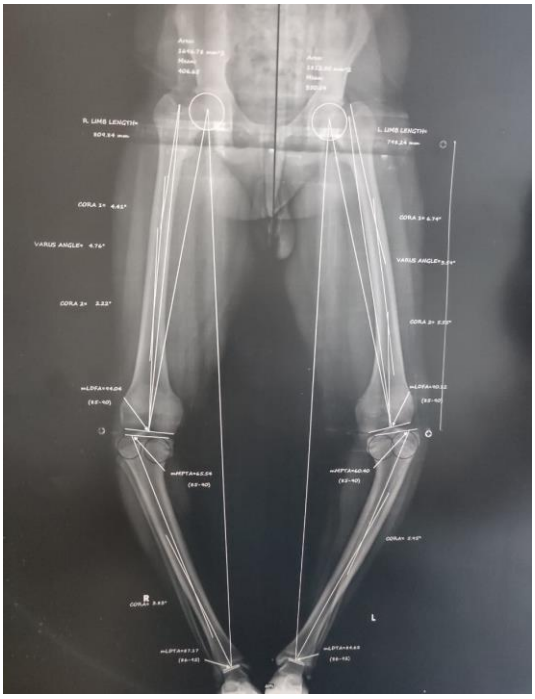

Figure (13) Before operation planning x- ray

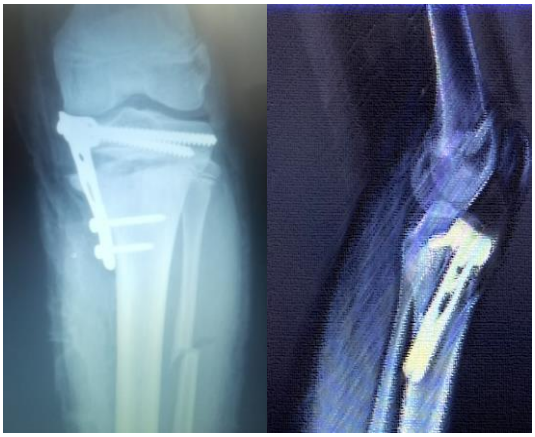

Figure (14) Follow up x-ray after 1 month.

Figure (15) Post-operative film after 3.5 months.

2.12.4. Case 4

A male patient aged 16 with bilateral genu-valgum. The limb on the right was operated using external fixator, figs. (16-19).

Figure (16) Pre-operative X-ray.

Figure (17) Post-operative X-ray after 1 month.

Figure (18) Post-operative X-ray after 2.5 months.

Figure (19) Clinical correction of the deformity after 2.5 months.

2.13. *Statistical analysis*

IBM Inc., Chicago, Illinois, USA, used SPSS v26 to conduct the statistical study. Mean and standard deviation (SD) were used to present quantitative information. Frequency and percentages (%) were used to illustrate qualitative characteristics.

3. Results

Age varied from 17.4 to 18 years in cases with internal fixation, with a mean age (±SD) of 17.7 (±0.31) years. 14 (50%) patients had a male gender split and 14 (50%) had a female gender split. 14 patients (50%) had genu-varum deformities, while 14 (50%) had genu-valgus deformities. Age varied from 10 to 16 years in the case of external fixation, with a mean value of 10.21± 4.06 years. Sex was male in14 (50%) patients and female in 14 (50%) patients. The type of deformity was Genu-varum in 14 (50%) patients Genu-valgum in 14 (50%) patients, tab. (1). The pre MPTA varied from 84.52 to 86 in cases with internal fixation, with a mean value (±SD) of 85.26 (±0.77). The pre LDFA had a mean value (±SD) of 87.81 (8.1) with a range of 80 to 95.62. Pre MPTA ranged from 84.52 to 86 in cases with external fixation, with a mean value (± SD) of 85.26. The pre LDFA had a mean value (±SD) of 87.81 with a range of 80 to 95.62, tab. (2 & 3). In case of internal fixation, that duration of union was about 3.5 months with a mean value (± SD) of 3.5 (±.2) m. Postoperative correction occurred in all cases. Pain score after union was mild in 14 (50%) patients and moderate in 14 (50%) patients. ROM of knee was >90 degree in 14 (50%) patients and >100 degree in 14 (50%) patients. Wound infection occurred in 4 (14.29%) patients and no infection occurred in 24 (85.71%) patients. In case of external fixation, the mean duration of union was (2.2 ± 0.42). 57.14 % of the patients had a mild pain score, 28.57 % had a moderate pain score, and 14.28 % had a severe pain score. In 21% of the patients, the range of motion was greater than 90, and in 79%, it was greater than 100. Pin tract infection was found during follow-up in (50%) of the patients, no infection in (41.7 %) of the patients and superficial infection in (8.33 %) of the patients. **Complications** Infection is most common complication that occurred in both techniques. Pin tract infection is a common complication in patients managed by external fixator that may continue until removal and in most conditions, it only needs good dressing. Infection in internal fixation is more difficult and resistant.

Table (1) Demographic information and the kind of deformity of the patients

Demographic data		Internal fixation	External fixation
Age (years)		17.7 ± 0.31	10.21 ± 4.06
Sex	Male	14 (50%)	14 (50 %)
	Female	14 (50%)	14 (50%)
Type of deformity	Genu varum	14 (50%)	14(50%)
	Genu valgus	14 (50%)	14 (50%)

The presentation of data is as the mean ±SD or frequency (%).

Table (2) Pre MPTA and pre LDFA of the studied patients

N=14	Internal	External
Pre MPTA	85.3 ± 0.77	85.26 ± 0.2
Pre LDFA	87.8 ± 8.1	87.81± 4.4

Medial proximal tibial angle (MPTA) and lateral distal femoral angle (LDFA) are used to provide data as mean± SD.

Table (3) Method of fixation, duration of union, postoperative correction, ROM of knee, pain score, infection during period of fixation of the studied patients

Method of fixation		Internal fixation	External fixation
Duration of union (m)		3.5 ± .22	2.2 ± 0.42
Postoperative correction		28 (100%)	28 (100%)
Pain score after union	*Mild*	4 (14.3%)	57.14 %
	Moderate	14 (50%)	28.57%
	Severe	10 (35.7%)	%14.28
ROM of knee (Degree of flexion)	*>90*	14 (50%)	6 (21%)
	>100	14 (50%)	22 (79%)
Infection after removal of fixation	*Wound infection*	4 (14.29%)	Pin tract infection 14 (50%)
	No	24 (85.71%)	Superficial infection 2 (8.33%)
			No infection 12 (41.7%)

The presentation of data is as the mean ± SD or frequency (%).

4. Discussion

Corrective osteotomy is one of the gold standards for correction of knee deformity. The method of fixation after osteotomy could be casting, k-wires and casting, external fixation or internal fixation by plating. Choice of method of fixation depends on multiple factors such as age, skeletal maturity, degree of deformity and other associated medical condition. In our study we studied two methods of fixation (external by mono lateral fixator and internal fixation by plate) to show the advantages and drawbacks of each method of fixation. In our study the most valuable data: Age varied from 10 to 16 in cases with external fixation, with a mean of 10.21 ± 4.06 years. Pre MPTA ranged from 84.52 to 86 with a mean value (± SD) of 85.26. The pre LDFA ranged from 80 to 95.62 with a mean value (± SD) of 87.81. mean duration of union (2.2 ± 0.42). 57.14% of the patients had a mild pain score, 28.57% had a moderate pain score, and 14.28% had a severe pain score. In 21% of the patients, the range of motion was greater than 90, and in 79%, it was greater than 100. Pin tract infection (50%) was the most common kind of infection found during follow-up, followed by no infection (41.7%) and superficial infection (8.33%). Age varied from 17.4 to 18 years in cases with internal fixation, with a mean age (± SD) of 17.7 (± 0.31) years. Sex was male in 14 (50%) patients and female in 14 (50%) patients. The type of deformity was genu varus in 14 (50%) patients and genu valgus in 14 (50%). With a mean value (± SD) of 85.26 (± 0.77), the pre MPTA had a range of 84.52 to 86. The pre LDFA had a mean value (± SD) of 87.81 (±8.1) with a range of 80 to 95.62. With a mean value (± SD) of 3.5 (± .2) months, the union lasted for 3.5 months. Postoperative correction occurred in all cases. Pain score after union was mild in 14 (50%) patients and moderate in 14 (50%) patients. ROM of knee was >90 degree in 14 (50%) patients and >100 degree in 14 (50%) patients. Wound infection occurred in 4 (14.29%) patients and no infection occurred in 24 (85. 71%) patients. The advantages of external fixation are less needed time for union and early partial weight bearing that affects later on the degree of knee flexion. Internal Fixation requires another operation for plate removal but it's better for older patients as body weight is higher and plate has stronger strain than external fixator. External fixator in cases of distal femur osteotomy causes irritation of iliotibial band which causes affection of knee flexion and needs longer time to gain full range of motion. No reported cases of nonunion or malunion were encountered. No reported cases of under correction were encountered. Hemiepiphysiodesis was tried by Castaneda et al in 35 individuals with juvenile Blount disease, however the outcomes were unsatisfactory. The effectiveness of both temporary and permanent Hemiepiphysiodesis employing techniques that were in use before tension band plates were invented. They argued that the primary reason for failure was the medial tibial physis's lack of development potential [6]. Ballal et al. assessed two individuals: one with plate and screw migration and one with profound infections who had surgical debridement; nonetheless, ongoing physeal tethers emerged after patient follow-up between six and thirty-two months after plate excision [7]. Burghardt et al. analysed eight plates of directed

growth in ten individuals (17 physes) with Genu-valgum deformity. The patients' mean age was 9.7 years. The range for the mean proposed growth time was 6 to 15 months, or 8.5 months. Sites receiving therapy encompassed 11 limbs with distal femur deviations and 3 limbs with paired distal femur and proximal tibia deformities. With the sole exception of two patients in whom the correction unsuccessful in both cases, femoral deformities (mLDFA) were fixed within 3o of their normal mean values and MPTA within 2o [8]. Using a monolateral external fixator, Lim et al. previously assessed surgical correction of proximal tibia deformity in young children and discovered statistically significant increases in MPTA from 73° to 90° in varus tibia and from 104° to 89° in valgus tibia, also MDA improved from 19º to 0º in varus tibia and from -25º to 2º in valgus tibia [9]. 43 patients with plates and 36 individuals with fixed externally were investigated by Ghasemi et al. with moderate uniplanar varus deformities and revealed statistically significant correction of MPTA from 83.9º to 90.9º with p-value 0.001 [10].

5. Conclusion

The premier option for resolving knee angular distortion is corrective osteotomy. Advantages of internal fixation by plating over external fixation by mono lateral external fixator include providing more rigid fixation with less incidence of infection during the time of the follow up as pin tract infection is a problem in case of external fixator. However, the advantages of external fixation over internal fixation include it being a mini-invasive surgery with less surgical complication such as bleeding, shorter duration of surgery, lesser risk of infection, early weight bearing with less need of rehabilitation for knee motion, no need to be bed-ridden during follow up and lesser risk of soft tissue exposure and compartment syndrome. Recommendations. We recommend that other studies could be conducted for larger groups and increase follow-up duration. Both methods of fixation are good but there are more advantages of using monolateral external fixator than internal fixation by plating. However, plating is more suitable for older children (16-18 years) as it provides more rigid fixation that can withstand heavy weight while external fixator is more suitable in younger age groups (10-16 years).

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