One-stage correction of angular deformities around the knee using internal fixation

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Background
Deformity correction has been long performed using internal fixation. Since the introduction of external fixation in orthopedic practice, it has gained popularity in correcting severe deformities, and many orthopedic surgeons have resorted to external fixation to correct severe deformities. The authors asked if internal fixation can be safely used to correct significant deformities with marked mechanical axis deviation thus abolishing the notion that external fixation is the only available option to correct severe deformities.
Patients and methods
A single-center, prospective study was conducted at an academic center from October 2014 to December 2016. A total of 37 patients with lower limb deformities were included in the study. Overall, 13 patients were corrected using locked plates and 24 patients were corrected using intramedullary nails. The average follow-up was 13.5 months (10–18 months).
Results
The desired correction was achieved in all patients. Union was quicker with plates, but this could be attributed to the younger age of patients in that group.
Discussion
Many methods of fixation have been used to correct angular deformities around the knee. With patients' satisfaction gaining utmost importance recently, surgeons have been revising their approach in managing various orthopedic conditions, and limb deformity is no exception. During the surgeons' pursuit to achieve their patients' maximum satisfaction without compromising the accuracy of correction or rigidity of fixation, two new techniques have emerged, namely, fixator-assisted plating and fixator-assisted nailing techniques, which represent a breakthrough in deformity correction, because they combine the advantages of internal and external fixation. The use of internal fixation usually yields higher patients' satisfaction.
Conclusion
Internal fixation is a safe and effective treatment option for correcting significant deformities of the lower limb.

Keywords:
deformity correction, internal fixation, knee deformity

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Introduction

Angular deformities are caused by various etiologies that may be acquired or developmental; they could be caused by fracture malunion, metabolic disorders, and idiopathic processes. Limb deformities affect the lower limb alignment and greatly influence the mechanical forces sustained across lower limb joints during locomotion, leading to the development of osteoarthritis [1,2].

Recently, new methods of deformity correction using internal fixation, namely, fixator-assisted plating (FAP) [3] and fixator-assisted nailing (FAN) [4], have been described. In both the methods, the deformity is corrected acutely intraoperatively using a temporary external fixator (removed at the end of surgery) and then the osteotomy site is fixed using internal fixation.

We asked if internal fixation can be safely used to correct significant deformities with marked mechanical axis deviation (MAD), thus abolishing the notion that external fixation is the only available option to correct severe deformities.

Patients and methods

A single-center, prospective study was conducted at an academic center from October 2014 to December 2016.

All procedures performed in studies involving human participants were in accordance with the ethical

standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

This study included a total of 37 patients with lower limb deformities with MAD; this means that mechanical axis line of the lower limb passes more than 1 cm away from the center of the knee joint according to Paley *et al*. [5] deformity analysis method. The application of this deformity analysis method also identified which bone (femur or tibia) was the source of deformity. A total of 13 patients were corrected using locked plates and 24 patients were corrected using intramedullary nails (IMN). Bones corrected were 18 femora and 19 tibiae.

Patients' age was on an average of 21.5 (11–42) years.

The body mass index of the patients was on an average of 25.5 (20–34) kg/m^2.

If the mechanical axis line of the lower limb was found to pass at the knee joint center, this was considered as 0 MAD (i.e. normal). If it was found to pass away from the center, the distance between the mechanical axis line and the knee center is measured in centimeters and is given a plus (+) sign if it passes medially or a negative (–) sign if it passes laterally. For example, MAD of +4 cm means genu varum deformity where the mechanical axis line passes 4 cm medial to the knee center, whereas MAD of –5 cm means genu valgum deformity where the mechanical axis line passes 5 cm lateral to the knee center. This method of quantifying for MAD was adopted by Paley *et al*. [5]. The authors believe that it is more accurate than older methods in which the knee joint width was divided into zones, which would not be applicable in patients where the mechanical axis line passes totally away from the knee joint.

The percentage improvement in MAD was calculated by comparing the MAD preoperatively and at the final follow-up, for example, a patient with a preoperative MAD of +5 cm (genu varum) who had a MAD of +1 cm at the final follow-up achieved 80% (4 out of the 5 cm) improvement in his/her MAD.

To evaluate deformity in the femur, we used the mechanical lateral distal femoral angle (mLDFA), whereas for the tibia, the medial proximal tibial angle (MPTA) was used. The angles' values measured on the deformed side were compared with the normal side in unilateral cases or compared with the population average value, which was 87° for both the mLDFA and MPTA.

For calculating the magnitude of deformity, the difference between measured mLDFA/MPTA and the normal value for these angles was considered the magnitude of deformity in degrees. For example, if a patient measured MPTA was 77°, this means there is 10° of angular deformity (as a normal MPTA is considered 87°).

All radiographic measurements were done by the author using long film standing radiography showing both lower limbs that were obtained preoperatively, postoperatively, and at the final follow-up. All surgeries were performed by the author.

Locked plates were used in patients who were skeletally immature or who were skeletally mature with thin limbs, whereas IMN was used in patients who were skeletally mature with big limbs.

All plates used were locked anatomical plates. All IMN used were regular trauma nails.

FAN was performed according to Paley *et al*. [4] method, whereas FAP was performed according to Eidelman [6] method.

Blocking (Poller) screws were used in cases where IMN were used to prevent toggling and loss of correction. The Poller screws were placed on the concave side of the deformity between the cortex and nail [7]; they were made to be at least 2 cm away from osteotomy site to avoid extension to osteotomy.

We observed the accuracy of correction (based on correction of the MAD and magnitude of angular deformity), duration of surgery, and complications.

Radiographs were performed monthly in the follow-up period to check for bone healing. Full weight bearing was allowed when full union (as evident by disappearance of fracture line on radiography) was achieved. Patients with bilateral deformities underwent separate surgery for each limb with 3–4-month interval.

The average follow-up was 13.5 months (10–18 months) (Tables 1 and 2).

Table 1 Data for patients with femoral deformity

Case number	Age	Sex	BMI	Medical comorbidity	Varus/ Valgus	Apex	Implant Used	Preoperative angle	Residual angle	Preoperative MAD in cm	Residual MAD	Time to Union	Complications
1	16	M	24	None	Varus	Metaphyseal	Nail	16	0	7.5	0	16	None
2	14	M	32	None	Varus	Metaphyseal	Plate	4	0	7	0.5	16	None
3	20	F	34	None	Varus	Metaphyseal	Nail	11	3	5.7	1	12	Infection
4	17	F	26	None	Varus	Metaphyseal	Nail	30	5	6.4	0	12	None
5	14	M	20	None	Varus	Metaphyseal	Plate	18	4	10.8	1.5	8	None
6	23	M	23	None	Varus	Metaphyseal	Nail	16	4	8	2	16	None
7	16	M	25	None	Varus	Metaphyseal	Nail	24	2	10	1	16	None
8	11	F	20	Bone softening disease	Varus	Metaphyseal	Nail	14	28	10	7.5	12	Recurrence
9	16	M	34	None	Varus	Metaphyseal	Nail	10	0	7	0	16	None
10	14	F	22	None	Valgus	Metaphyseal	Plate	10	2	5.9	1	12	Infection
11	18	F	26	None	Valgus	Metaphyseal	Nail	3	0	4.7	0	16	None
12	16	F	28	None	Valgus	Metaphyseal	Nail	10	–2	7	–2.5	12	None
13	17	M	21	None	Valgus	Metaphyseal	Plate	5	–10	7.9	0	16	None
14	17	M	22	None	Valgus	Metaphyseal	Nail	5	2	5	0	12	None
15	17	F	26	None	Valgus	Diaphyseal	Nail	7	0	5.5	0	12	None
16	13	F	26	None	Valgus	Diaphyseal	Plate	2	0	8.3	0	12	None
17	13	M	26	None	Valgus	Physeal	Plate	17	0	7	0	12	None
18	24	F	32	None	Valgus	Metaphyseal	Nail	20	2	10	2	16	None

F, female; M, male; MAD, mechanical axis deviation.

Table 2 Data for patients with tibial deformity

Case	Age	Sex	BMI	Varus/ Valgus	Apex	Implant Used	Preoperative deformity magnitude in degrees	Residual deformity magnitude in degrees	Preoperative MAD measured in cm	Final MAD measured in cm	Percentage improvement in MAD	Follow-up time after union in months	Time to Union in weeks	Complications
1	18	M	27	Varus	Metaphyseal	Nail	11	2	+5.7	+1	82	18	16	None
2	11	M	32	Varus	Metaphyseal	Plate	21	0	+8.7	0	100	18	12	Superf. Infection
3	19	M	24	Varus	Metaphyseal	Nail	5	0	+7.5	0	100	12	12	None
4	14	M	32	Varus	Metaphyseal	Plate	18	2	+7	+0.5	92	10	12	None
5	35	M	26	Varus	Metaphyseal	Nail	5	0	+3.3	0	100	16	14	None
6	30	M	23	Varus	Metaphyseal	Plate	11	0	+4.5	0	100	14	10	None
7	30	M	23	Varus	Metaphyseal	Nail	10	–2	+4.5	+0.6	86	16	10	Late infection
8	14	M	20	Varus	Metaphyseal	Plate	12	2	+10.8	+1	90	14	8	None
9	18	M	23	Varus	Metaphyseal	Nail	8	2	+6.5	+0.9	86	18	12	None
10	18	M	30	Varus	Metaphyseal	Nail	8	0	+5	0	100	17	12	None
11	20	M	21	Valgus	Metaphyseal	Nail	15	0	–7.9	0	100	16	12	None
12	21	M	22	Valgus	Diaphyseal	Nail	10	0	–5	0	100	11	12	None
13	24	F	26	Valgus	Diaphyseal	Nail	6	0	–5.5	0	100	12	12	None
14	13	F	26	Valgus	Metaphyseal	Plate	27	3	–8.3	–0.8	90	13	12	None
15	15	M	20	Valgus	Epiphyseal	Plate	28	0	–9	0	100	11	12	None
16	15	M	24	Valgus	Physeal	Plate	4	0	–7	0	100	10	10	None
17	30	M	24	Valgus	Diaphyseal	Nail	20	0	–6	0	100	10	12	Superf. Infection
18	30	M	27	Valgus	Diaphyseal	Nail	11	0	–4	0	100	11	16	None
19	32	M	26	Valgus	Diaphyseal	Nail	15	0	–5	0	100	12	16	None

F, female; M, male; MAD, mechanical axis deviation.

Results

Preoperative magnitude of deformity was 14° on an average (5–30°), and the final magnitude of deformity was 2° on an average (0–14°).

Preoperative MAD was 10.2 cm on an average (1.6–20 cm), and the final MAD was 0.4 cm on an average (0–2.4 cm).

Percentage improvement of MAD was 92 % on an average (68–100%).

Normal alignment (in which the mechanical axis of the lower limb passed within 1 cm of the center of the knee joint line) was achieved in all patients.

Only one case of recurrence was seen, where the patient had hyperparathyroidism for which she underwent subtotal parathyroidectomy before deformity correction. This patient had a multiapical deformity which required two osteotomies for correction; hence, an IMN was used to span the whole bone. Correction was successful intraoperatively, and healing occurred uneventfully. However, recurrence occurred later when the patient started full weight bearing.

Time to union was 12 weeks (8–16). Union was faster with plates, but this may be attributed to the younger age of patients in that group (most of them were skeletally immature).

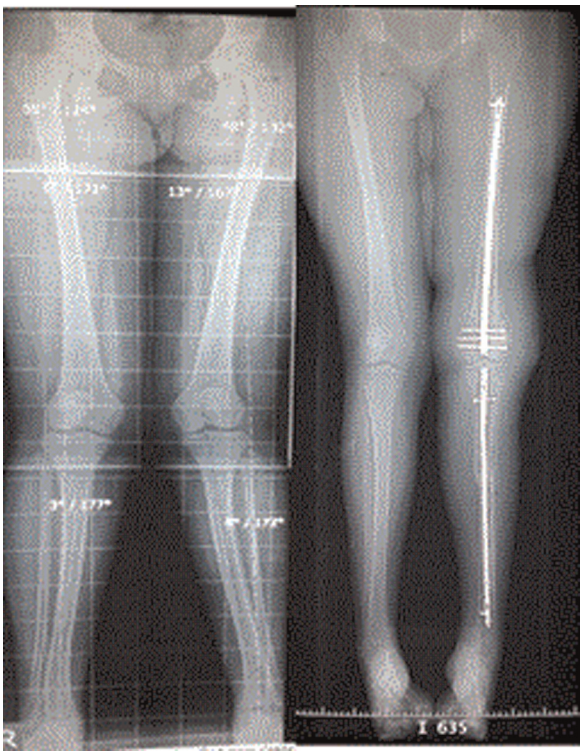
Postoperative blood transfusion was needed in four of the eight patients who underwent FAP but none of the patients who underwent FAN. All patients who underwent FAP reported hardware irritation (which could be attributed to the fact that most of them had thin limbs), but none required removal.

Two cases showed superficial surgical wound site infection that did not require debridement or implant removal and resolved completely by a course of intravenous antibiotics and wound daily dressing. No other major complications were noted (Figs 1 and 2).

Discussion

Many methods of fixation have been used to correct angular deformities around the knee and compared in the literature. Patients with a significant limb deformity were previously thought to be best managed by external fixators, which allows for accurate correction through minimal incisions, but it involved wearing a bulky construct for several months, which something the patients did not prefer.

Figure 1



Example of correction by intramedullary nails.

Figure 2

Example of correction by plates.

With the patients' satisfaction gaining utmost importance recently, surgeons have been revising their approach in managing various orthopedic

conditions, and limb deformity is no exception. During the surgeons' pursuit to achieve their patients' maximum satisfaction without compromising the accuracy of correction or rigidity of fixation, two new techniques have emerged, namely, FAP and FAN techniques, which represent a breakthrough in deformity correction because they combine the advantages of internal and external fixation. Using internal fixation usually yields higher patients' satisfaction.

A study conducted by Seah *et al.* [8] reviewed 34 deformed limbs in 26 patients who underwent a distal femoral osteotomy. Some patients had their osteotomies fixed by a unilateral fixator, whereas others with a locking plate. They concluded that both techniques were equally effective.

A similar study was conducted by Eralp *et al.* [9], which in comparison with the study by Rozbruch et. al [8] not only included femoral but also tibial deformities in a rachitic population. Some of the patients had their osteotomies fixed by an Ilizarov frame, whereas others by an IMN. They reported better patient satisfaction in the internal fixation group compared with the external fixation group.

Eidelman *et al.* [6] reported the use of FAP technique for six patients (seven femora) who had distal femoral valgus deformity. They showed that this method is minimally invasive and had minimal morbidity.

None of these limited number of studies gave data about the magnitude of deformity in their patients to give the reader an idea whether these new methods in deformity correction using internal fixation could be used in patients with significant deformity who were previously thought that it could be managed by external fixation only. In this study, we provide a relatively large group of patients with details about magnitude of deformity measured by two different methods and have shown that even in patients with significant deformity, acute deformity correction by internal fixation is safe and effective, challenging the notion that significant limb deformities can be safely corrected only by external fixation.

Among the limitations of this study is the need to have surgical experience with external fixation, and also the fact that all surgeries were performed by the same surgeon which may raise the possibility that the results may not be easily reproducible; hence, more studies that include matched groups and surgeries done by multiple surgeons may be needed to make sure that the results obtained in this study are easily reproducible.

Conclusion

Internal fixation is a safe and effective treatment option for correcting significant deformities of the lower limb.

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Conflicts of interest

There are no conflicts of interest.

References

1 Tetsworth K, Paley D. Malalignment and degenerative arthropathy. Orthop Clin North Am 1994; 25:367–377.

2 Kettelkamp DB, Hillberry BM, Murrish DE, Heck DA. Degenerative arthritis of the knee secondary to fracture malunion. Clin Orthop Relat Res 1988; 234:159–169.

3 Robert Rozbruch S. Fixator-assisted plating of limb deformities. Oper Tech Orthop 2011; 21:174–179.

4 Paley D, Herzenberg John E, Bor Noam MD. Fixator-assisted nailing of femoral and tibial deformities. Tech Orthop 1997; 12:260–275.

5 Paley D, Herzenberg JE, Tetsworth K, McKie J, Bhave A. Deformity planning for frontal and sagittal plane corrective osteotomies. Orthop Clin North Am 1994; 25:425–465.

6 Eidelman M, Keren Y, Norman D. Correction of distal femoral valgus deformities in adolescents and young adults using minimally invasive fixator? assisted locking plating (FALP). J Pediatr Orthop B 2012; 21:558–562.

7 Krettek C, Stephan C, Schandelmaier P, Richter M, Pape HC, Miclau T, *et al.* The use of poller screws as blocking screws in stabilising tibial fractures treated with small diameter intramedullary nails. J Bone Joint Surg Br 1999; 81:963–968.

8 Seah KT, Shafi R, Fragomen AT, Rozbruch SR. Distal femoral osteotomy: Is internal fixation better than external? Clin Orthop Relat Res 2011; 469:2003–2011.

9 Eralp L, Kocaoglu M, Toker B, Balci HI, Awad A. Comparison of fixator? assisted nailing versus circular external fixator for bone realignment of lower extremity angular deformities in rickets disease. Arch Orthop Trauma Surg 2011; 131:581–589.