Correction of Proximal Tibia Varus with External Fixation

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Abstract

Correction of proximal tibia varus deformity has been used with success. Our Protocol is to use monolateral frame to correct varus of less than 10 degrees and to use the Taylor spatial frame for deformities greater than 10 degrees and for multiplanar deformities. Is this protocol successful? Ninety-one limbs in 68 patients with proximal tibia varus were treated with percutaneous proximal tibial osteotomy and external fixation. The monolateral and spatial frames were used for 36 and 55 limbs, respectively. Each group was further subdivided into neutral or intentionally overcorrected subgroups. Monolateral group time of correction and time in frame was 15 days (8 to 20) and 101 days (81 to 133), respectively. The preoperative mechanical axis deviation (MAD) was 22 mm medial (10 to 44). Postoperative MAD in the neutral subgroup was 5 mm lateral (2 to 10) and 3 mm medial (0 to 7). Postoperative MAD in the overcorrected subgroup was 10 mm lateral (4 to 20) and one patient was 5 mm medial. Medial proximal tibial angle (MPTA) improved from 85 degrees (79 to 89) to 90 degrees (85 to 96) in the neutral group and to 92 degrees (85 to 98) in the overcorrected group. Spatial frame group time of correction and time in frame was 34 days (7 to 99) and 130 days (95 to 177), respectively. The preoperative MAD was 40 mm medial (range 5 to 155). This improved to 5 mm medial (0 to 30) and 4 mm lateral (0 to 7) in the neutral group, and 17 mm medial (0 to 35) and 11 mm lateral (4 to 28) in the overcorrection group. MPTA improved from 80 degrees (40 to 87) to 88 degrees (83 to 96) in the neutral group and to 84 degrees (89 to 97) in the overcorrected group. In both groups, there was no significant change in the ankle or knee range of motion. There was one refracture in both groups. Our algorithm for treating proximal tibial varus deformities is safe and effective. For simple varus deformities, we recommend use of the monolateral frame. We reserve the use of the spatial frame for large or complex deformity correction.

Keywords
- ► tibia vara
- ► proximal tibial osteotomy
- ► external fixation

Malalignment of the mechanical axis of the lower extremity and rotational deformity can lead to the transmission of abnormal forces across the knee joint.[1–3] This may later bring about osteoarthritis (OA)[2,4–6] affecting the patients quality of life by causing pain, further deformity, and limiting daily routine activities.[7,8] Proximal tibial osteotomy (PTO) was first reported by Jackson et al[9] in 1958 as a surgical procedure for the treatment of OA of the knee. PTO has gained acceptance as a treatment option for young patients with lower extremity varus malalignment and symptomatic medial tibiofemoral compartment arthrosis. The value of osteotomy to correct malalignment has followed the principle of transferring load to the unaffected (lateral) compartment of the knee to relieve symptoms and slow disease progression on the medial side.

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As Coventry[1,10] advocated, the results of high tibial osteotomy (HTO) in this scenario have been best when the anatomical axis is corrected to 8 to 10 of valgus.[11] However, too much overcorrection may yield poor results, particularly in ligamentously lax individuals, in which bony overcorrection may lead to a significant clinical deformity. Closing wedge osteotomy by an open technique has several limitations including wide exposure, lack of accuracy, loss of bone stock, proximal migration of fibula, and can lead to nerve compromise, wound problems, and compartment syndrome as the deformity is corrected acutely.[12–15] Percutaneous PTO performed distal to the tibial tubercle is a technique that has been used to correct varus deformities.[1,7,16] It does not adversely affect metaphyseal bone stock and does not affect the patellar tendon tension.

For varus deformity of less than 10 degrees, we use the monolateral frame for gradual correction. The fibula is not cut and lateral cortex of the tibia is left intact. For varus deformity of greater than 10 degrees or if associated with sagittal or axial plane deformity, we use Taylor spatial frame (TSF; Smith and Nephew Inc., Memphis, TN) for gradual correction. The fibula is cut and a PTO is performed. With the use of this protocol, we have addressed all proximal tibial deformity on our service.

In our experience, gradually correcting the proximal tibial varus deformities of less than 10 degrees by using the hemicallotasis monolateral frame and 10 degrees of varus deformity or greater with or without sagittal and/or axial plane deformity by using spatial frame avoids the common problems associated with the closing wedge HTO via techniques such as Puddu plate.

The procedure involves small incisions and minimal soft tissue stripping. The spatial frame corrects angulation and translation in the coronal, sagittal, and axial planes around a virtual hinge, hence the term "six-axis correction." The stability of this multiplanar circular fixator permits early weight bearing and provides an ideal environment for both new-bone formation and soft tissue healing. Computer-generated schedules and struts have greatly simplified patient involvement, which is crucial to the success of this technique. Studies have reported[17–21] few complications with the use of spatial frame.

We asked the following questions regarding the accuracy of both the spatial and the monolateral frames in correcting the proximal tibial varus deformity:

1. How accurate is the mechanical axis deviation (MAD) correction at the proximal tibia?
2. How accurate is the medial proximal tibial angle (MPTA) correction at the proximal tibia?
3. What are the outcomes regarding Short Form-36 (SF-36) scores, rate of complications, and need for knee replacement?
4. Is our protocol for use of external fixation successful in treatment of proximal tibial varus deformity?

Material and Methods

Our Institutional Review Board–approved osteotomy registry was used to identify 68 patients (91 tibias) who underwent tibial osteotomy surgery for deformity correction using either the monolateral or the spatial frames using our protocol between 2000 and 2007. Our indication for use of monolateral fixator was varus deformity in the proximal tibia of less than 10 degrees and for the spatial frame, varus deformity of greater than 10 degrees, oblique plane deformity, presence of rotational deformity, or compromised soft tissue. In the spatial frame group, the average age was 39 years (range 21 to 72 years), and in the monolateral group, the average age was 44 years (range, 23 to 73 years). Twenty-three of the 68 patients had bilateral surgeries. Thirteen patients had spatial frames on both legs, while seven patients had monolateral frames on both legs. Three patients were treated with both spatial and monolateral frames (one on each leg). In the spatial frame group, deformity was corrected in 34 days (17 to 99), whereas total time in the frame averaged 130 days (95 to 177). In the monolateral group, deformity was corrected in 15 days (8 to 20), whereas total time in the frame averaged 101 days (81 to 133). The average preoperative varus deformity in the monolateral group was 7 degrees (4 to 9), while in the spatial frame group, it was 12 degrees (4–46) (►**Table 4**). The cause of deformity included traumatic, congenital, developmental, and neurologic etiologies.

Patients were subdivided into two groups depending on the presence or absence of unicompartmental knee arthritis[11,22] and the goal of correction. Group 1 included patients without medial joint space narrowing. The goal of realignment in this group was MAD of 0 mm. Group 2 included patients with medial joint space narrowing and the goal was overcorrection to 10 mm lateral.

There were 13 extremities out of 36 in the monolateral group, and 28 extremities out of 55 in the spatial frame group which were intentionally overcorrected to unload medial compartment OA. The average follow-up after surgery was 51 (14 to 85) months in the monolateral group and 74 (13 to 127) months in the spatial frame group. Four patients in the monolateral and five in the spatial frame group were lost to follow-up.

We arranged the postoperative MAD to either medial or lateral separately. This was done to illustrate most accurately the final alignment. We also averaged the postoperative MAD as an absolute deviation from the goal of treatment. This is a more useful way to apply statistics to the data.

Clinical preoperative evaluation included history and physical examination. Gait was observed. Frontal plane deformity was measured on a 51-inch erect leg, bipedal radiograph. MAD and MPTA were measured using the methods described by Paley.[3] For tibia vara with a normal femur, the proximal mechanical axis of the tibia was established by extending a line drawn from the center of hip through the center of knee. When neutral mechanical axis alignment was the goal, the proximal mechanical axis line was drawn through the center of the knee. When overcorrection was the goal, the proximal mechanical axis line was drawn through the desired location as per Jacob modification of Fujisawa method in the lateral compartment of the knee.[23] In addition, anteroposterior (AP) and lateral X-rays of the tibia were routinely obtained and posterior proximal tibial angle (PPTA) was measured.[21]

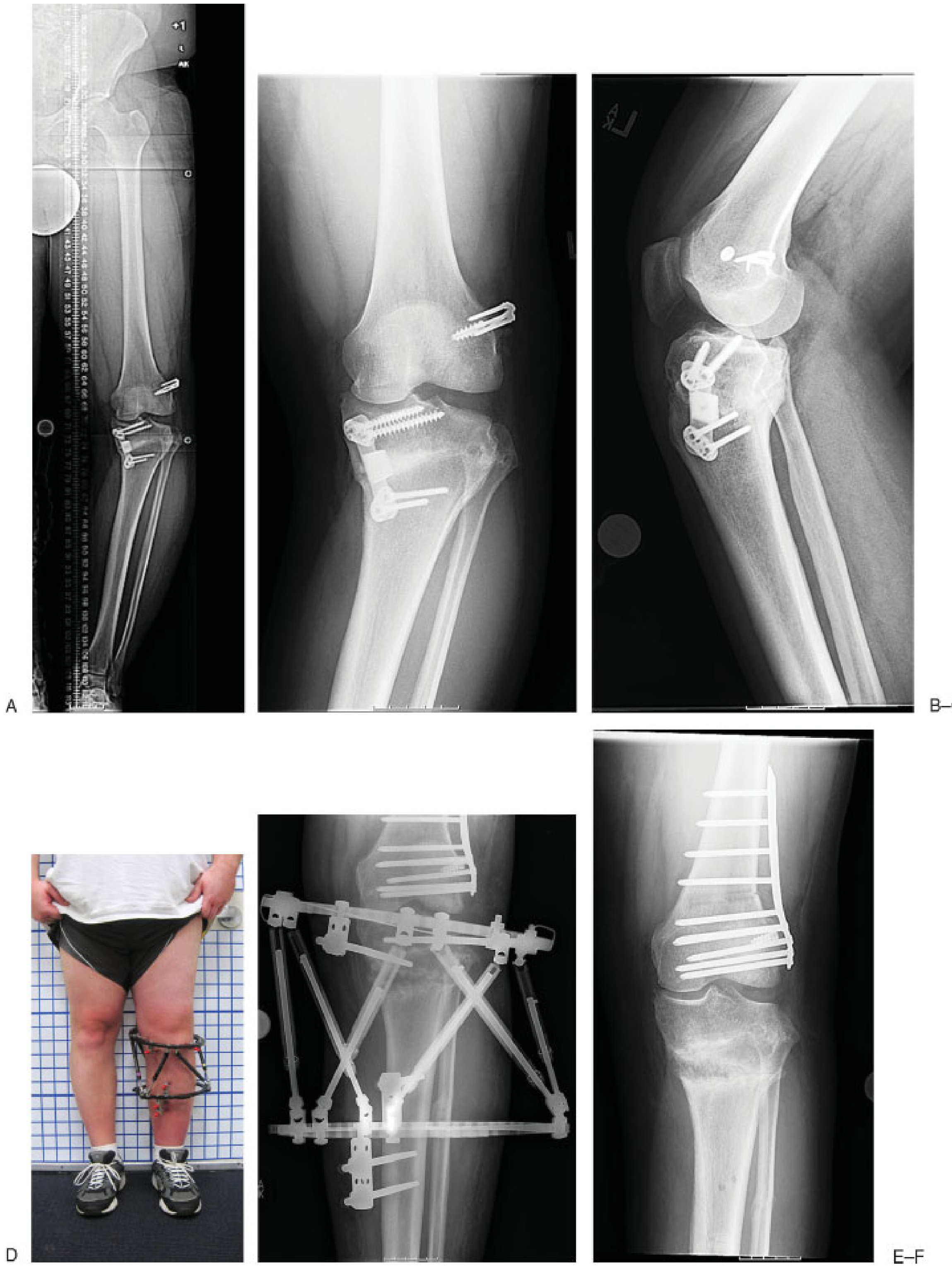

Figure 1 A 31-year-old man with large varus and procurvatum deformity of left knee. Prior opening wedge osteotomy and ACL reconstruction were done. Hardware removal, tibial osteotomy, and gradual correction of complex deformity were done with TSF. Closing wedge distal femur osteotomy was also done. (A) Preoperative standing hip to ankle radiograph showing large MAD. (B) Preoperative AP X-ray showing knee varus and widening of the lateral joint space from LCL laxity. (C) Lateral knee X-ray showing procurvatum deformity. (D) After deformity correction with TSF. (E) AP knee X-ray after deformity correction with TSF. Note the bony regenerate of opening wedge correction. (F) Six-month AP X-ray of knee showing healed osteotomy and normal alignment. Lateral joint widening is improved. (G) Six-month lateral knee radiograph showing correction of procurvatum deformity. (H) Six-month standing hip to ankle radiograph showing mild lateral overcorrection of MAD. ACL, anterior cruciate ligament; AP, anteroposterior; LCL, lateral collateral ligament; MAD, mechanical axis deviation; TSF, Taylor spatial frame.

G H

Figure 1 Continued.

All surgeries were performed by the senior authors (S.R.R. and A.T.F.). The tibial osteotomy was performed through a 1 cm incision distal to the tibial tubercle, using a multiple drill hole and osteotome technique. In the spatial frame group (►**Fig. 1**), complete tibial osteotomy was made. In the monolateral group (►**Fig. 2**), the lateral cortex of the tibia was left intact. No acute correction of the deformity was attempted, and no fasciotomy was performed. In the monolateral group, fibular osteotomy was not performed, whereas in the spatial frame group, an oblique osteotomy of fibula was made in the midshaft with a microsagittal saw. Hydroxyapatite-coated half pins and smooth tensioned wires were used to stabilize the spatial frame to the bone, whereas in the monolateral group, only half pins (hydroxyapatite coated) were used. All pins and wires were stainless steel. For the spatial frame group, deformity parameters were entered into the web-based computer program and a schedule was generated for frame adjustment. The patient was instructed to gradually adjust the six struts on the spatial frame three times a day starting on postoperative day 7. At the end of the schedule, lasting around 2 to 6 weeks, patients were evaluated clinically and radiologically for limb alignment and another schedule was given for any residual deformity.

For monolateral frame, patients were instructed and taught to start adjusting the frame at a rate of quarter turns four times a day (1 mm per day) for a period of 2 weeks, starting on postoperative day 7, at which time they were also evaluated clinically and radiologically for the correction of deformity. The outcomes of MAD and MPTA were analyzed according to preoperative treatment goal (neutral vs. overcorrection) while the PPTA outcomes were combined for the entire group. Patients were allowed to walk weight bearing as tolerated from postoperative day 1. Supervised physical therapy focusing on knee and ankle range of motion exercises were recommended and encouraged. Our protocol for postoperative follow-up visits was every 2 weeks until the optimal alignment was achieved and then at monthly intervals until frame was removed. After frame removal patients were seen at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year. At each office visit, patients were examined for joint range of motion and X-rays were taken. A 51-inch erect leg X-rays was done at 6 weeks and 1 year. Patients were encouraged to follow-up yearly. All patients were contacted by telephone during the study to see if there were any clinical changes. Outcome measures included the SF-36 Health Survey scores (physical function, role physical, bodily pain, general health, vitality,

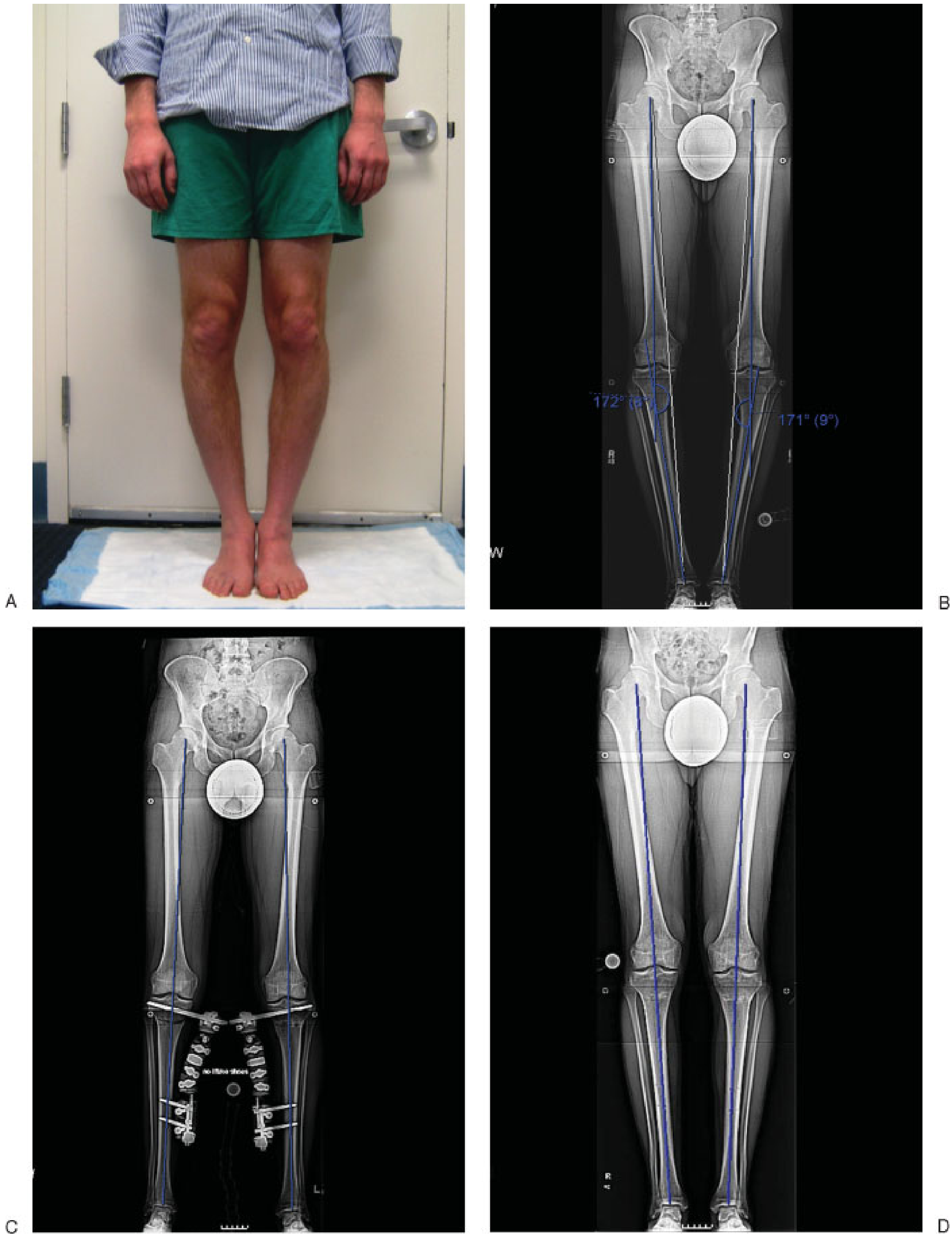

Figure 2 A 28-year-old man with bilateral bowleg deformities and knee pain. Staged bilateral tibial osteotomy was performed. Deformity correction was done gradually with monolateral frames. (A) Preoperative front view. (B) Preoperative erect leg bipedal radiograph showing medial MAD and angular deformity. (C) After deformity correction, MAD is 0. (D) One-year follow-up showing no deformity. (E) One-year follow-up knee X-rays showing well-healed osteotomies and normal knee joints. MAD, mechanical axis deviation.

Figure 2 Continued.

social functioning, role emotional, and mental health). It was administered preoperatively and at the latest follow-up visit.

Results

Monolateral Group

The MAD improved from 22 mm medial (10 to 44) to 3 mm medial (0 to 7) and 5 mm lateral (2 to 10) in the neutral group. In the overcorrected group, the MAD improved from 22 mm medial to 5 mm medial and 10 mm lateral (4 to 20) (►**Table 1**). The MPTA improved from 85 degrees (79 to 89) preoperative to 90 degrees (85 to 96) in the neutral group and to 92 degrees (85 to 98) in the overcorrected group (►**Table 2**). The absolute change in MAD was 4 mm (0–15) (►**Table 12**). The SF-36 Health Survey scores improved in all categories except for general health, which remained constant (►**Table 3**).

Spatial Frame Group

The MAD improved from 40 mm medial (10 to 75) to 5 mm medial (0 to 30) and 4 mm lateral (0 to 7) in the neutral group. In the overcorrected group, MAD improved from 40 mm medial to 17 mm medial (0 to 35) and 11 mm lateral (4 to 28) (►**Table 5**). The MPTA improved from 80 degrees (40 to 87) to 88 degrees (83 to 96) in the neutral group and to 84 degrees (89 to 97) in the overcorrected group (►**Table 6**). The procurvatum deformity improved from 63 degrees (45 to 75) to 78 degrees (73 to 80) (►**Table 7**). The absolute change in the MAD was 5 mm (0 to 45) (►**Table 12**).

The SF-36 Health Survey scores improved in all categories except for general health, which remained constant (►**Table 8**). With regard to accuracy, grades 1 and 2 outcomes (►**Table 9**) were achieved in 34 limbs (94.44%) in the monolateral group and in 49 limbs (86%) in the spatial frame group. Two limbs (5.54%) in the monolateral group and eight limbs (14.03%) in the spatial frame group had grades 3 and 4 outcomes (►**Table 10**).

There was one similar, major complication in both of the groups: collapse of the osteotomy site regenerate bone (►**Table 11**). Patients in both the groups were treated with open reduction internal fixation with a locking plate. The majority of patients in the spatial frame group had a superficial infection of one of the pin sites during the course of treatment which were treated successfully by oral antibiotics in all cases. There were no cases of neurapraxia, neurovascular injury, compartment syndrome, patella baja, nonunion, osteomyelitis, or a need for bone grafting.

None of these patients underwent knee replacement until latest follow-up. There was no significant change in knee or ankle range of motion in either of the groups.

Discussion

PTO is frequently used for the surgical treatment of patients with medial knee arthrosis associated with varus deformity. PTO is aimed at decompressing the medial compartment of the knee by changing the mechanical axis of the lower extremity. Different treatment options are available for correcting proximal tibial varus deformity including acute correction of the deformity and fixation with an internal device and gradual correction by percutaneous osteotomy and application of external fixator. Use of an external fixator and

Table 1 Preoperative and Postoperative MAD, Monolateral Group

MAD (mm)	Preoperative MAD	Postoperative Goal (Neutral)		Postoperative Goal (Overcorrection)	
		Medial	Lateral	Medial[a]	Lateral
Mean (SD)	22 (8)	3 (3)[b]	5 (3)[b]	5 (0)[b]	10 (5)[b]
Range	10–44	0–7	2–10	5–5	4–20
Number	36	15	8	1	12

Note: Neutral, medial p value: <0.001; neutral, lateral p value: <0.001; overcorrected, medial: n/a; overcorrected, lateral: <0.001.
[a]Complication (collapse).
[b]Statistically significant difference from preoperative MAD ($p < 0.05$).
MAD, mechanical axis deviation.

Table 2 Preoperative and Postoperative MPTA, Monolateral Group

MPTA (Degrees)	Preoperative MPTA	Postoperative MPTA	
		Neutral	Overcorrected
Mean (SD)	85 (3)	90 (3)[a]	92 (4)[a]
Range	79–89	85–96	85–98
N	36	23	13

Note: Neutral *p* value: < 0.001; overcorrected *p* value: < 0.001.
[a]Statistically significant difference from preoperative MPTA ($p < 0.05$).
MPTA, medial proximal tibial angle.

Table 3 Preoperative and Postoperative SF-36 Health Survey Scores, Monolateral Group

	Physical Function	Role Physical	Bodily Pain	General Health	Vitality	Social Functioning	Role Emotional	Mental Health
Preoperative	54	83	55	77	57	75	49	77
Postoperative	64	93	67	78	64	87	73	83

Table 4 Preoperative Deformity Parameters (Degrees), Taylor Spatial Frame Group

Deformity Parameter	Varus	Apex Anterior	Apex Posterior	Internal Rotation	External Rotation
Mean (SD)	12 (9)	10 (10)	8 (3)	14 (2)	15 (5)
Range	4–46	2–30	5–15	10–15	7–25
N	55	18	8	7	16

Table 5 Preoperative and Postoperative MAD, Taylor Spatial Frame Group

MAD (mm)	Preoperative MAD	Postoperative Goal (Neutral)		Postoperative Goal (Overcorrection)	
		Medial	Lateral	Medial[a]	Lateral
Mean (SD)	40 (35)	5 (7)[b]	4 (3)[b]	17 (25)	11 (7)[b]
Range	5–155	0–30	0–7	0–35	4–28
N	55	35	6	2	12

Note: Neutral, medial *p* value: < 0.001; neutral, lateral *p* value: < 0.001; overcorrected, medial: 0.371; overcorrected, lateral: < 0.001.
[a]Complication (collapse).
[b]Statistically significant difference from preoperative MAD ($p < 0.05$).
MAD, mechanical axis deviation.

Table 6 Preoperative and Postoperative MPTA, Taylor Spatial Frame Group

MPTA (Degrees)	Preoperative MPTA	Postoperative	
		Neutral	Overcorrected
Mean (SD)	80 (8)	88 (2)[a]	84 (3)[a]
Range	40–87	83–96	89–97
N	55	41	14

Note: Neutral *p* value: <0.001; overcorrected *p* value: 0.020.
[a]Statistically significant difference from preoperative MPTA ($p < 0.05$).
MPTA, medial proximal tibial angles.

gradual correction has several potential advantages over a single-stage correction. Large corrections may be technically unfeasible with standard closing or opening wedge techniques. This is either because of excessive bone removal compromising fixation and stability or soft tissue tensioning problems. External fixators can be adjusted in the postoperative period to fine tune alignment during the healing process and optimize alignment.[24] Circular external fixators also

Table 7 Preoperative and Postoperative Procurvatum Deformity PPTA

PPTA	Preoperative	Postoperative	Mean Difference	*p* Value
Mean (SD)	63 (12)	78 (3)	14 (8)	0.062
Range	45–75	73–80		
N	5	5		

PPTA, posterior proximal tibial angle.

Table 8 Preoperative and Postoperative SF-36 Health Survey Scores, Taylor Spatial Frame Group

	Physical Function	Role Physical	Bodily Pain	General Health	Vitality	Social Functioning	Role Emotional	Mental Health
Preoperative	47	39	47	74	52	62	67	68
Postoperative	66	65	66	75	62	78	79	79

Table 9 Accuracy Grade

Grade 1(excellent)	MAD within 5 mm of the desired goal
Grade 2 (good)	MAD within 10 mm of the desired goal
Grade 3 (fair)	MAD within 15 mm of the desired goal
Grade 4 (poor)	MAD more than 15 mm of the desired goal

Table 10 Results

	Monolateral N (%)	TSF N (%)	*p* Value
Excellent	27 (75.0)	30 (52.6)	0.125
Good	7 (19.4)	19 (33.3)	
Fair	1 (2.8)	7 (12.3)	
Poor	1 (2.8)	1 (1.8)	

TSF, Taylor spatial frame.

Table 11 Major Complication in Both Groups

	TSF	Monolateral
Complication	Collapse	Collapse
No. of patients	1	1

TSF, Taylor spatial frame.

Table 12 Absolute Change in MAD from Goal

MAD (mm)	Absolute Change in MAD (Neutral/Overcorrected)[a]	*p* Value
Monolateral		
Mean (SD)	4 (3)	$<$ 0.001
Range	0–15	
N	36	
TSF		
Mean (SD)	5 (8)	$<$ 0.001
Range	0–45	
N	55	

Note: Statistically significant change from preoperative MAD ($p < 0.05$).
[a]Neutral defined as 0 mm away from preoperative goal, overcorrected defined as 10 mm away from preoperative goal.
MAD, mechanical axis deviation; TSF, Taylor spatial frame.

allow easy manipulation of angular and translational correction in all three planes as necessary.[4] These advantages are balanced by other drawbacks including the possibility of pin site infection,[25–27] which if not successfully treated can lead to deeper infection and compromise later surgery, particularly arthroplasty.

We therefore asked the following questions regarding the spatial and the monolateral frames in correcting the proximal tibial varus deformity:

1. How accurate is the MAD correction at the proximal tibia?
2. How accurate is the MPTA and PPTA correction at the proximal tibia?
3. What are the outcomes regarding SF-36 scores, rate of complications, and need for knee replacement?
4. Is our protocol for use of external fixation successful in treatment of proximal tibial varus deformity?

A successful osteotomy procedure leads to improvement in joint function and alleviation of pain, and it can also postpone the need for total knee arthroplasty or even allow total knee arthroplasty to be avoided.[28,29] Patients with varus knee deformity generally have better results when the osteotomy is performed early in the arthrosis process, before the exposure of subchondral bone in the medial tibiofemoral compartment.[6,16,21] Although the clinical success of total knee arthroplasty has resulted in fewer tibial osteotomies being done during the past decade, PTO remains useful in appropriately selected patients with unicompartmental knee disease. In our study, the primary goal was to assess the accuracy of correction of MAD and joint orientation angles (MPTA, PPTA), radiographically at the time of latest follow-up. As we divided our patients into neutral and overcorrected groups based on the absence or presence of medial compartment arthritis, respectively, our outcome for MAD was either medial or lateral to the midline. All medial and lateral MAD data points were then averaged separately and recorded with the range for precision. Similarly, we reported the correction of MPTA separately in the neutral and overcorrected groups. Only one study by Feldman et al[30] reported the MAD and MPTA correction in PTO comparing acute and gradual corrections. Our results were comparable but more detailed as we had a neutral group and an overcorrected group.

We had only one major complication in each group which was collapse of the osteotomy site. Both of these patients were treated with an acute, open reduction, and internal fixation using a locking plate, leading to complete union. The collapse was caught early, before malunion occurred, allowing for an acute correction. Both patients elected internal fixation to avoid excessive time wearing an external fixator.

Lastly, we compared preoperative and postoperative SF-36 Health Survey scores in both the groups, which showed improvement in all the categories, except for general health which remained constant.

Only one study in the literature[19] measured SF-36 scores as their outcome. In our study, three patients were treated with spatial frame on one extremity and monolateral frame on the other. They all reported increased ease and comfort with the use of monolateral frame. However, they went on to say that, although spatial frame was a little cumbersome, they felt more secure and confident with the spatial frame leg during mobilization and weight bearing.

We believe that the accuracy of correction directly influences the clinical results after PTO. Studies have shown that excessive overcorrection leads to rapid wear of the lateral compartment. Similarly, undercorrection will not adequately relieve medial-sided pain.[31] External fixation provides excellent control over the accuracy of correction as we have demonstrated. The two failures do not represent poor accuracy of the external fixator. In fact in both cases the early postoperative alignment was highly accurate. After the fixators were removed the regenerate bone collapsed indicating that the bone had not healed enough at the time of frame removal. The accuracy of measurement and correction varies greatly in the literature.[32–34]

Certainly there are limitations to the present study. A minimum follow-up period of 6 months does not allow us to draw conclusions about the further clinical course of our patients, including the necessity of performing total knee arthroplasty in the future. Several questions remain to be answered, such as the value of arthroscopic preassessment, treatment results compared with other surgical alternatives (such as unicompartmental knee replacement), the relationship between disease severity and outcome, and the influence of age and weight, to name a few. Nevertheless, the data we present here provide a solid foundation on which accurate conclusions can be built at a later stage of follow-up. Our results were comparable to previous studies of HTO which have shown excellent outcomes in more than 80% of cases.[35–37] However, several studies with long-term follow-up reported that the results of HTO deteriorated with time, especially after more than 10 years. The rates of recurrence of varus alignment reported by other authors appear to increase with the amount of time from surgery. Dejour et al[40] reported 11% undercorrection rate (5 of 44 knees) at a mean of 3.5 years after surgery. Ivarsson et al[38] reported a 31% undercorrection rate (25 of 81 knees) a mean of 5.7 years after surgery. Hernigou et al[13]observed 76 patients for a mean of 11.5 years after surgery and reported that most had changes in alignment over time toward varus; 34 knees (45%) were in varus at the final evaluation. Several factors have been identified as affecting the results of HTO, but they remain controversial. These include sex, age at surgery, body weight, preoperative severity of knee OA, method of osteotomy and fixation, correction angle, amount of preoperative adduction moment, and time since surgery.[35–37,39] One study reported[24] 5 and 10 years survivorship rate of 89 and 63%, respectively, after HTO for a medial compartment OA using an Ilizarov frame.

We suggest following our treatment algorithm by using the monolateral frame to treat proximal tibial varus deformities of less than 10 degrees and the spatial frame for deformities more than 10 degrees or those that are associated with sagittal or axial plane deformity. This technique is minimally invasive, carries a low risk of complications, and is highly accurate.

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