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Deformity Correction about Knee with Ilizarov Technique: Accuracy of Correction and Effectiveness of Gradual Distraction after Conventional Straight Cut Osteotomy

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SUMMARY

Background. The aim of the study was to retrospectively analyse the long term clinical outcome, accuracy of correction, and the complication rate in patients treated for deformities around the knee with gradual distraction with or without additional limb lengthening using Ilizarov technique.

Material and methods. The study presents a retrospective analysis of 26 patients treated for deformities about the knee by gradual distraction with Ilizarov technique with an average follow-up of 6.1 yrs (2-13 yrs). Preoperative and post-operative radiographs of all patients were assessed for the deformities. Deformity involved the tibia in 16 patients and the femur in 9 patients and one patient had both components. The deformity comprised of varus in 15 patients and valgus in 11 patients, and deformity in two planes (oblique plane) in 2 patients, while 8 patients had either deformity with associated average shortening of 4.75 cms (2-7 cm).The mean angle of deformity in the frontal plane was 30 degrees (15-60 degrees) and 48 deg on sagital plane. The CORA (centre of rotation of angulation) was located in the juxtaepiphyseal region in 15 patients, metaphysis in 6 patients and at the metadiaphyseal junction in 5 patients.

Results. All except two adult patients achieved exact correction with gradual distraction at an average correction of 30 degrees. Exact limb lengthening was achieved in all 8 patients with shortening. Complications involved mild procurvatum in three patients, mild mismatch of the mechanical and anatomical axes in two patients with tibial deformities, pin tract infection in two patients and one incidence of pin breakage, however, with no true complications.

Conclusion. Gradual distraction after conventional corticotomy provides excellent results with deformities around the knee with or without additional limb lengthening.

Key words: gradual distraction, straight cut osteotomy, knee deformity, Ilizarov technique

BACKGROUND

Deviation in the mechanical axis of the lower limb may result from deformities about the knee joint. Such deformities arise secondary to epiphyseal growth arrest, congenital bone diseases, infections, mal-united fractures or may be idiopathic [1]. Restoration of a normal mechanical axis is mandatory to prevent development of early osteoarthritis and abnormalities of gait [2,4]. Correction using ring fixators is advantageous in terms of less invasive nature of the surgery, no hardware left in place after completion of treatment, fixation of bone fragments not amenable to internal fixation and simultaneous limb lengthening. The greatest advantage perhaps is potential of post-operative correction of any residual deformity; however, the technique demands meticulous pre-operative planning and methodical execution for excellent results [4]. Using Ilizarov technique, different studies have discussed acute/gradual correction, using either straight cut osteotomy or a focal dome osteotomy with varying results [1,5,6]. The present study was aimed at assessing the accuracy of correction and effectiveness of gradual distraction after a conventional straight cut osteotomy.

MATERIAL AND METHODS

Out of 300 patients operated for various deformities with Ilizarov technique by the first author over a period of 13 years between 1997 and 2010, we reviewed the results of 26 patients operated for deformities around the knee. The review included the amount of initial deformity, correction achieved, length gained, time in external fixator, healing index and any complications. The group included 17 females and 9 males in an age group of 10-56 years (Average 21.8 years) (Tab. 1). The right knee was involved in 10 and the left knee in 12 patients while 4 patients had bilateral involvement. The aetiology of deformity was idiopathic in 12, post-traumatic in 11, post-osteomyelitic in 2 and Blount's direase in one patient. Deformity involved tibia in 16 patients and femur in 9 patients and one patient had both components. The deformity comprised of varus in 15 patients and valgus in 11 patients (Fig. 1), deformity in two planes (oblique

Tab. 1. Detail of Patients

Pt. No.	Age	Sex	side involved	Side operated	Deformed bone	Aetiology	Follow up yrs
1	16	Male	Left	Left	Tibia	Post-osteomyelitic growth arrest	13
2	15	Male	Left	Left	Femur	Post-traumatic growth arrest	13
3	19	Male	Right	Right	Tibia	Post-osteomyelitic	10
4	10	Male	Right	Right	Tibia	Post-traumatic growth arrest with proximal tibio-fibular dislocation	9
5	56	Female	Left	Left	Tibia	Idiopathic varus tibia with OA	9
6	13	Male	Left	Left	Femur	Post-traumatic (firearm) growth arrest	9
7	20	Female	Right	Right	Femur	Idiopathic	8
8	35	Female	Left	Left	Tibia	Idiopathic varus with OA	8
9	16	Male	Right	Right	Tibia	Post-traumatic growth arrest	7
10	52	Female	Left	Left	Tibia	Malunited proximal tibial fracture	7
11	16	Female	Left	Left	Tibia	Idiopathic	7
12	10	Male	Right	Right	Femur	Post-traumatic growth arrest	6
13	15	Female	bilateral	Left	Femur	Idiopathic	5
14	10	Male	bilateral	Right	Tibia	Blount's disease	5
15	12	Female	Left	Left	Tibia	Post-traumatic growth arrest	5
16	17	Female	Left	Left	Tibia	Post-traumatic growth arrest	5
17	20	Female	Right	Right	Femur	Idiopathic	4
18	27	Female	Left	Left	Tibia	Idiopathic	4
19	22	Female	Left	Left	Tibia	Idiopathic	4
20	56	Male	Right	Right	Tibia	Malunited fracture	4
21	18	Female	bilateral	Right	Femur	Idiopathic	3
22	20	Female	Right	Right	Femur	Idiopathic	3
23	17	Female	Left	left	Both	Post-traumatic growth arrest	3
24	16	Female	Right	Right	Tibia	Post-traumatic growth arrest	3
25	23	Female	Right	Right	Femur	Idiopathic	3
26	17	Female	Bilateral	Right	Tibia	Idiopathic	2

plane) in 2 patients (Fig. 2) while 8 patients had either deformity with associated average shortening of 4.75 cms (2-7 cm).The mean angle of deformity in the frontal plane was 30 degrees (15-60 degrees) and 48 deg on in the sagittal plane (Tab. 2).

Pre operative planning

All except a few initial patients planned for surgery had pre-operative CT scanogram/full length radiographs of both lower limbs to assess deformities and limb length discrepancy. Anatomical angles were measured at the hip, knee, ankle and the centre of rotation of angulation (CORA) of the deformity identified and the amount of mechanical axis deviation (MAD) was calculated (Fig. 3). The deformities were identified at distal femur in 9 patients and at proximal tibia in 16 patients while both segments were responsible in one patient. The CORA (centre of rotation of angulation) was located in the juxtaepiphyseal region in 15 patients, metaphysis in 6 patients and at meta-diaphyseal junction in 5 patients. The Ilizarov frame was constructed pre-operatively to shorten the operating time. It comprised of two rings across the corticotomy site and the third ring above the ankle in cases of tibial deformity and an Italian arch at the subtrochanteric level in cases of femoral deformities. The frame construction was planned according to the osteotomy principles of Paley [8] in order to create simple open wedge correction in deformities at metaphysis and meta-diaphyseal junction and open wedge and translation in deformities with CORA at the juxtaepiphyseal region to realign the mechanical axis. In patients with additional lengthening to be achieved, the hinges were placed in the

Tab. 2. Details of deformity

Pt. No.	Preop deformity Frontal plane	Postop deformity Frontal plane	Amount of correction	Preop deformity sagittal	Postop deformity sagittal	External fixation time in weeks	Complications
1	45 deg valgus	Nil	45	Nil	10 deg	20	
2	60 degvalgus with 3 cm shortening	Nil	60	Nil	Nil	17	
3	45 deg varus with 6cm shortening	Nil	45	40	Nil	36	Mild PTI
4	20 deg valgus with 2cm shortening	Nil	20	Nil	Nil	12	
5	20 deg. varus	5 deg varus	15	Nil	5 deg procurvatum	20	
6	50 deg valgus with 5 cm shortening	Nil	50	Nil	Nil	32	
7	30 deg valgus	Nil	30	Nil	Nil	6	
8	25 deg varus	5 deg varus	20	Nil	5 deg procurvatum	21	
9	45 deg valgus with 6cm shortening	Nil	45	56l	Nil	22	Nil
10	45 deg varus	Nil	45	Nil	Nil	10	
11	18 deg varus	Nil	18	Nil	Nil	32	
12	25 deg varus with 5 cm shortening	Nil	25	Nil	Nil	25	Pin breakage
13	35 deg valgus	Nil	35	Nil	Nil	16	Mild PTI
14	18 deg varus	NIl	18	Nil	Nil	7	Nil
15	18 deg varus	Nil	18	Nil	Nil	12	Nil
16	28 deg varus	nil	28	Nil	Nil	8	Nil
17	25 deg valgus	Nil	25	Nil	Nil	8	Nil
18	25 deg varus	Nil	25	Nil	Nil	14	Nil
19	26 deg varus	Nil	26	Nil	Nil	16	Nil
20	30 deg varus	Nil	30	Nil	Nil	13	Nil
21	34 deg valgus	Nil	34	Nil	Nil	17	Nil
22	25 deg valgus	Nil	25	Nil	Nil	12	Nil
23	15 deg varus shortening 4cm	Nil	15	Nil	Nil	20	Nil
24	30 deg varus with 7cm shortening	Nil	30	Nil	Nil	33	Nil
25	18 deg valgus	Nil	18	Nil	Nil	16	Nil
26	35 deg varus	Nil	35	Nil	Nil	14	Nil

Fig. 1. Patient No. 9 – preoperative clinical photograph showing valgus deformity of right knee

Fig. 3. Full-length radiograph showing mechanical axis deviation

Fig. 2. Preoperative radiograph showing deformity in two planes

Fig. 4. Postoperative clinical photograph showing deformity correction

Fig. 5. Final full-length radiograph showing correction of mechanical axis deviation

lengthening mode. In two patients with a malunited proximal tibial fracture, one best joint line method was applied [9].

Surgery was performed under spinal anaesthesia in all patients. In cases of tibial deformities, fibular osteotomy was performed at the junction of its middle and distal third. In one patient with proximal tibial arrest and dislocation of the proximal tibiofibular joint, no fibular osteotomy was performed in order to relocate the tibiofibular joint after deformity correction. A low energy corticotomy was performed at the planned site (just below the tibial tuberosity for tibial deformities and at the meta-diaphyseal junction in cases of femoral deformities). The average operating time was 40 minutes. The patients were ambulated on the first operative day and discharged on the 2nd day after being taught physiotherapy and the distraction methods. Distraction at the motor unit was performed at an average delay of 7 days at a rate calculated using the rule of triangles to achieve 1mm distraction per day [10]. The patients were followed initially at weekly intervals till correction of deformity and later at 3-weekly intervals till consolidation of the regenerate and achievement of desired length. Removal of the ring fixator was performed once three cortices were visible on two plane radiographs.

RESULTS

The deformity correction was assessed both clinically and radiologically (Fig. 4, Fig. 5). All except two patients achieved accurate correction in the frontal plane and restoration of the mechanical axis. Two patients achieved simultaneous correction in the sagittal plane also. The mean duration of external fixation was 17.65 weeks. All patients retained their initial range of motion around the knee. The patients requiring simultaneous lengthening healed at an average healing index of 5.43weeks/cm. However, in two adult patients with a varus tibia, there was 5 degree residual deformity after removal of the external fixator. 3 patients developed a minor deformity in the coronal plane (procurvatum). In two patients there was a mild translation at the distraction site during treatment and as such they had a mild deviation from the mechanical axis. Radiological review of these patients revealed a discrepancy between the osteotomy and the hinge placement which had been ignored at the time of treatment. One patient, in whom a 7 cm lengthening was achieved in addition to the deformity correction, developed a mild valgus at the distraction zone which was corrected by differential distraction within the frame and no further intervention was required. Other complications included grade one pin tract infection in two patients and one incidence of pin breakage. However, there were no true complications as per Paley D et al [11].

DISCUSSION

Deformity correction proceeded uneventfully and the correction was accurate in most of the patients as per the preoperative planning. A few initial patients (n=3) presented with a mild procurvatum deformity during correction which was prevented in future cases by using a threaded half-pin in the anterioposterior direction in the proximal ring. 5 degrees residual deformity in two adult patients was perhaps due to the misinterpretation of post-operative radiographs during the follow-up period due to steel rings superimposing at the joint line. We now use carbon fiber rings to avoid this difficulty. Mild mechanical axis deviation in two patients which was identified to be due to the discrepancy in osteotomy and hinge placement emphasizes the need to adhere to the principles of deformity correction. Testworth K and Paley D [4] found gradual correction by dynamic external fixator to be very accurate in complex deformities. It diminishes the risk of nerve traction injuries in proximal valgus deformities and can also be applied in cases of previous or active infection [4]. Deformities of lesser magnitude have been effectively treated using acute

correction with straight cut or focal dome osteotomy [1,5]. However, larger deformities and deformities associated with limb length discrepancies are better managed with gradual distraction [1,4,7]. Watanabe K et al [1] concluded that acute correction with focal dome osteotomy was effective in their series of 15 patients. However, in their series the mean angle of correction was only 16 degrees as compared to ours of 30 degrees. They do not recommend acute correction in patients with simultaneous lengthening to be performed because of a high external fixation index of 70.9 days. There are reports of faster healing in average deformity correction with focal dome osteotomy as compared to transverse osteotomy [7]. However, El Rosay M et al [5] did not find any benefit of focal dome osteotomy over straight cut osteotomy in their series of 36 bone segments in 27 patients. Moreover, straight cut osteotomy is easier to perform than a focal dome osteotomy. Feldman DS [6] in their study found gradual correction to be a more accurate method in tibia vara than acute correction. All our patients retained their initial range of motion around the knee. This is of the utmost importance in our patient population as they do not accept any loss of range of motion for their squatting and prayer habits. The healing index in the lengthening group matches that of tibial lengthening in the literature. [12] None of our patients complained of cumbersome nature of the Ilizarov frame. Zarek S et al [13] in their series also found iIlizarov method as very effective in the treatment of complex deformities of the distal epiphysis of the femur. Kim SJ [14] et al in their study concluded that limb realignment using gradual distraction by illizarov method is a reliable option even in skeletal dysplasias. Sun Lei et al [15] in their study clearly demonstrated the advantages of the Illizarov ring fixator in knee deformity correction in terms of soft tissue handling and versatility of adjustment in the postoperative period. There are reports of clear advantages of the Taylors spatial frame over the Ilizarov ring fixator in terms of easy handling [16] but because of its cost effectiveness and equally comparable results our patients prefer the Ilizarov ring fixator.

CONCLUSION

Gradual distraction after conventional straight cut corticotomy is a safe and accurate method of correction at a minimal complication rate provided the principles of deformity correction are adhered to.

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