PROGRESSIVE OPENING-WEDGE OSTEOTOMY FOR ANGULAR LONG-BONE DEFORMITIES IN ADOLESCENTS

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We report the treatment in 17 patients of 27 angular deformities of the long bones by progressive opening-wedge osteotomy. The technique consists of percutaneous osteotomy and progressive angular correction using a modified Wagner distractor.

Ten patients (20 bone segments) had adolescent bilateral idiopathic tibia vara with a mean angular deformity of 12° varus (10 to 16). Seven other adolescent patients had secondary angular deformities either at the distal femur or the distal tibia. One of the femoral deformities had an associated 5.5 cm of shortening which was treated simultaneously. The patients with idiopathic tibia vara achieved a final mean angular correction of 15° (mechanical axis from 12° varus to 3° valgus). In patients with secondary angular deformities the mean angular correction was 17°. The Wagner device was removed in an average period of 12 weeks (9 to 27), and no major complications were observed.

Progressive opening-wedge osteotomy is an alternative to conventional osteotomies for the treatment of angular deformities of the long bones in adolescent patients, and has the advantage of requiring less invasive surgery, allowing progressive and adjustable correction with bone lengthening if needed.

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Opening- and closing-wedge osteotomies are commonly used to correct angular deformities of the long bones in both adults and children (Smith and Harrison 1979; Hofmann, Jones and Herring 1982; Smith 1982; Henderson, Kemp and Greene 1992; Schoenecker et al 1992; Scheffer and Peterson 1994). Satisfactory results can be achieved, but conventional osteotomies usually need internal fixation and its later removal, and are also difficult to adjust in the postoperative period (Loder, Schaffer and Bardenstein 1991). In addition, opening-wedge osteotomy has risks of traction injury to the soft tissues, and potential problems with consolidation and stability at the osteotomy site. Closing-wedge osteotomies produce some shortening.

To minimise the disadvantages of conventional osteotomies and to obtain gradual correction, we devised a technique for the correction of angular deformities of percutaneous osteotomy followed by progressive correction using a modified Wagner distractor. A simple modification of this device automatically converts a longitudinal distraction force in the telescopic body of the distractor into a rotational movement at one of the pin-holder clamps (de Pablos, Barrios and Azcárate 1991). Postoperative adjustment of the correction is possible.

We have reviewed our clinical experience with this method of treating angular deformity of the long bones in adolescents and young adults.

PATIENTS AND METHODS

From 1987 to 1991, we treated 27 angular deformities of the long bones in 17 patients by percutaneous osteotomy and progressive angular correction by a modified Wagner device.

There were two main groups of patients. Group A consisted of ten patients (6 male, 4 female) with adolescent bilateral idiopathic tibia vara (20 bone segments). Their mean age was 13 years, and the average follow-up was 39 months (24 to 51). Before surgery, the mean angular deformity was 12° varus (10 to 16), always at the proximal tibia. None of the 20 operated knees was painful; all the patients requested operation for reasons of appearance.

Group B consisted of seven patients (Table I). The deformity was post-traumatic in five, a sequel of infection in one, and of postradiation injury in another. Their mean age was 15 years (14 to 16), and the average follow-up was

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Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Fig. 1e

Standing radiographs of an adolescent patient with idiopathic tibia vara treated by progressive opening-wedge osteotomy. Preoperative (a), just after correction (b) and at two years (c). Clinical photographs before (d) and after (e) progressive opening-wedge osteotomy. The scars at the osteotomy site are barely visible.

33 months (26 to 43). Five patients had valgus deformity of the distal femur and the other two had varus deformity of the distal tibia. The greatest deformity was 30° in a post-traumatic tibia vara and the smallest was 9° in a distal femur. One of the patients with a femoral deformity also had shortening of 5.5 cm, which was treated at the same procedure. Only two had pain; the other five wanted correction for cosmetic reasons.

Technique of operation. We used a Wagner fixator-distractor (Jacquet-Howmedica, Geneva, Switzerland), modified to achieve progressive angular correction (de Pablos et al 1991; de Pablos and Franzreb 1993). A simple free-moving hinge on the end of the apparatus nearest to the level of the deformity converted applied longitudinal distraction into angular movement at the metaphyseal-epiphyseal screws. In two cases in group B a 'T'-shaped pin-holder clamp was used to allow insertion of the screws in a perpendicular plane (de Pablos and Franzreb 1993).

The placement of the device starts by the guided insertion of two or three metaepiphyseal screws close to the

level of the deformity, and then two or three diaphyseal screws. The latter were perpendicular to the axis of the shaft and the metaepiphyseal screws were parallel to the adjacent articular surface. The body of the fixator-distractor was then assembled parallel to the longitudinal axis of the bone. We used predrilled self-tapered 6 mm diameter screws (Apex: Howmedica, Geneva, Switzerland).

When the fixator was secure, percutaneous osteotomy was performed as near as possible to the apex of the deformity. Through a 1 cm skin incision, several holes were drilled in the bone with a 3.2 mm drill to facilitate osteotomy which was completed by a chisel. No immediate correction of the deformity was attempted. An image intensifier was used to check the osteotomy and the proper insertion of the screws. Osteotomy of the fibula was not required in patients having correction of tibial deformities. The patients with bilateral idiopathic tibia vara had both sides operated on simultaneously.

Distraction started seven days after surgery at a rate of 1.5 (2×0.75) mm/day; this continued at the same rate

Table I. Details of seven patients (group B) who had progressive opening-wedge osteotomy

Case	Sex/age (yr)	Follow-up (mth)	Deformity		Shortening (cm)	Aetiology	Correction		Removal of device (wk)
			Site	Severity of deviation (mechanical axis)			Angular deformity	Shortening	
1	F:16	30	Distal femur	9° valgus	-	Physal fracture	3° varus	-	9
2	M:14	26	Distal femur	16° valgus	-	Physal fracture	Complete	-	12
3	M:15	33	Distal femur	12° valgus	-	Physal fracture	5° varus	-	9
4	M:14	28	Distal femur	16° valgus	-	Meningococcal sepsis	Complete	-	14
5	F:16	37	Distal femur	19° valgus	5.5	Radiotherapy	Complete	Complete	27
6	M:14	43	Distal tibia	15° varus	-	Physal fracture	Complete	-	10
7	M:16	36	Distal tibia	30° varus	-	Physal fracture	Complete	-	13

until complete correction was achieved. The free-moving hinge was then blocked until the device was removed. In the patient also requiring bone lengthening symmetrical distraction was continued after the completion of angular correction at a rate of 1 (2×0.5) mm/day. The fixator was removed when sequential radiographs showed satisfactory bone healing.

In group-A patients, the results were considered satisfactory when the mechanical axis of the limb after treatment ranged from 0° to 5° valgus (mild hypercorrection). In group-B patients, correction to normal within $\pm 2^\circ$ was judged as satisfactory.

Weight-bearing was allowed from the second postoperative week, and patients were encouraged actively to

mobilise the joints adjacent to the fixator throughout the period of treatment. When necessary, a physiotherapy programme was started after the removal of the distractor, but never before.

RESULTS

In all 27 bones, correction of the deformity was achieved with no major problems. The final mean angular correction in patients with idiopathic tibia vara (group A) was 15° , changing from a mean preoperative mechanical axis of 12° varus to 3° valgus (Fig. 1). In this group, there was one case of undercorrection (4° varus) at follow-up. In group B, one patient with varus deformity of the distal tibia also

Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Fig. 2e

Fig. 2f

Fig. 2g

Fig. 2h

Figures 2a,b,c and d – Radiographs showing progressive correction of a post-traumatic 30° varus deformity of the right distal tibia in a 16-year-old boy. This was the most severe deformity in our series. Figures 2e and 2f – Anteroposterior and lateral radiographs of the distal tibia 36 months after surgery. The correction and the joint space are well maintained. Figures 2g and 2h – Clinical photographs before and 36 months after progressive opening-wedge osteotomy.

required excision of an exostosis at the distal fibula to restore congruence at the ankle before correction of the deformity. No other associated operations were required.

In group B, the mean angular correction was 17° (Fig. 2). At follow-up two patients showed an overcorrection of the distal femur of 3° and 5° varus, respectively.

Patients in group A wore the Wagner device for an average period of ten weeks (9 to 12) and those in group B for 13 weeks (9 to 27). Six of the ten patients in group A, and five of the seven in group B, were discharged from hospital partially weight-bearing with crutches.

Consolidation of the osteotomised area was satisfactory in all patients without the need for bone grafting and none required either an additional period of cast immobilisation, or any method of stimulation of osteogenesis after the removal of the fixator. This was always removed in the outpatient clinic without anaesthesia.

There were no major complications leading to interruption of treatment. Minor complications included transient or mild pin-track infections which were seen at almost 40% of pin sites. These infections responded well to antibiotics and rest. By the end of follow-up, all patients had reached skeletal maturity and corrections were well maintained. Loss of correction after removal of the external fixator was seen only in one of the patients in group A.

DISCUSSION

The use of a modified unilateral external fixation-distraction device provides an attractive alternative to conventional osteotomies for the acute correction of angular deformities of the long bones. The advantages include less invasive surgery, progressive correction, the possibility of accurate adjustment of the correction throughout the postoperative period and smaller scars. Bone lengthening can be added when required and no second operation is needed for bone grafting or the removal of internal fixation.

There is a risk of over- or undercorrection using internally-fixed conventional osteotomies (Loder et al 1991; Henderson et al 1992), and opening-wedge procedures have a higher risk for damage of neural and vascular structures (Gibson et al 1986). Bone grafting is often necessary to stabilise the fragments and assist consolidation. Our progressive opening-wedge osteotomy minimises these problems. One patient had slight undercorrection. There were no traction lesions of nerves or vessels and consolidation was achieved without bone grafting. Bone grafting requires a second operation, usually on the iliac crest, which increases morbidity (Scheffer and Peterson 1994).

Closing-wedge osteotomy, perhaps the most popular method, has the drawback of producing shortening (Fowler, Gie and MacEachern 1991; Henderson et al 1992). Our technique prevents such shortening, but does produce slight lengthening of the operated segment. More bone lengthening is easily possible if needed, as in one of our cases. Conventional closing-wedge osteotomy for the treatment of

tibia vara always requires either fibular osteotomy or disruption of the proximal tibiofibular syndesmosis, both of which carry a risk of complications, including peroneal nerve damage.

Conventional osteotomies stabilised by minimal osteosynthesis such as staples require cast or brace support during the postoperative period. No additional stabilising methods were used after surgery. Progressive opening-wedge osteotomy does not need this: bilateral deformities can be addressed without severe discomfort. Our technique also allows patients to move the adjacent joints from the early postoperative period, particularly in adolescent tibia vara in which the operated knee is slightly restricted for only a very short period.

Either circular or unilateral frames may be used, but the latter are more simple to manage and avoid transfixing the leg. In our opinion, the modified Wagner device (de Pablos et al 1991) has advantages over other unilateral systems such as Orthofix (De Bastiani et al 1989; Fowler et al 1991) for the correction of angular deformities. Like Paley and Tetsworth (1992) we consider it important to correct the deformity at its apex. Where the deformity is close to the end of a long bone, it is very useful to be able to apply the Wagner device in its orthogonal configuration, as for physal distraction (de Pablos et al 1991; de Pablos and Franzreb 1993).

The amount of correction in cases of idiopathic tibia vara is still controversial. A mechanical axis ranging from 5° varus to 2° valgus has been considered to be an excellent outcome in adolescent Blount's disease (Henderson et al 1992), and Loder et al (1991) accept as satisfactory a 5° residual varus in the same type of patient. In adult tibia vara, however, optimal results have been found after slight overcorrection (Valenti et al 1990; Coventry, Ilstrup and Wallrichs 1993). In our group A, we aimed at overcorrection to a maximum of 3° valgus.

Our group of patients with idiopathic adolescent tibia vara must be distinguished from those with adolescent Blount's disease in whom the deformity is usually more severe and correction more difficult. It seems possible that an intraepiphyseal osteotomy of the proximal tibia (Schoenecker et al 1992) could be an alternative to conventional closing osteotomy in some cases of adolescent Blount's disease.

For tibia vara or valgus deformity of the femur we advise progressive angular correction first, followed by bone lengthening if needed. By contrast, using unilateral devices, varus deformity of the distal femur or valgus of the tibia requires any necessary bone lengthening *before* acute correction of the angular deformity (Cañadell and de Pablos 1992; de Pablos and Franzreb 1993).

Progressive opening-wedge osteotomy may have indications in diaphyseal angular deformities, independent of skeletal maturity, and in metaepiphyseal deformities in mature patients. In adolescents with the physal growth plate still open, angular deformities near the physis can be

treated by physal distraction (Monticelli and Spinelli 1984; Peltonen, Karaharju and Alitalo 1984; Cañadell and de Pablos 1985, 1992; Connolly et al 1986; Grill 1989; de Pablos and Cañadell 1990; Hamanishi et al 1990; Azcárate, de Pablos and Cañadell 1992; de Pablos and Franzreb 1993), by physal arrest methods, or by Langenskiöld's technique at earlier stages of growth (Phemister 1933; Blount and Clark 1949). In spite of our good results with progressive opening osteotomy, we are very cautious in our use of this technique in adults for two main reasons: the frequent poor tolerance of older patients to external fixators and their lower osteogenic capacity which could require long periods of treatment.

Few studies have reported the long-term outcome in patients with untreated angular deformities of the long bones, but it is clear that osteoarthritis is likely to develop and this has been described in patients with Blount's disease (Zayer 1980; Hofmann et al 1982), but not in idiopathic tibia vara as in our group A. We consider that surgical correction is indicated when the deformity exceeds 10° varus.

The most serious disadvantage of progressive opening-wedge osteotomy is the prolonged period of external fixation, especially for femoral deformities. Apart from patient tolerance, the long periods of treatment increase the risk of pin-track infection. Another important limitation of the unilateral frame is that it can be used only for femoral deformities in valgus and for tibia vara, but these axial deviations are the most common deformities in normal orthopaedic practice.

Summary. Progressive opening-wedge osteotomy is a valid alternative to conventional osteotomy. Good indications are severe angular deformities particularly if there is an associated limb-length discrepancy. Progressive opening-wedge osteotomy is reliable, allows adjustment during treatment, and is a less aggressive surgical procedure.

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REFERENCES

- Azcárate J, de Pablos J, Cañadell J. Treatment of premature partial physal closure by means of physal distraction: an experimental study. *J Pediatr Orthop* 1992;1:39-44.
- Blount WP, Clark GR. Control of bone growth by epiphyseal stapling: a preliminary report. *J Bone Joint Surg [Am]* 1949;31-A:464-78.
- Cañadell J, de Pablos J. Breaking bony bridges by physal distraction: a new approach. *Int Orthop* 1985;9:223-9.
- Cañadell J, de Pablos J. Correction of angular deformities by physal distraction. *Clin Orthop* 1992;283:98-105.
- Connolly JF, Huurman WW, Lippiello L, Pankaj R. Epiphyseal traction to correct acquired growth deformities: an animal and clinical investigation. *Clin Orthop* 1986;202:258-68.
- Coventry MB, Ilstrup DM, Wallrichs SL. Proximal tibial osteotomy: a critical long-term study of eighty-seven cases. *J Bone Joint Surg [Am]* 1993;75-A:196-201.
- De Bastiani G, Aldegheri R, Renzi Brivio L, Trivella GP. Dynamic axial external fixation. *Automedica* 1989;10:235-72.
- de Pablos J, Barrios C, Azcárate J. Modificación del aparato de Wagner para la corrección progresiva de deformidades angulares de los huesos largos. *Rev Ortop Traum* 1991;35:498-93.
- de Pablos J, Cañadell J. Experimental physal distraction in immature sheep. *Clin Orthop* 1990;250:73-80.
- de Pablos J, Franzreb M. Treatment of adolescent tibia vara by asymmetrical physal distraction. *J Bone Joint Surg [Br]* 1993;75-B:592-6.
- Fowler JL, Gie GA, MacEachern AG. Upper tibial valgus osteotomy using dynamic external fixator. *J Bone Joint Surg [Br]* 1991;73-B:690-1.
- Gibson MJ, Barnes MR, Allen MJ, Chan RNW. Weakness of foot dorsiflexion and changes in compartment pressures after tibial osteotomy. *J Bone Joint Surg [Br]* 1986;68-B:471-5.
- Grill F. Correction of complicated extremity deformities by external fixation. *Clin Orthop* 1989;241:166-76.
- Hamanishi C, Tanaka S, Tamura K, Fujio K. Correction of asymmetric physal closure: rotatory distraction in 3 cases. *Acta Orthop Scand* 1990;61:58-61.
- Henderson RC, Kemp GJ, Greene WB. Adolescent tibia vara: alternatives for operative treatment. *J Bone Joint Surg [Am]* 1992;74-A:342-50.
- Hofmann A, Jones RE, Herring JA. Blount's disease after skeletal maturity. *J Bone Joint Surg [Br]* 1982;64-B:1004-9.
- Loder RT, Schaffer JJ, Bardenstein MB. Late-onset tibia vara. *J Pediatr Orthop* 1991;11:162-7.
- Monticelli G, Spinelli R. A new method of treating the advanced stages of tibia vara (Blount's disease). *Ital J Orthop Traumatol* 1984;10:295-303.
- Paley D, Tetsworth K. Mechanical axis deviation of the lower limbs: preoperative planning of uniapical angular deformities of the tibia and femur. *Clin Orthop* 1992;280:48-64.
- Peltonen JI, Karaharju EO, Alitalo I. Experimental epiphyseal distraction producing and correcting angular deformities. *J Bone Joint Surg [Br]* 1984;66-B:598-602.
- Phemister DB. Operative arrestment of longitudinal growth of bones in the treatment of deformities. *J Bone Joint Surg* 1933;15:1-15.
- Scheffer MM, Peterson HA. Opening-wedge osteotomy for angular deformities of long bones in children. *J Bone Joint Surg [Am]* 1994;76-A:325-34.
- Schoenecker PL, Johnston R, Rich MM, Capelli AM. Elevation of the medial plateau of the tibia in the treatment of Blount disease. *J Bone Joint Surg [Am]* 1992;74-A:351-8.
- Smith CF. Tibia vara (Blount's disease). *J Bone Joint Surg [Am]* 1982;64-A:630-2.
- Smith DN, Harrison MHM. The correction of angular deformities of long bones by osteotomy-osteoclasts. *J Bone Joint Surg [Br]* 1979;61-B:410-4.
- Valenti JR, Calvo R, Lopez R, Canadell J. Long term evaluation of high tibial valgus osteotomy. *Int Orthop* 1990;14:347-9.
- Zayer M. Osteoarthritis following Blount's disease. *Int Orthop* 1980;4:63-6.