



Results of Angular Knee Deformities Treated with Temporary Hemiepiphysiodesis by Eight-Plate

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Abstract

Background: The physal manipulation (guided growth) provides a method for angular deformity correction of the knee joint with fewer complications than an osteotomy.

The temporary partial growth arrest is of the least invasive physal manipulation procedures

Material and Methods: Eighteen children patients (12 boys and 6 girls) with 36 knee angular deformities were treated by temporary epiphysiodesis method using the eight-plate (8-plate). Non-locked titanium 4.5-mm cannulated screws were used with the plate. The mean average age of the children at a time of the operation was 6.5 years (range, 4–11 years).

Results: All patients achieved complete deformity correction after plate removal and 2 cases had intended over correction of 8-10 degrees due to anticipated deformity recurrence because of the cause of deformity was Blount's disease. These cases get corrected at three years the final follow-up after removal of the plates. Neutral mechanical axis with no MAD was the sign of complete correction.

Conclusion: The technique of eight-plate with its pivoting screw and plate design is a valid technique for angular knee deformities correction. According to the outcome of this study, we recommend using eight-Plate technique in correcting knee joint angular deformities with the proper patient selection.

Keywords: hemiepiphysiodesis, knee, angular, deformity, 8-plate.

INTRODUCTION

Physiological angular changes of the lower limb alignment from about 15° varus to 8–10° valgus at approximately 3– 4 years of age in children, and subsequently decreasing to 6–7° of valgus at the age of 5–6 years [1-3]. Many factors can compromise the limb alignment during skeletal growth. Many generalized conditions can affect the skeletal growth like rickets, endocrinopathies, and skeletal dysplasias. The physis growth may be structurally damaged or pathologically affected in those patients. The medical treatment of such conditions can give good results to prevent progression of the deformity, but the need for surgical realignment of the lower limbs may still need. The application of orthosis in the condition of severe deformities may be ineffective, and eventual surgical intervention is mandatory [4-7]. The standard treatment procedure to correct the angular deformity surgically is osteotomy, but the dangers of immobilization and delayed weight-bearing are still causing a problem added to the reported complications. The difficulty accompanied with the acute correction by osteotomy leded orthopedic surgeons to search for other less invasive options [8,9]. One reliable method is the distraction osteogenesis using external fixation provides a method for gradual correction of angular deformity; however, poor patient compliance, with the long time of the technique are important disadvantages. The physal manipulation (guided growth) provides a method for correction of angular deformity with less complication than an osteotomy.

The temporary partial growth arrest is the least invasive of physal manipulation procedures [1, 3, 10]. The initial definition of hemiepiphysiodesis was by Blount and Clarke in 1949 [11] which is an alternative

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to osteotomy for leg straightening in adolescents. Screws, wires, and staples were tried as techniques for epiphysiodesis [12]. Complications as fractures of the material, implant loosening, or injury to growth plates have been reported [13]. Eight-Plates (Orthofix, USA) was first described by Stevens are simple to use [1]. Fewer complications were reported with the use of 8 plates due to flexible screw/plate connection in the first series of cases [14]. The hypothesis of the current study is that temporary hemiepiphysiodesis by using 8-plate with its pivoting screw and plate design gives better results compared to the other procedures used for treatment of angular knee deformities in children. So we try to answer the following queries as, what is the mechanism, the indications, the suitable age, the limitation, the complications and the advantages and the disadvantages of temporary hemiepiphysiodesis by using 8-plate procedure.

The aim of this prospective study is to evaluate the outcome results of temporary hemiepiphysiodesis by using 8-plate technique for treatment of angular knee deformities in 18 patients (36 knees).

PATIENTS AND METHODS

In the duration from January 2011 to May 2016, eighteen patients (12 boys and 6 girls) with 36 knee angular deformities were treated by temporary epiphysiodesis method using the eight-plate (8-plate). Non-locked titanium 4.5-mm cannulated screws were used with the plate. The mean age of the cases at the time of the operation was 6.5 years (range, 4–11 years).

Fourteen patients have bilateral genu varum deformities while four were with genu valgum of the knees. Twelve cases had both femoral and tibial bowing, and six cases were mainly tibial. Preoperative patient's clinical evaluation included limb lengths measurement, measurement of rotational and angular deformities with evaluation of the gait. The inter-condylar distance was recorded for genu varum. The patellar tracking and any ligamentous laxity were recorded. Radiographic evaluation: Full-length weight bearing plain x-ray (AP view) of both lower limbs with the patellae facing forward was done for all patients. The mechanical axis deviation (MAD) from the knee joint was recorded for all cases. It was drawn from the center of the hip to the center of the ankle passing by the knee joint as shown in **(Fig 1)**. As the mechanical axis normally bisecting the knee, the knee is divided into 4 zones when zone 1 is normal, if the mechanical axis displaced into zone 2 or 3 it is an indication for intervention, especially when the deformity is progressive and symptomatic. To determine the origin of the deformity (femoral, tibial or combined), the mechanical lateral distal femoral angle (mLDFA) and the medial proximal tibial angle (MPTA) were measured for all patients as shown in **(Fig 2)**. When indicated, the multiplier method was used to determine if there is sufficient predicted growth remaining to achieve the desired correction through guided growth.

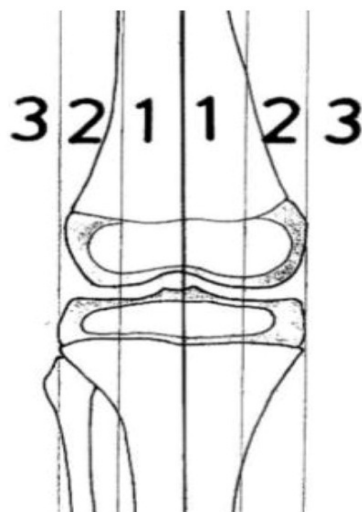


Figure1. zones of mechanical axis deviation of knee in angular deformities.

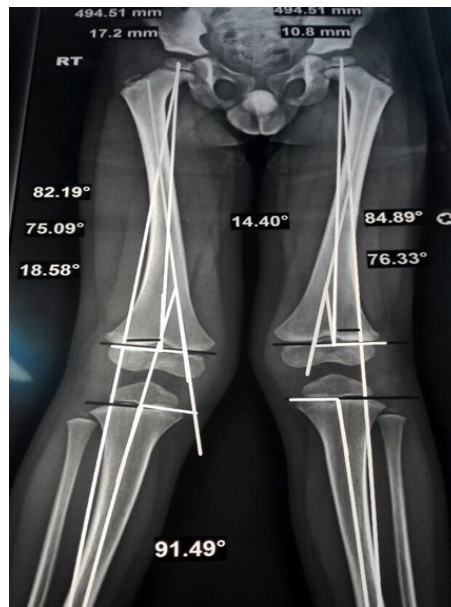


Figure 2. measurement of angle in knee angular deformities.

Operative Technique

As a day case surgery, all cases were operated on under general anesthesia, in the supine position with the application of a tourniquet. Under C-Arm fluoroscopic radiation, 3 cm long skin incision opposite the physis was done laterally; or medially in cases with genu valgum then the dissection was done through the fascia, between muscles, without elevating the periosteum as shown in (Fig 3, 4). To localize the physis, a needle was inserted through the perichondrial ring under fluoroscopy. The plate of 12 or 16 mm was chosen, then threaded guide pins were inserted through the centers of holes of the plate. A cannulated drill bit of 3.2 mm caliber was used over the guide wire, and then two 4.5-mm self-tapping cannulated screws were applied with lengths of the screw does not pass the midline. After securing the screws, the wound was closed and the compression bandage was applied. After two weeks the stitches were removed and monthly follow up was recommended for the patients with serial x-rays for correction. Plate removal was scheduled when the legs are straight and follow-up radiographs were documented.

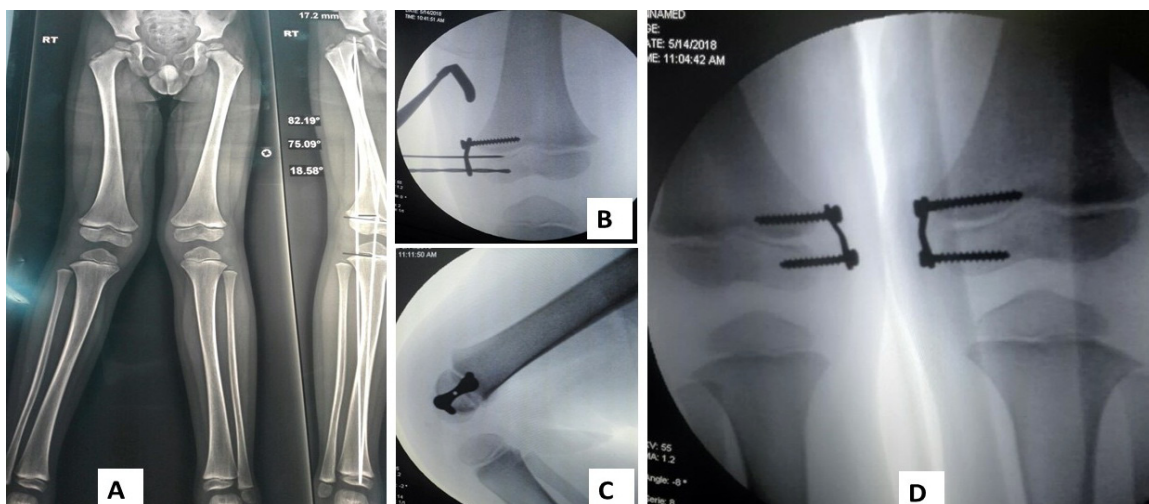


Figure 3. operative technique in bilateral genu valgum with main femoral deformity.

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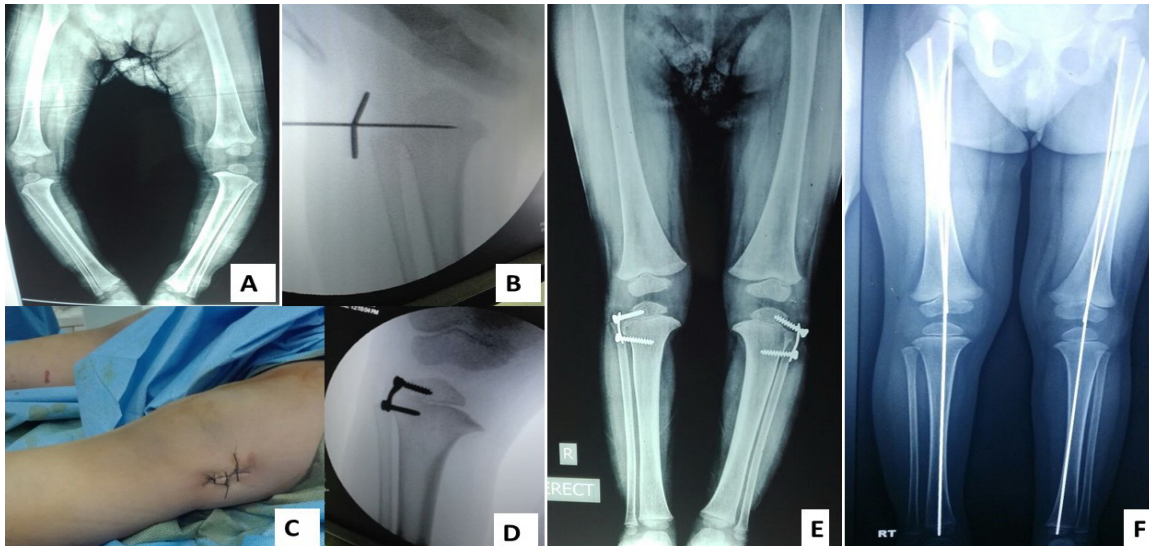


Figure 4. bilateral genu varum with 8-plate epiphysiodesis in both tibiae; **a)** preoperative x-ray; **b)** intraoperative x-ray during fixation; **c)** skin incision; **d)** intraoperative x-ray with plate applied; **e)** full correction x-ray with plate; **f)** after plate extraction with full correction.

Statistical Analysis

Data was collected throughout history, basic clinical examination; laboratory investigations and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) (Statistical Package for the Social Sciences) software for analysis.

According to the type of data qualitative represent as number and percentage, quantitative continues group represented by mean \pm SD, the following tests were used to test differences for significance. Differences between quantitative paired groups by paired t-test. P value was set at <0.05 for significant results & <0.001 for high significant result.

RESULTS

The average time of plate removal was 18.4 ± 2.1 months (range 16–24 months). The mean follow-up was 36.7 ± 6.3 months (range 24–48 months) after plate removal. Four patients reached skeletal maturity at the final follow up. The eight-plates were inserted on the lateral distal femur in 4 patients (22.2%), in proximal tibia in 10 (55.6%) patients and on both femur and tibia bilaterally in 4 patients (22.2%). All patients achieved complete deformity correction after plate removal, and 2 (11.1%) cases had intended over correction of 8–10 degrees due to anticipated recurrence of the deformity because the cause of deformity was Blount's disease. These cases get corrected at the final follow three years after removal of the plates. Neutral mechanical axis with no MAD was the sign of complete correction. Alignment improved in all cases at final follow up. In cases when the deformity origin was femoral, the average of mL DFA decreased from $98.4^\circ \pm 4.6$ to $87.4^\circ \pm 2.3$ significantly ($P=0.003^*$), which constitutes an average change of 11° , and when the origin of deformity was tibial, the average MPTA increased from $77^\circ.3 \pm 3.1$ to $85^\circ.4 \pm 4.8$ significantly ($P=0.00^{**}$) which constitute an average change of 8° , as shown in (**Fig 5**), **Table 1**. No intraoperative complications were recorded. Postoperative superficial infections were reported in two cases (11.1%) and treated by repeated dressing and IV cephalosporin antibiotics for 10 days. Wound dehiscence, reactive synovitis, or hardware failures, were not observed in this series. No cases required any osteotomy or repeat the eight-Plate insertion until final follow up.

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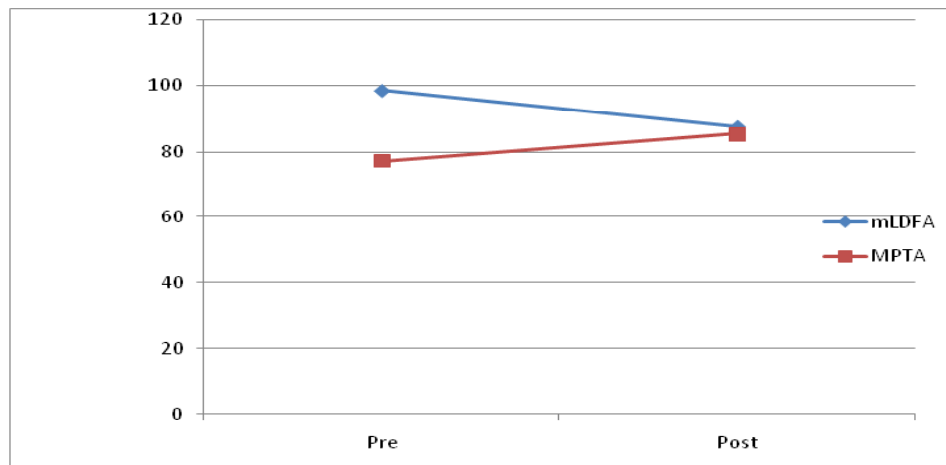


Figure 5. Chart showing, in cases when the deformity origin was femoral, the average of mLDFA decreased from $98.4^{\circ} \pm 4.6$ to $87.4^{\circ} \pm 2.3$ significantly ($P=0.003^*$), which constitutes an average change of 11° , and when the origin of deformity was tibial, the average MPTA increased from $77.3^{\circ} \pm 3.1$ to $85.4^{\circ} \pm 4.8$ significantly ($P=0.00^{**}$) which constitute an average change of 8°

(mLDFA)* = The mechanical lateral distal femoral angle. (MPTA)* = the medial proximal tibial angle.

Table 1. In cases when the deformity origin was femoral, the average of mLDFA decreased from $98.4^{\circ} \pm 4.6$ to $87.4^{\circ} \pm 2.3$ significantly ($P=0.003^*$), which constitutes an average change of 11° , and when the origin of deformity was tibial, the average MPTA increased from $77.3^{\circ} \pm 3.1$ to $85.4^{\circ} \pm 4.8$ significantly ($P=0.00^{**}$) which constitute an average change of 8° .

	Pre	Post	P
mLDFA	$98.4^{\circ} \pm 4.6$	$87.4^{\circ} \pm 2.3$	0.003*
MPTA	$77.3^{\circ} \pm 2.1$	$85.4^{\circ} \pm 3.8$	0.00**

(mLDFA)* = The mechanical lateral distal femoral angle. (MPTA)* = the medial proximal tibial angle.

DISCUSSION

The guided growth procedure via temporary hemiepiphysiodesis is a technique for correction of angular deformities of the lower limb in children [1]. The creation of a tether on the convex side of the physis and subsequent growth from the unarrested side gives correction of the angular deformity. This technique is a less invasive surgery achieved with a very low morbidity and can be suspended once the adequate alignment is obtained [2-6]. The concept of the eight-plate lies in the placement of a non-rigid extra periosteal plate and two screws, serving as a focal hinge at the perimeter of the physis [10]. Because the fulcrum of the plate falls outside the physis, it has a longer moment arm and does not exert a relative compression effect on the physis without limiting the growth potential [14]. In this study, the diversion of the two screws was observed while correction of the deformities. Also, the screw heads were angled at the interface between the screw and the plate, as the screw was not locked at the plate-hole. Toggling of the screws of the 8-plate is an advantage in that it applies a tether only at the periphery of the physis, which unlike staples, makes the technique to be ideal in younger children. When using a staple in the extremity of a young child, there is a tendency to back out of the staple. As the epiphysis is largely unossified in young children, extrusion can occur because only the tip of each tine is lodged in bone. Most of the length of each tine is embedded in unossified cartilage [9, 13]. In contrast, the eight-Plate eases this problem by using threaded screws. Screws offer a stronger purchase than smooth staples. In this series, none of the screws broke or backed out, as the screws are free to pivot in the plate holes [14]. Pivoting of screws might apply less pressure to the physis offering the advantage of physeal preservation

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through reducing the danger of bar formation [15]. In a study done by Park et al [16], they demonstrated that hemiepiphysal stapling of the lateral surface of the proximal tibial physis and, as needed, the lateral aspect of the distal femoral physis is safe and effective in children with late-onset tibia vara provided that the physes are sufficiently open and the varus deformity is mild to moderate. They found that the procedure is most effective in patients younger than 10 years. El-Batrawy et al [17] in their series which included the application of 43 eight-plates in 22 patients with angular knee joint deformities and recently Zajonz et al [1] in their study that included 198 eight-plates that were implanted near the knee in 132 children suffered from angular knee joint deformities had reported good results. Both of them found that guided growth with 8 plate technique is proved to be safe and effective in the treatment of angular knee deformities with advantages over other commonly used techniques in children from 3 up to 12 years. They also found that the reported failure is due to poor patient selection, not the device malfunction. Particularly in young patients with high growth potential and risk groups such as overweight patients, slight overcorrection is needed due to the rebound phenomenon. In children with low growth potential (older than 14 years), due to expected low correction potential, the indication should be strictly reviewed and the possible failure of therapy should be discussed with the patient and parents. In this series 3 patients were over the age of 10 years and responded quite well to this technique. All cases in the current series had achieved full correction, but this was the preliminary results in a small sample size. Additional studies are needed over a larger sample size and longer follow-up periods to give more long-term results to be validated, as further follow-up studies are needed to confirm that growth will start after eight-Plate removal. Parents should be informed that subsequent growth could be asymmetrical, leading to a relapse of the deformity. However the results of the present study raising our hypothesis about the validity of hemiepiphysiodesis by the eight-plate with its pivoting screw technique compared to the other methods used to treat angular knee deformities.

CONCLUSION

The technique of eight-plate with its pivoting screw and plate design is a valid technique for correction of angular deformities around the knee. According to the outcome results of this study, we recommend using eight-Plate in correcting around knee angular deformities with the proper patient selection.

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Compliance with Ethical Standards

Ethical Standards: All human studies have been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Ethical Approval: All the procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1975 Helsinki Declaration as revised in 2000.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

REFERENCES

1. Zajonz D, Schumann E, Wojan M, Kübler FB, Josten C, Bühligen U, Heyde CE. (2017): Treatment of genu valgum in children by means of temporary hemiepiphysiodesis using eight-plates: short-term findings - BMC Musculoskeletal Disorders, 18:456.
2. Stevens PM. (2007): Guided growth for angular correction: a preliminary series using a tension band plate - J Pediatr Orthop, 27:253-259.

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3. Ashby E, Eastwood D. (2015): Characterization of knee alignment in children with mucopolysaccharidosis types I and II and outcome of treatment with guided growth - J Child Orthop , 9:227-33.
4. Sprouse C, Tosi L, Stapleton E, Gropman AL, Mitchell FL, Peret R. (2013): Musculoskeletal anomalies in a large cohort of boys with 49, XXXXY - Am J Med Genet C Semin Med Genet, 163C:44-9.
5. MacMahon EB, Carmines DV, Irani RN. (1995): Physiologic bowing in children: an analysis of the pendulum mechanism - J Pediatr Orthop B, 4:100-105.
6. Stevens PM1, Klatt JB. (2008): Guided Growth for Pathological Physes: Radiographic Improvement During Realignment - J Pediatr Orthop, 28(6):632-639.
7. Raab P, Wild A, Seller K (2001): Correction of length discrepancies and angular deformities of the leg by Blount's epiphyseal stapling - Eur J Pediatr, 160(11):668-674.
8. Muller K, Muller-Farber J. (1984): Indications, localization and planning osteotomies .about the knee - Hierholzer G, Muller K, eds. Corrective osteotomies of the lower extremity after trauma. Berlin: Springer-Verlag, 195- 223.
9. Wiemann J M, Tryon C, Szalay E A. (2009): Physeal stapling versus 8-plate hemiepiphysiodesis for guided correction of angular deformity about the knee - J Pediatr Orthop, 29 (5): 481-5.
10. Burghardt RD, Herzenberg JE. (2010): Temporary hemiepiphysiodesis with the eight-plate for angular deformities: mid-term results - J Orthop Sci, 15: 699-704.
11. Blount WP, Clarke GR. (1949) : Control of bone growth by epiphyseal stapling: a preliminary report - J Bone Joint Surg Am, 31:464-78.
12. Burghardt RD, Herzenberg JE, Standard SC, Paley D. (2008): Temporary
13. Hemiepiphysal arrest using a screw and plate device to treat knee and ankle deformities in children: a preliminary report - J Child Orthop, 2:187-97.
14. Wiemann JM, 4th. Tryon C, Szalay EA. (2009): Physeal stapling versus 8-plate hemiepiphysiodesis for guided correction of angular deformity about the knee - J Pediatr Orthop, 29:481-485.
15. Jelinek EM, Bittersohl B, Martiny F, Scharfstadt A, Krauspe R, Westhoff B. (2012) : The 8-plate versus physeal stapling for temporary hemiepiphysodesis correcting genu valgum and genu varum: a retrospective analysis of thirty five patients - Int Orthop, 36:599-605.
16. Mielke CH, Stevens PM. (1996): Hemiepiphysal stapling for knee deformities in children younger than 10 years: a preliminary report - J Pediatr Orthop, 16:423-429.
17. Park SS¹, Gordon JE, Luhmann SJ, Dobbs MB, Schoenecker PL. (2005): Outcome of hemiepiphysal stapling for late-onset tibia vara - J Bone Joint Surg Am, 87(10):2259-2266.
18. ElBatrawy Y, Mahran M, EL Gebeily M (2014): Temporary Epiphysiodesis In The Correction Of Angular Knee Deformities Using Guided Growth Principle With Eight-Plate. Ain-Shams, University orthopedic journal ;(1-7).

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