Incomplete Follow-up After Growth Modulation Surgery: Incidence and Associated Complications

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Background: Extraperiosteal tension plates have become the predominant method for angular deformity correction in skeletally immature patients, with some surgeons using them in very young children with the intent of removing the implants once the correction is complete. The purpose of this study is to determine the incidence of incomplete follow-up and to assess the outcomes of children who were lost to follow-up with retained implants.

Methods: A quality initiative survey was performed at 2 institutions on children treated with extraperiosteal tension plates around the knee because of sentinel events that occurred at each institution. Compliance with follow-up was noted, and children with open perigenicular physes on latest radiograph with retained implants were identified with attempts to reestablish care. Subsequent review of those children was performed, including clinical results, radiographic results, and the need for second deformity surgery.

Results: A total of 200 children treated with tension plates were identified (116 at institution #1, 84 at institution #2). The most common indication for surgery was genu valgum (54%), and the mean age at initial surgery was 11.7 years (range, 3.1 to 16.8 y). A high rate of retained implants with incomplete follow-up was identified at both institutions, where a total of 23 patients (12%) were lost with implants still in place. Only 7 of 23 patients returned for evaluation: 3 reached skeletal maturity with no complications, but 4 overcorrected creating the opposite angular deformity. Two of those children required osteotomies to remedy their overcorrection. Two additional patients were reachable, but failed to return for follow-up and the remaining patients were unreachable.

Conclusions: The incidence of incomplete follow-up was significant at both institutions (12% combined incidence). Of those who were found for follow-up, nearly one third required a surgery beyond simple implant removal. Incomplete follow-up among this cohort was identified as a significant quality of care issue, and an EMR system has been established to actively follow children receiving growth modulation surgery.

Level of Evidence: Level IV.

Key Words: growth modulation, genu varum, genu valgum, epiphysiodesis, hemiepiphysiodesis

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In the mid 1940s, Haas introduced the use of wires and staples to temporarily cease physeal growth in a canine model, leading the way for correction of angular deformity by guided growth techniques. Shortly following, Blount described the use of a physeal staple for gradual correction of angular deformity in children, which became a popular method of angular deformity correction in children.[1]

In 2007, based on principles popularized by Blount, Stevens[2] introduced the use of extraperiosteal tension plates for angular correction, which, like Blount's staples, allow for gradual correction with growth, are technically simple, and removable (allowing for physiological variation of growth velocity between patients). Consequently, tension plates are now the predominant method used for angular correction in immature patients and are commonly used for other indications including knee flexion contractures and correction of leg-length discrepancies.[3–5] The implants can be placed at any age, the correction of deformity can be monitored radiographically, and the implants can be removed when the correction is optimized. But, what if these young patients fail to return for removal of the implants?

This study seeks to answer 2 questions regarding growth modulation surgery: (1) What is the incidence of incomplete follow-up after tension plate placement for growth modulation? and (2) What are the outcomes of children that were lost to follow-up with retained implants? We also discuss the quality improvement initiative that commenced to reduce the risk of complications if patients undergoing growth modulation surgery are lost to follow-up.

METHODS

This series includes patients from 2 institutions who were lost to follow-up after placement of tension plates, some of which subsequently endured significant complications due to incomplete follow-up. Both institutions

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that participated in this study became aware of the potential complication of growth modulation surgery patients becoming lost to follow-up by sentinel events. In each case a family presented a second time when they believed the original deformity to have recurred, but in fact the opposite deformity had developed due to persistent growth and the indwelling tension plates (Figs. 1, 2). Both institutions independently began quality initiative surveys on patients who underwent epiphysiodesis, or hemiepiphysiodesis, with extraperiosteal transphyseal plates for any diagnosis. Per institution guidelines, Institutional Review Board approval was obtained to perform their respective patient reviews.

At institution #1, children operated on between 2008 and 2011 were reviewed and at institution #2, children who received surgery between 2003 and 2010 were included. The date of surgery and date of implant removal, if applicable, were noted. The most recent office note was reviewed to determine whether families were compliant with their follow-up visits. Patients who had failed to return as planned were further reviewed to determine the status of their implants and skeletal maturity at last follow-up.

Skeletally immature patients with indwelling plates were contacted to return for an evaluation and the results of these contacts were analyzed. These consisted of failure to make contact, treatment at an outside facility, outcomes of those who returned for evaluation, and additional procedures including implant removal or corrective osteotomies.

RESULTS

Two hundred children who received treatment with perigenicular tension plates were identified at the 2 participating institutions: 116 children at institution #1, and 84 children at institution #2. Mean patient age at initial implantation (11.7 y; range, 3.1 to 16.8 y) was similar between the 2 institutions. The most common deformity was genu valgum, followed by genu varum, leg-length discrepancy, knee flexion contracture, and combined deformities.

A high rate of incomplete follow-up was noted at both institutions, with 23 of 200 children (12%) lost to follow-up with indwelling implants. After identifying skeletally immature patients with retained implants, both

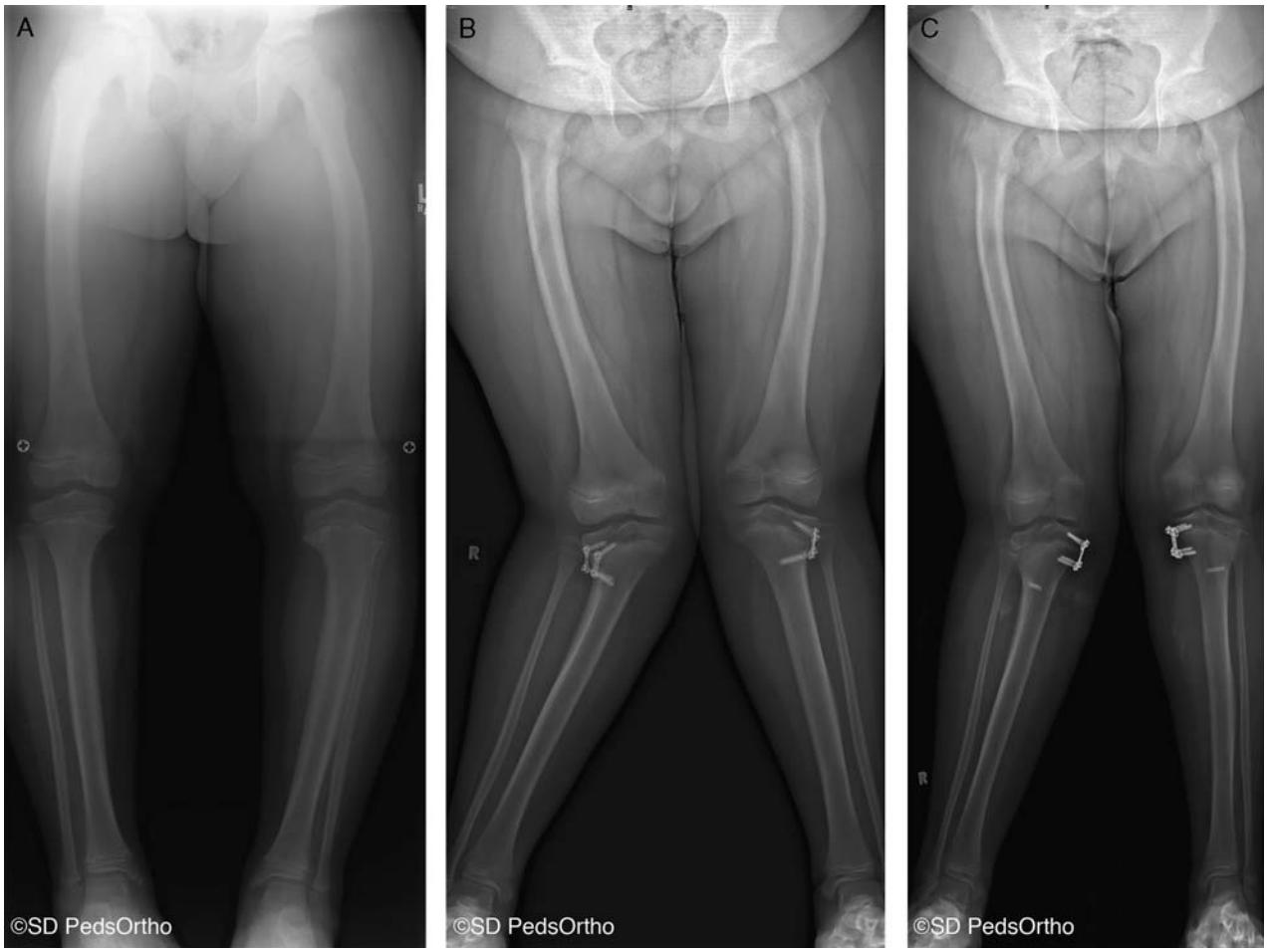

FIGURE 1. An 8-year-old boy presenting with bilateral tibia vara (A). Three years after placement of lateral guided growth plates, he returned with iatrogenic bilateral genu valgum (B), which was treated with guided growth plates on the medial proximal tibias. Again lost to follow-up, he eventually returned with overcorrection of his left knee into genu varum (C).

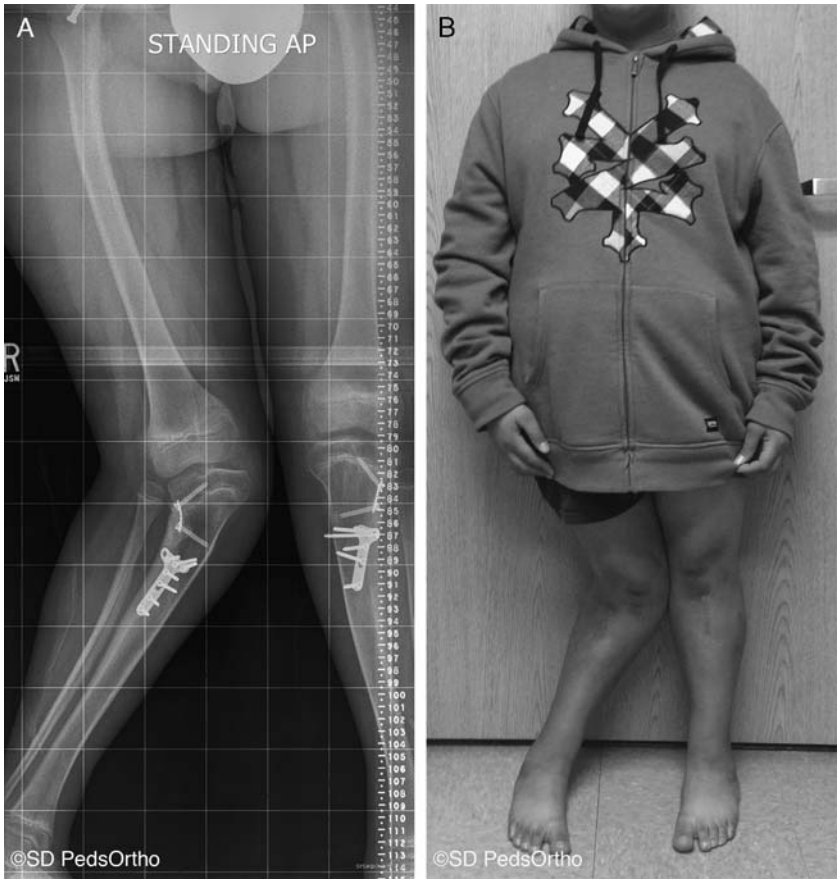

FIGURE 2. A 12-year-old boy previously treated at an outside institution for tibia vara who presented with hip pain. Evaluation revealed a slipped capital femoral epiphysis and iatrogenic genu valgum (A and B). He subsequently required reconstruction with osteotomies and external fixation.

institutions then made attempts to contact those families. Fourteen of the 23 patients were unreachable. Of the remaining 9, 1 had the plates removed at another center, 2 reached skeletal maturity without complication, and 4 had overcorrection and development of the opposite deformity. Of these 4 patients, 3 had corrective osteotomies recommended, but only 2 elected to undergo the more extensive procedures for their overcorrection. The other elected for implant removal, only, as did the fourth patient who was not advised to have osteotomies. Two remaining patients who were contacted failed to return for follow-up despite multiple attempts to have them return. In total, 29% of children evaluated with retained implants and incomplete follow-up required additional surgery beyond simple implant removal to remedy the overcorrection of their original deformity.

Figures 1 and 2 illustrate the 2 sentinel events that triggered the quality review at each institution, both illustrating the potential complications that can arise from incomplete follow-up after growth modulation surgery.

DISCUSSION

Beginning with Blount's staples in 1949 and continuing with extraperiosteal tension plates popularized by Stevens, correction of lower limb deformity with guided growth has a long history of success. Tension plates have now become the predominant method of angular deformity correction in skeletally immature patients. The excellent safety profile has been supported by many authors[2,6–8] and the low rate of premature physeal closure has prompted their placement in very young patients. In Stevens'[2] original report, plates were placed and successfully removed in patients as young as 20 months old. Over the current study period, patients as young as 3 years old were treated with growth modulation using tension plates at our institutions. Here, we have explored the incidence of incomplete follow-up in patients treated with growth modulation and examined the outcomes of attempts to contact these patients.

The underlying assumption that accompanies temporary epiphysiodesis is that the plates or staples will be removed when the deformity has corrected. Blount and Clarke[1] wisely advised in their original article that "the patient must be observed frequently, so that the staples may be removed at just the right time." Clearly, an iatrogenically induced growth modulation has potential to overcorrect to the opposite deformity if the implant is retained for too long, but few such occurrences are reported in the literature. In this study, we report a 12% incidence of

incomplete follow-up among families being treated with tension plating for lower extremity deformity correction. This is an alarming rate considering the ill effects the plates can have if not removed at the optimal time, as demonstrated in our illustrative cases.

Figure 1 illustrates the need for an active follow-up plan after growth modulation surgery. This child had an episode of overcorrection requiring placement of additional plates to correct the iatrogenic injury. Although the need for continued follow-up into skeletal maturity was stressed to the child's family, and despite his previous iatrogenic deformity development, his family once again failed to return resulting in a windswept iatrogenic deformity. Clearly, relying on the patient's family to return was not sufficient and active involvement on part of the treating physician was required to ensure subsequent follow-up.

Although not part of our study population because his plates were placed at an outside institution, Figure 2 demonstrates the significant morbidity that can result from incomplete follow-up. Nearly 5 years after his growth modulation procedures, this child required a complex reconstruction due to iatrogenically induced deformity. In our review, many of the 23 patients lost to follow-up with their tension plates still in place were unreachable by phone or mail, leaving one to wonder what iatrogenic deformities may have occurred after surgery in these children. Of the 7 that did return for evaluation, 29% (n = 2) required substantial surgery beyond plate removal. Although these 2 children comprise only 1% of the 200 children receiving growth modulation surgery in our study, the iatrogenic complication is avoidable if proper mechanisms are in place to ensure proper follow-up.

Admittedly, we do not have a good understanding of why so many patients did not return. Possible reasons include transportation issues, insurance changes, fear of further surgery, having moved to another area, or simply that they did not understand the consequences of incomplete follow-up. Clearly, we did not adequately identify at-risk patients or did not communicate the importance of compliant follow-up to them, but it is also unrealistic to think that all scenarios leading to incomplete follow-up can be identified preoperatively. Thus, it is imperative that surgeons have a system in place to track and actively follow patients undergoing growth modulation surgery.

The need for active involvement on the part of the surgeon motivated a quality initiative program within the orthopaedic departments at both institutions. At institution #1, using the hospital's EMR system, a treating surgeon can "flag" patients at risk of iatrogenic morbidity if lost to follow-up and set a specific date to return. This indicator is then available to all providers involved in the patient's care, including primary care physicians, emergency room practitioners, and other allied health professionals that may access the EMR. This "flag" warns the practitioner that the patient needs to return to orthopaedics and they can be encouraged to follow-up near the target date. Moreover, each month, a report is generated of patients near or beyond their target follow-up date and they are contacted to request a return visit. At institution #2, a database has been created to track patients who have undergone growth modulation surgery.

As with any retrospective study, ours is not without limitations. Data were gathered independently from 2 institutions and collaboration culminated after collection began. Because each center began their collection at different time points, the date ranges are slightly different. However, the dates include nearly all growth modulation procedures performed around the knee at each institution until the respective data collections began. This study also focused on a specific problem associated with growth modulation surgery—incomplete follow-up. A complete review of all complications associated with tension plates—such as undercorrection, rebound, implant failure, or infection—would be valuable, but we believe the important message of active surgeon involvement in patient follow-up would be lost in an exhaustive review of our experience with tension plates. Finally, many of the patients with incomplete follow-up were unreachable, limiting the analysis of their outcomes and leaving questions about the result of their correction.

CONCLUSIONS

A high rate of incomplete follow-up was noted in children receiving perigenicular growth modulation surgery, resulting in iatrogenic deformity that required additional surgery beyond simple implant removal in nearly one third of those presenting after being lost to follow-up. With the expansion of the concept of growth modulation surgery into other areas of pediatric orthopaedics, such as spine surgery,[9,10] surgeons performing such procedures should have structured mechanisms in place to ensure that families return for follow-up visits to avoid iatrogenic complications.

The quality and safety of these growth-modulating surgeries are highly dependent on whether or not the child and their family return to for their follow-up evaluation; and with the growing utilization of electronic medical records, the success of these follow-up return visits should be improved. Moreover, successful treatment of these children will likely involve the recruitment of their primary care physicians to help aide monitoring of follow-up status, as well as serving a guiding role to the family to keep their appointments with the orthopaedic surgeon.

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