An Original Study

Pin-Tract Infection During Limb Lengthening Using External Fixation

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Abstract

We evaluated the incidence of pin-tract infection (PTI) during limb lengthening using external fixation in 88 patients and the effects of infection on final outcomes and incidence of additional procedures. The PTI rate was 96.6%. The rate of half-pin site infection was significantly (*P*<.05) higher in half-pin fixators (100%) than in hybrid fixators (78%). There was a significantly (*P*<.05) higher incidence of half-pin site infection (78%) than fine-wire site infection (33%). The rate of additional surgeries for treating PTI was higher for half-pin sites than for fine-wire sites. Three (3.4%) of the 88 cases led to chronic osteomyelitis. Careful insertion and a simple, well-defined, excellent pin-care protocol can minimize PTI.

Pin-tract infection (PTI) is the most frequent complication during limb lengthening using external fixation.[1-4] Results from many clinical studies have shown that almost all patients undergoing limb lengthening developed PTI.[1-3,5] Although many causes of PTI have been identified,[6-9] and strategies have been devised to reduce it,[10-13] it is still a common problem that needs to be addressed. Many authors[5,6,14,15] consider it a minor complication, but it can lead to chronic osteomyelitis[1,5,16,17] and decrease the stability of the pin–bone interface.[4,8,12,16] The mechanical properties of an external fixation frame, used during bone lengthening, determine the biomechanical environment in the healing bone gap.[18-21] Contemporary techniques of external fixation (manual insertion of self-drilling half-pins, use of tapered pins after drilling a pilot hole, use of fine-tensioned wires, meticulous pin-site care) are options during limb lengthening, but patients are still burdened by PTI.

In this study, we evaluated the incidence of PTI during limb lengthening using external fixation and the effects of infection on final outcomes and incidence of additional procedures.

Materials and Methods

We conducted a retrospective study of 88 consecutive patients who underwent 62 tibial and 54 femoral lengthenings between January 1990 and December 2003. The etiology was congenital in 46 lengthened segments and acquired in 70 lengthened segments. Mean age at time of surgery was 13.5 years (range, 4-20 years). Mean follow-up was 4 years (range, 2-12 years). There was lengthening alone in about half the cases (57 bones, 49.1%), 2-dimensional deformity correction in 41 bones (35.3%), and 3-dimensional deformity correction in 18 bones (15.5%). Lengthening was initiated a mean of 5.7 days after osteotomy at a rate of 0.25 mm 4 times a day at the distraction site. The distraction rate was adjusted according to the efficiency of new bone formation or to patient's tolerance.

Pin-tract infection was defined as signs and symptoms of infection around a pin or wire that required increasing the frequency of local cleansing, protecting the pin site with dressing, using an oral or intravenous (IV) antibiotic, removing the pin or wire, or performing surgical débridement. PTIs were graded according to Paley[6]: grade 1, soft-tissue inflammation; grade 2, soft-tissue infection; grade 3, bone infection. These infections were treated in stepwise fashion. In all cases, step 1 was obtaining a proper culture from the pin tract.

For grade 1 infection, step 2 was increasing the frequency of local cleansing, protecting the pin site with dressing, and starting an oral antibiotic. Cephalexin was the antibiotic preferred for the period before culture results were learned. If the infection resolved with a 1-week course of antibiotic, the antibiotic was discontinued, and regular pin-site care was started. If the infection progressed to grade 2, step 3 was changing the oral antibiotic or starting an IV antibiotic. Step 4 was removing the pin or wire.

For grade 2 infection, step 2 was increasing the frequency of local cleansing, protecting the pin site with dressing, and starting an oral antibiotic. If the infection resolved with a 1-week course of antibiotic, the antibiotic was discontinued, and regular pin-site care was started.

For grade 3 infection, step 3 was starting an IV antibiotic, and step 4 was removing the pin or wire. If pus was

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Table I. Pin-Tract and Associated Infections Rate

Complications	Per Patient Absolute	Per Patient %	Per Segment Absolute	Per Segment %
Pin-tract infections	85	96.6	113	97.4
Half-pins	85	96.6	97	83.6
Fine wires	24	27.3	24	20.7
Osteomyelitis	5	5.7	5	4.3
Acute	2	2.3	2	1.7
Chronic	3	3.4	3	2.6
Bacteremia	1	1.1	1	0.9
Bacterial endocarditis	1	1.1	1	0.9
Toxic shock syndrome	1	1.1	1	0.9

Table II. External Fixator Type and Pin-Tract Infection Rate

		Pin-Tract Infection			
		Fine-Wire Site		Half-Pin Site	
External Fixator Type	No.	Absolute	%	Absolute	%
Half-pins	41	N/A	N/A	41	100
Hybrid (fine wires & half-pins)	72	24	33	56	78

found collecting, formal débridement and curettage were performed in the operating room. Culture results and the clinical course were used to guide antimicrobial therapy. Additional débridement was performed as needed.

Hospital and clinic data were retrospectively reviewed. Records were reviewed for external fixator type, number of pins or wires used, external fixation duration (days), length of distraction regenerate (cm), angular correction, lengthening percentage (percentage increase in bone length), lengthening index (days per centimeter), complications, pin-site care and treatment, and additional surgeries. PTIs were divided into fine-wire and half-pin site infections. In addition, we compared the rate of half-pin site infection in half-pin fixators and hybrid external fixators. All patients received parenteral prophylactic perioperative antibiotics. The pin-care protocol involved using sterile gauze packing around the skin–pin junction acutely at surgery and removing it on postoperative day 2. Sterile gauze packing was continued as needed until the pin site was dry. Patients were allowed to shower and to clean pin sites with soap and water daily, to use sterile cotton swab tips to remove crust adhering to pins, and to use frame covers for pin care.

Statistical analyses were conducted with SAS (SAS Institute, Cary, NC). Two-sample *t* tests assuming unequal variances and analysis of variance were followed by post hoc *t* tests with an α level of $P<.05$. Continuous data were reported as means and SDs.

Results

Lengthening index was 33 days/cm (SD, 1.1 days/cm), distraction regenerate length was 6 cm (SD, 0.4 cm), lengthening percentage was 21% (SD, 2.1%), and external fixation length was 181 days (SD, 86 days). Fifty-five hybrid fixators were Ilizarov (Smith & Nephew, Memphis, Tenn), and 1 was EBI (EBI Medical Systems Inc, Parsippany, NJ). Of the half-pin fixators, 37 were Ilizarov (Smith & Nephew), 2 were EBI, and 2 were Orthofix (Orthofix SRL, Verona, Italy).

The PTI rate was 96.6% (Table I). The rate of half-pin site infection was significantly ($P<.05$) higher in half-pin fixators (100%) than in hybrid fixators (78%) (Table II). The rate of half-pin site infection (78%) was significantly ($P<.05$) higher than that of fine-wire site infection (33%) in hybrid external fixation. All 5 cases of osteomyelitis were associated with grade 3 half-pin site infection (Table III). In addition, 3 cases of half-pin site grade 2 infection were associated with bacteremia, bacterial endocarditis, and toxic shock syndrome. The most common etiology of infection was *Staphylococcus aureus* (47.1%), followed by *Staphylococcus epidermidis, Escherichia coli,* and *Pseudomonas aeruginosa* (Table IV). The rate of additional surgeries and interventions for treating PTI was associated more with half-pin sites than with fine-wire sites (Table V).

Discussion

The results of pediatric limb lengthening by distraction osteogenesis are impressive. Although the gain in bone length is imposing, outcomes should be evaluated in the context of extended time in the external fixator and the large number of complications and additional procedures required.[1,3,4,14] In this study, we assessed a qualitative parameter of distraction osteogenesis: incidence of PTI during limb lengthening and its effects on final outcomes and incidence of additional procedures.

Although the initiators of the technique[22-24] did not report a significant rate of PTI, in our study we found the infection rate to be a concern in distraction osteogenesis (Table I). Despite regular daily local cleansing, most patients developed a pin-site infection. PTIs were treated by increasing the frequency of local cleansing, protecting

Table III. Grades of Pin-Tract Infection

Grade	Fine-Wire Site Absolute	Fine-Wire Site %	Half-Pin Site Absolute	Half-Pin Site %
1	10	41.7	37	43.5
2	14	58.3	43	50.8
3	0	0	5	5.7

Table V. Additional Surgeries and Interventions to Treat Pin-Tract Infections

Surgery/Intervention	Half-Pins Absolute	Half-Pins %	Fine Wires Absolute	Fine Wires %
Pin-site release	3	3.1	1	4.2
Pin exchange	7	7.2	1	4.2
Pin removal	4	4.1	1	4.2
Irrigation and débridement	1	1	0	0
Total	15	15.5	3	12.5

the pin site with dressing, and using an oral antibiotic. Five cases of grade 3 infections and 3 cases of grade 2 infections were treated with IV antibiotics. In 5 cases, pins were removed; in 8 cases, pins were exchanged without compromising the stability of the frame. Although another surgical procedure was required in 18 cases because of PTIs, it did not significantly lengthen time in the frame or affect the lengthening protocol. All PTIs fully resolved by the end of the treatment period, except for 3 cases (3.4%), which persisted after external fixator removal and led to chronic osteomyelitis (Table I).

It is well recognized that PTI is the most common complication during limb lengthening using external fixation.[2-4,17] Infection rates vary. Part of the variation may result from differences in how authors report complications. Some authors report pins with minor drainage, and others report only pins marked by osteolysis, which is usually considered a deep infection. Dahl and colleagues,[1] analyzing 110 patients with 140 bone segments lengthened, reported that almost all these patients experienced wire or pin infection but that only 5% to 10% of the infections influenced treatment outcomes. Maffulli and colleagues[2,3] also reported almost 100% pin-site infections. Theis and colleagues[5] wrote that PTIs were almost universal but that they responded well to oral antibiotics and seldom led to osteomyelitis or required pin removal. Eldridge and Bell[17] stated that almost all patients experienced an inflamed pin tract during their course of lengthening but that only 3% developed pin-site osteomyelitis.

Our results are in good accord with those from many previous studies on PTI with contemporary external fixation. For our patients, the most common etiology of PTI was *S aureus* (47.1%) followed by *S epidermidis* (11.8%). This agrees with the work of Collinge and colleagues,[10] who found that external fixation wires and pins are colonized with bacteria, usually *S aureus* and *S epidermidis*. Mahan and colleagues[25] reported that 74.8% of screw tips cultured positive at removal, with a higher rate of gram-positive bacteria (90.6% *S epidermidis,* 37.5% *S aureus*) versus gram-negative bacteria (9.4% *E coli*). The incidence of chronic osteomyelitis after PTI in our patients was 3.4%. This incidence has been reported to be 4%.[16] We found methicillin-resistant *S aureus* (MRSA) in the cultures of all 3 patients with chronic osteomyelitis. Also, in all 3 patients, the first cultured bacteria associated with the PTI were MRSA. Our data indicate that incidence of PTI is higher with half-pin external fixators than with hybrid fixators using fine wires in addition to half-pins (Table II). It seems that, compared with the fine-wire site, the half-pin site is more prone to PTI. This conclusion is supported by results from the study by Parameswaran and colleagues.[8] Also, the rate of additional surgeries and interventions for treating PTIs was higher with the half-pin site (Table V).

Table IV. Etiology of Pin-Tract Infection

Bacterium	No. Patients	%
Methicillin-sensitive *Staphylococcus aureus*	30	35.3
Methicillin-resistant *S aureus*	10	11.8
Staphylococcus epidermidis	10	11.8
Escherichia coli	8	9.4
Pseudomonas aeruginosa	8	9.4
Streptococcus spp.	3	3.5
Enterococcus faecalis	2	2.4
Serratia marcescens	2	2.4
Vibrio vulnificus	2	2.4
Mixed flora	3	3.5
Other	7	8.1

PTI is the major complication of external fixation of fractures. PTI rates range from 0.5% to 30%,[7,8,25,26] but the incidence of deep infection (4%) and chronic osteomyelitis (4%) is about the same as in limb lengthening using external fixators.[7,16] Use of various definitions for PTI prevents comparison between different studies. From our data, it is apparent that PTIs tend to increase with longer external fixation in place. This trend is supported by results from the study by Parameswaran and colleagues,[8] who found a significant difference in frame duration between patients who developed an infection (180 days) and patients who did not (78 days). Hutson and Zych[7] concluded that the PTI rate increases with a prolonged frame time. In our study, external fixation duration in patients who developed PTI was 181 days (SD, 86 days). In agreement with what Parameswaran and colleagues[8] reported, our data suggest that the PTI rate starts escalating once the fixator has been in place for 3 months—confirming that external fixation duration is an important factor in PTI rates.

Many patients can benefit from lengthening procedures, and new techniques and methods for preventing PTI need to be developed to improve the risk–benefit balance. Current possibilities are hydroxyapatite and chlorhexidine coatings,[11,12] antibiotic pin sleeves,[13] biodegradable pins, and silver coatings. Collinge and colleagues[10] reported that silver-coated pins resulted in less infection and motion at the pin site. Massè and colleagues[26] found that the silver coating on fixator pins decreased bacterial colonization, but they also found a significant amount of silver in the blood serum. Using an in vitro model, Campbell and colleagues[11] reported that hydroxyapatite-chlorhexidine–coated pins showed significant antimicrobial action. The investigators also noted that the hydroxyapatite coating had a dual benefit, with enhanced bony stability through bonding to the pin and localized release of chlorhexidine. Moroni and colleagues[12] reported that hydroxyapatite-coated pins showed good bone–pin interface strength and optimal bone–pin contact. Forster and colleagues[13] assessed the potential of antibiotic-coated polyurethane sleeves to inhibit bacterial colonization on external fixation pins and concluded that this inhibition should substantially reduce PTI incidence.

A new perspective in preventing PTI is covalent bonding of antibiotics to the surface of titanium to develop pins that have sustained antibiotic activity to protect against postoperative infection.[27] Parameswaran and colleagues[8] suggested using oral prophylactic antibiotics for the entire duration of external fixation. We disagree on using antibiotics prophylactically but do think that antibiotics should be used in all cases of detected PTI. We agree with Paley[6] that PTIs develop from outside to inside, from soft-tissue inflammation to soft-tissue infection and finally to bone infection. In our study, we noticed that, in cases in which patients with PTI around a pin did not start antibiotics, adjacent pins became infected soon after. This clinical observation supports the conclusion by Clasper and colleagues[28] that PTI can spread within the medullary canal. This is why we think that treating PTI with local pin care and pin exchange alone is not enough. Patients need antibiotic therapy to fight medullary canal colonization.

One of the most important factors in PTI rates is postoperative local pin-site care. Many different approaches to pin care have been used without any one having more of an advantage than another.[8,29] Gordon and colleagues[29] developed a "nihilistic approach" to pin-site care in children; they recommended showering but not doing any other physical pin cleaning. Twice-daily pin care consisting of cleaning with hydrogen peroxide and povidone-iodine has been recommended.[30] Paley[6] reported using antibiotic-soaked sponges over pin sites. He also recommended minimizing pin–skin motion by applying pressure to the skin—by using gauze compressed by rubber or by using cubicle foam sponges pushed down with plastic clips. Placing antiseptic-soaked sponges over the pin site for the duration of external fixation was successful.[4] Hoffmann[9] recommended relieving skin tension around pins in order to prevent infection. Another important factor in PTI rates is the pin–bone interface: Pin loosening leads to a high rate of infection.[4,12,14] For prevention, we recommend using external fixation techniques that adequately control the stiffness of fixation.[31-34]

Orthopedic surgeons should expect that, during limb lengthening by distraction osteogenesis using external fixation, almost all patients will develop a PTI. Careful insertion and a simple, well-defined, excellent pin-care protocol can minimize PTIs. Patients must be fully informed, well educated, and followed up often. Detected PTIs must be treated aggressively to prevent the spread of infection. More methods of PTI prevention need to be developed.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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