

Mini Review

Pin site infections in pediatric population, microbiology, treatment and long-term functional disability

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Abstract

Pin site or pin track infection (PTI) is the most common complication when applying external fixation. In case of failure of proper treatment, PTI will progress to soft tissue infection and osteomyelitis and cause mechanical loosening of the osteosynthesis and instability. Thus pin site infection remains a clinical challenge in deformity corrections, limb lengthening, and pediatric fracture osteosynthesis. This article discusses the pathophysiology, microbiology, and epidemiology of pin site infection in pediatric populations, as well as treatment and long-term functional outcomes.

Keywords: Pediatric, Hand, Upper extremity, Infections, Osteomyelitis

Introduction

External fixation is a commonly used method in pediatric populations¹. Supracondylar fractures Gartland II, IIIa, IIIb, the 60% of all elbow fractures, are treated with close reduction and percutaneous pinning². Moreover, external fixation is applied to open fractures, congenital and acquired deformities, infected non-unions, mobilisation of stiff joints.

Pin track infection is the most common complication encountered. High rates of morbidity are reported, especially when the treatment is prolonged. PTIs do not follow a uniform definition and a classification, so the rates are ranging from 1 to 100%. Current literature proposes to define PTI infection as the signs and symptoms of inflammation around the pins and wires, that require antibiotics, pin or wire removal or even surgical debridement³.

Pathogenesis

The immense question concerning the PTI is the direction of the path that the infection follows. Several authors propose that the infection starts from the “outside”⁴. Soft tissue inflammation around the pins and the wires of the external fixation progress in deeper tissue, resulting in soft tissue infection and finally osteomyelitis. In this case mechanical instability and pin loosening follow^{4,5}.

Other authors, propose that the pin-bone instability may lead to mechanical loosening that will result to irritation and

infection around the pin. In addition, instability hinders bone reconstruction and prevents the inflammatory factors from healing the bone damage⁵.

Colonisation

Bacterial colonisation starts from the surgical table⁵. When the pin or the wire is applied, plasma proteins coat the surface of the implant creating a favourable environment for bacteria to grow and bind. Certain bacterial species create a protein layer – the biofilm⁶. Thus, they become invincible to antibiotics. Biofilm bacteria related to infections are considered to be the most difficult to treat and cure with the conventional antibiotic armamentarium. It is, therefore, crucial to recognise and treat the infection prior to the biofilm formation⁶.

The most common bacteria found in pin track infections

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are *Staphylococcus epidermidis*, *S. aureus* and *Escherichia coli*⁷. *Staphylococci* species cause the most frequent biofilm-related infections⁷. *Staphylococci* thrive on the human skin and therefore percutaneous pinning results insertion of the bacteria in the soft tissue around the implant. Mixed flora, in some rare cases, increases the level of difficulty in treatment and post-operative care.

Classification

Current literature lacks a uniform classification of PTI. Some studies propose to classify the infection considering subjective signs and symptoms as pain, clinical signs of irritation and infection, radiological signs or microbiological diagnosis of infection. Nevertheless, there is no systemic methodology for describing the PTI and estimating the severity of the infection.

Clint et al. classification, based on clinical signs as pain and erythema propose the terms “good”, “bad” and “ugly” whereas Santy et al. propose “calm”, “irritated” and “infected”^{8,9}. Other authors describe the depth of the infection starting from the skin and its progress to the soft tissue and finally the os or even the presence of purulent discharge¹. Using the radiological signs of pin loosening studies classify PTI considering the osteolysis around the pins. Response to antibiotics and surgical drainage has also been used as a form of classification of the severity of the infection.

Prevention

Prevention of the pin track infection should start with the planning of the surgical strategy and with the choice of the suitable implant. Respect for the mechanical stability during the external fixation and the choice of the fixator seem to be key points. Parameswaran et al. suggested that monolateral and hybrid fixators have a higher incidence of PTI than ring fixator¹⁰. In addition, the combination of half pins and fine wires in hybrid fixator seems more beneficial^{1,2,8}.

Moreover, selection of the patients that are treated with external fixation is a crucial part of the prevention. Patients with diabetes, immunodeficiency, fever or pulmonary infections should be carefully excluded. Insertion of an implant in such cases may be subject to inflammation and pin infection, so conservative treatment is preferable⁴. In the case that we are obliged to use an implant, the physician should take precaution in order to minimise the risk of infection.

Surgical technique

The application of the pins or wires is of great importance. The insertion should be as atraumatic as possible. Minimum trauma requires proper surgical design of the fixator, high surgical skills and suitable surgical equipment. Percutaneous pinning should respect the layers of the skin, soft tissue and bone^{1,2,8}. The incision should comply with the diameter of the pin. The surgeon should select immediate subcutaneous bone surfaces in order to avoid soft tissue iatrogenic damage.

Wires should not be drilled through soft tissue. The drilling technique should follow manoeuvres, so that loosening is avoided. Traversed muscles should be stretched to avoid shortening. The drilling tools should be strong enough to avoid overheating that could cause thermal necrosis^{1,11-13}. To avoid overheating the surgeon should ensure continuous cold saline irrigation¹. Moreover, for half pin implantation pre-drilling is needed. A “no-touch” technique for pin insertion, described by Davie’s, using chlorhexidine or alcoholic iodine-soaked swabs to handle the implant, is widely recommended¹².

Post-operative management

The careful post operating management of the external fixation, especially in pediatric populations, is crucial. The optimal pin care is not yet established as a patterned protocol. The physicians follow their subjective experience and clinical judgment. The methods described vary in all aspects, from the frequency of changing the dressings to the solutions and the materials used. According to the literature pin and wire cleaning is recommended every two days, starting 48 h from the surgery, in order to estimate any early signs of inflammation around the implant^{11,12}. The frequency may vary from twice a day, once a day, weekly, or when needed according to each and every patient. The frequency of dressing changes may be altered as the post-operative period unfolds. If the pin sites are clean and dry, it is recommended to decrease the dressing changes to once a week^{1,11,12}.

Physicians use a wide variety of solutions for the post-operative care of pins and wires of the external fixation. Literature proposes water and soap, sterile water, normal saline, isopropyl alcohol, polyhexamethylene biguanide, chlorhexidine aqueous, peroxide and alcoholic solutions^{1,11}.

Moreover, due to the lack of objective classification it is crucial that the management of the external fixation post operatively has continuity in medical observation. If possible, the same medical-nursing team or even the same physician should take care of the dressing changes.

Innovations

The direction of the research has been made towards implants with an antibacterial coating of the wire and the pins^{11,12}. Antibiotic films or chemical substances such as hydroxyapatite, hydroxyapatite with chlorhexidine, silver nanoparticles, chlorhexidine, zinc or titanium oxide and micron-thin sol-gel films^{11,12}. Pins coated with hydroxyapatite improve stabilization and fixation strength. Thus, osteolysis around the pins is reduced and the incidence of bone loosening and infections is lower.

Silver coated pins reduce antibacterial colonization resulting in lower incidence of PTI. Nevertheless, some authors reported diffusion of silver ions in the blood circulation that ruins intracellular function when entering the cells. Nano-titanium (TiO₂) pins irritated by ultraviolet light, show antibacterial activity. Some clinicians introduce pins

coated with antibiotics that could lower the infections by creating an antibacterial environment^{1,9}.

Treatment

The treatment of pin-track infections is a complicated algorithm that requires strategy and planning. The severity of the infection must be assessed and each and every patient must be classified and treated according to a patterned algorithm. Many authors propose the Checketts-Otterburn PTI classification as guide for treatment planning³. According to this classification the infections are divided into two categories, minor (grades 1-3) and major (grades 4-6). Grade 1 infection show slight redness and little discharge. The patients are treated with improved pin site care. Patients with grade 2 have red skin around the pins, discharge, pain and tenderness in the soft tissue. In addition to aggressive pin site care, Grade 2 patients receive oral antibiotics that they are altered after the results of the cultivations. Cases that do not respond to oral antibiotics upgrade to Grade 3. The affected pins are repositioned, pin site care is upgraded with more aggressive dressing changes twice a day and more specialized solutions. However, it is very important not to disturb the stability of the fixation, so it is advisable for many authors to change the "infected" pins or wires and reposition the external fixation.

The crucial point is that for all infections characterised as major (grade 4, 5 and 6) the external fixation device has to be removed. Grade 4 is a severe soft tissue infection involving more than one pin or wire, in association with pin loosening. When the above are combined with radiographic findings that show bone lesions or signs indicative of osteomyelitis, the infection is characterised as Grade 5.

Grade 6 indicates infection after the abandonment of the external fixation and the removal of all pins and wires. Pin tracks request surgical debridement and curettage.

Although pin track infections are very common, only in a few cases the complication is major. The majority of the infections respond to aggressive dressing changes. In these cases the frequency is increased. Cultivation with swabs from the pins is crucial for the antibiotic medication to be directed.

Long-term functional outcome

Studies have been made to determinate the long-term functional outcome of pin-track infections in children. Supracodylar humeral fractures are the most common elbow fractures in pediatric orthopaedic traumatology. It is established that closed reduction and percutaneous pinning of displaced supracondylar humeral fractures is the gold standard treatment. The most common complication, alongside hardware failure and iatrogenic ischemia and nerve injury, is infection of the pin site. Clinical studies performed in a 20-year period revealed 21 of the 490 children (4,3%), who were admitted with pin track infection after closed reduction and osteosynthesis of displaced supracondylar

humerus pediatric fracture with percutaneous pin fixation. The mean age was five years old, thirteen boys and eight girls, eleven left and ten right elbows^{12,14}. According to Wilking's modification of the Gartland classification, there were 8 children presented fracture type II and 13 presented type III^{2,6}. Pin configuration followed different patterns based on the different orthopaedic surgeon. 19 children, the 47% of the cases did not receive preoperative antibiotics. Children arrived at the emergency room and headed to the operating theatre in 35 to 77 hours, range 1 h to 14 days. The average surgical delay was 1 h to 23 h. The majority of the infections, (15 children), concerned superficial inflammation around the pin, while 6 children presented deep infection. Among them there was one case of osteomyelitis with septic arthritis, one osteomyelitis, one case of septic arthritis and three children with deep soft tissue infections. All children presented a variety of signs and symptoms including severe pain and irritation, discharge of the pin site, fever, lethargy, loss of appetite, fatigue, swelling, loosening or migration of the pins and lucency in the radiographic follow-up^{1,3}.

The most interesting point of the study was the follow-up interview of these patients at the age of 18 years old. 15 of the 21 former-patients responded. All cases presented excellent DASH, quick DASH and PREE scores, and impeccable cosmetic result, full rotation of movement equal to the opposite extremity and reported no limitations in sports or everyday activities^{1,10,15}.

Conclusions

Pin track infections are very common in the paediatric populations. There are many signs and symptoms presented and a wide variety of bacteria involved. There is no standardised classification widely accepted. Prevention of the pin track infections starts at the point O, from the planning of the treatment, the surgical technique, to the post-operative management. There are plenty of innovations concerning the management of the infections, the solutions for the dressing changes and the implants used. The treatment differs according to the grade of each case and varies from aggressive dressing changes to intravenous antibiotics, removal of the implants and surgical debridement or/and curettage.

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