

Journal of Orthopaedics Study and Sports Medicine

Genesis-JOSSM-1(1)-02
Volume 1 | Issue 1
Open Access

Current Thinking in Pin-Site Management in External Hexagonal Frames

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Citation: Slater G, Mathen L. (2023) Current Thinking in Pin-Site Management in External Hexagonal Frames. J Orthop Study Sports Med. 1(1):1-9.

Received: May 01, 2023 | **Published:** May 15, 2023

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Abstract

In this article, the authors review the literature for the current thinking in management of pin sites after external framing. Pin site management remains a challenge after external framing and is perhaps the most significant barrier to the use of this technology. Infection after framing ranges from 1% to 100% depending on the criteria used to diagnose. Clarity will be sought with regards to defining and identifying infection, as well as the appropriate treatment to infection. The paper looks at current methods of managing pin sites, and their advantages and shortcomings. The authors will also investigate the future of pin-site management, and where it is headed. Literature has differing opinions on a gold standard for managing pin sites. This paper will aim to provide the best practice to lower and control the incidence of infection for external fixation during post-operative care. This paper will aim to provide a consensus that will facilitate specialists, nurses, and patients in their respective management of infection.

Keywords

Percutaneous pins; Staphylococcus aureus; Escherichia coli; Skin redness

Introduction

External fixation is a popular technique that attaches percutaneous pins to an external frame to provide support for the joint in case of injury or limb reconstruction (Fragomen, 2007). Despite the effectiveness of external fixation, it is often associated with the troubling complication of pin site infection [1]. Infections vary in degree of severity for each patient, and it is important the proper pin site management is followed to minimise the detrimental impacts of infection. The potential outcomes of infection are damaging both commercially and in terms of patient health. Such outcomes include increased clinic visits, additional treatment such as antibiotics or surgery, osteomyelitis, instability due to pin loosening and frame removal [2], not to mention the potential psychological implications for prolonged treatment. Literature has differing opinions on a gold standard for managing pin sites. This paper will aim to provide the best practice to lower and control the incidence of infection for external fixation during post-operative care.

Background

What is external fixation and why is it important? Why is infection associated commonly with external fixation and what are the challenges? What is infection and how is it measured?

External fixation

External fixation frames are used to provide limb and joint support. Typically applications include limb reconstructions following trauma or due to congenital factors, arthrodesis, distraction, management of osteomyelitis, limb salvage in charcot and deformity correction [3]. External fixators have gained some popularity due to their numerous benefits. Compared with internal plates and nails, external frames are cause less trauma to the adjacent soft tissues, blood supply to the area and the periosteum. They are indicated for patients with open wounds, skin contusions, or chronic trauma where skin is populated with grafts and muscle flaps. External fixator devices are also adaptable to the circumstances of individual patients, and can be attached in multiple planes [3]. This allows a frame to correct multiple different deformities in the same limb. It can even be used in competing strategies of fusion and distraction arthroplasty in adjacent joints. One of the most popular configuration is demonstrated below where the struts are placed to allow for three dimensional manipulation of the limb (Figure 1).



Figure 1: External fixator frame.

Idiopathic fixed pes planovalgus deformity treated with key hole osteotomies of calcaneus and M1 to M5 than manipulated by slow correction over 4 weeks.(M=metatarsal).Portals have been left open and good healing is demonstrated (Figure 2).



Figure 2: Pre-operative and post-operative external fixation.

Infection

There are two main classification systems commonly found in literature to grade infections occurring at the pin site. One popular system defines three different categories of infection following external fixator frame attachment: Reaction, Colonisation, and Infection [4]. These three categories are useful as they denote qualitative data that can be observed by patients. Reaction represents normal changes that occur post-surgery, which are expected to resolve within 72 hours, including skin redness, pin site heat and minor levels of serous fluid or blood discharge. Colonisation involves further redness and warmth post 72 hours and accommodates for pain and exudate occurring at one or more of the pin sites. Infection involves purulent discharge and potential loosening of the pin. This review also includes quantitative measures of bacterial counts at each stage. Whilst this classification system is useful for patients to identify the severity of their infection, it provides no solution to the infection, and fails to account for infection that may be deeper inside the tissue. A typical six-point grading system is expressed in (Table 1).

Level of Infection	Symptoms	Treatment Method
Grade 1	Slight redness around the pin. Minimal discharge. Should improve with proper care and hygiene. Can progress into serious infection.	Increase level of cleaning and perform massaging to prevent pin adherence. Ensure wound is appropriately draining and remove crusts.
Grade 2	Skin redness, discharge, and pain in soft tissues.	Administer oral antibiotics. Oral antibiotic depends on the bacteria, which is usually <i>Staphylococcus aureus</i> .
Grade 3	Grade 2 infections that continue despite improved care and oral antibiotic.	Administer intravenous antibiotics. Pins potentially re-sited. External fixation continues.
Grade 4	Severe infection that involves multiple pins. Pins may be loosened.	The pin is removed. External fixation is discontinued.
Grade 5	Tissue is infected and bone may be involved. Osteolysis and sequestrum formation is present from radiographs.	Infected tissue is removed surgically to prevent the spread of infection. Will resolve after fixator removal.
Grade 6	Chronic osteomyelitis (infection of the bone).	Typical treatment will involve debridement or treatment through antibiotic agents. Can lead to long-term disability and discomfort.

Table 1: Symptoms and treatment methods for different grades of pin-site infection.

Grade 1-3 infections are classified as minor, and can be managed with the external fixator still in place. Grade 4-6 infections are major, and required abandonment of external fixation [1]. Grade 1 and 2 are useful for patients in their management of pin sites, however this framework is excessively detailed and may be intimidating for patients. For managing pin sites at home, Lee-Smith's "Reaction, Colonisation and Infection" framework is the recommended guideline due to its simplicity and clarity.

Bacteria typically found

It is important to be aware of the type of bacteria present in a pin-site infection in order to properly administer antibiotics. *Staphylococcus Aureus* is the most common type of bacteria found [6]. They exist frequently on skin surfaces and mucus, and can thus easily become implicated when a medical device penetrates the skin. *Staphylococcus Epidermis* and *Escherichia coli* (*E. coli*) are other bacteria that may cause pin site infections [7].

Management

General principles

There are a few general principles for management in which there is consensus in the literature.. First, hand hygiene must be performed at all times when taking care of pin sites, particularly in removing dressings, washing the sites, showering and massaging [1]. Additionally, cross-contamination between pin sites should always be avoided [4]. Using something like a toothbrush for cleaning encourages cross-contamination, so should not be used. Pin site management should also aim to minimise the use of antibiotics, as a result of the increasing presence of drug-resistant micro-organisms. Antibiotics should only be taken if necessary and in consultation with the doctor [4].

Crusts

The overall consensus regarding crusts based on research and practical experience would recommend that crusts should be removed. Crust removal reduces the infection rate as it allows fluid to be moved away from the wound site, and prevents it from being held up in the wound area [8]. It also allows the wound site to be visualised which is paramount in the prevention of infection. [4]. The method of crust removal remains uncertain. A gentle scab peeling approach is the most logical method, and persistent scabs can be dry rubbed gently with gauze [4]. An alternate perspective highlights the nature of crusts to act as a biological dressing, and postulates they should be kept. The study revealed that patients where crust was retained had lower infection rates. However, where infection did occur, the group that retained crusts had more severe infection and required a more urgent administration of antibiotics. It was concluded that crusts should be retained so long as the site was uninfected [9]. Despite this, the clear advantages of crust removal through visualisation and drainage is preferable than the chance of a severe infection occurring from crust retention. Regular crust removal is something every patient should engage in to minimise the risk of infection.

Cleaning

Various studies using different cleaning solutions have failed to demonstrate a statistical significance to recommend one cleaning solution over another.. Many sterile and non-sterile techniques exist in literature, and typical solutions studied include sterile chlorhexidine, betadine, alcohol and hydrogen peroxide. Non-sterile solutions include saline, soap and warm sterile water. A few studies suggest there is no significant benefit between different cleaning solutions [10]. Despite this, chlorhexidine alone has been shown to less effective than when it is combined with alcohol. The study recommends avoiding this solution closer to the wound, and instead using saline to encourage granulation and remove exudate or blood [11]. Another study has found chlorhexidine to be superior to saline in its cleaning capability, with a high presence of *S. aureus* in saline treatment sites. Whilst chlorhexidine didn't lead to lower infection rates, it resulted in lower bacterial colonisation and decreased use of antibiotics when compared to saline [2]. Alcohol is damaging to the skin and can cause pain at the pin sites, so should be avoided. Iodine-based products should also be avoided due to metal corrosion, staining and high costs [4]. Hydrogen peroxide represents a source of contention. It has damaging properties towards healthy skin tissue, however it is effective in killing bacteria and wound debridement [11]. It is recommended that hydrogen peroxide is used scarcely and only in event of grade 3 infections. Some studies indicate

saline as something that has higher infection rates compared to control groups, however it is still recommended as a washing agent [6].

Dressing

Studies have once again failed to demonstrate superiority in terms of type of dressing used, however it is clear that some form of dressing is essential for prevention of bacterial infection by absorbing blood and exudate. An important role of the dressing is also to prevent tenting, which occurs where the skin climbs up along the wire. Tenting can lead to skin tenderness and may need to be addressed surgically. Prevention can be managed through pressure when applying a dressing [11]. It is also paramount that the dressing does not leak fibres into the skin. For example, gauze rubbing against the wound area may result in detachment of fibres that can enter the wound site [11].

Managing patients from a psychological perspective

The importance of physical care is paramount and must be adequate to minimise infection, however the importance of emotional and psychological care for the patient is often overlooked. We identify sufficient education and guidance to be an appropriate measure to deal with the intimidating nature of having an external fixator frame. Written and verbal information can reduce anxiety for patients. Lee-Smith clarifies how providing psychosocial support can help patients deal with issues pertaining to self-image, which will in turn result in greater compliance with cleaning protocol, and thus improve pin site management [4]. External fixation devices have been shown to contribute to patient anxiety and depression, with more than half of patients experiencing some form of anxiety or depression, due to uncertainty, fearful reaction, post-removal re-injury. Results suggest use of support groups and education [12].

- Help patients deal with the operation – provide information, education, contact
- How can patient handouts be more effective?
 - Visual information
 - More education
 - More clarity on the process, e.g. clarity with infection definitions.

Future Directions

What will be potential best practices going forward?

There are several areas of interest for pin site management that would increase the utility of external fixation as common practice for joint salvage. One study demonstrated the effectiveness of a lipid stabilized hydroxyapatite / chlorhexidine coating. The study used goats and demonstrated a decreased infection rate and improved fixation of the frame [13]. A more recent study postulated the use of antimicrobial gauze as a dressing to reduce the incidence of infection. Using polyhexamethylene biguanide-impregnated gauze reduced the risk of infection in a level 1 therapeutic study.

- Lee-Smith 2001: Pins impregnated with anti-bacterial agents [4].

- Lee 2012: Antimicrobial gauze as a dressing reduces pin site infection. PHMB polyheamethylene biguanide. Effective against range of bacteria including s. Aureus which causes most infections in pin sites [14].

Our experience

We reviewed our last 50 consecutive distraction frames. No patients were excluded. In that time there were 720 separate pin sites that were monitored. Our resume was:

- Antibiotics used with induction. Usually Keflex 1gm or flouclloxacin 1gm.
- Chlormycetin or betadine ointment applied to pin sites intra-operatively.
- Proximal tibial pins were placed with diamond tipped predrilling.
- All pins fixations were smooth interference fit 2.7 mm hard wire system . No use of Steinman pins or tensioned wires.
- Wires were inserted without tourniquet. Minimise the chance of tissue necrosis.
- The patient was administered antibiotics for a four week period. Discharge from hospital pre planned and within 24 to 48 hrs.
- pin sites were lavaged with hydrogen peroxide or betadine twice daily for the first 4 weeks.

This was continued if issues. Note that use of swabs and gauze not used unless a crust was to form. Simplification of the cleaning process is recommended as patients manage the pin sites themselves and cross contamination is a very high risk.

Almost all wire points experienced redness at some point. These largely resolved with the standard protocol.

1 patient had a grade 3 infection requiring 3 weeks of intravenous antibiotics. This involved two calcaneal pin sites. 2 sites. Staphylococcus aureus.

1 patient had a grade 4 infection requiring removal and replacement of a wire. This was a proximal pin site. Staphylococcus aureus

Discussion

There an increasing desire in the community to salvage limbs and joints and employ minimally invasive technologies to achieve this. In the foot and ankle external framing is a technique that can be used to achieve these objectives in increasing indications. The scourge on the technology has always been the possibility of infection at the pin-sites. This frontier represents a defect in the normal barrier of the body to the external environment this is compounded by there being a foreign body at this surface.

The definition of what represents an infection is also contentious. Most likely redness after surgery of 72 hours is a normal and transitory state. Even so it should not be ignored as some of these will lead to a bone fide infection. If we define infection as only occurring if redness is persisting after 72 hr, spreading erythema, temperature increase, pain (nb beware charcot patients) and or purulent discharge than infection with an appropriate resume should fall well below 5%. Infection should rarely deteriorate to the point that wire removal is required.

Conclusion

External fixation using ringed hexagonal external framing systems is complex surgery requiring intricate pre-operative planning and effective post-operative management to maximise the chance of success. Hexagonal framing systems allow combinations of minimally invasive surgical techniques that can be combine minimally invasive image guided corrections, fusion and distraction technologies. It is likely that with increasing advances in biologics that joint salvage procedures and minimally invasive techniques will increase the usage of frames.

There is no consensus how to minimise the chance of pin site infection. The definition of what substantiates an infection also confuses the data. Depending on how sensitive the definition of infection of the pin sites is infection can be deemed to occur from 1 to 100%. There is consensus that infection of pin sites in external framing remains one of the most serious and frequent complications that occur with external framing. Our approach is to begin with optimising the health of the patient. Carefully plan the pin positions, minimise thermal necrosis and engage aggressive measure to pre-empt potential infection.

What are key takeout's from this?

- Place wires without tourniquet to decrease the possibility of thermal necrosis.
- Tibial wires more likely to generate heat and experience necrosis and secondary infection. direct wires away from the thick anterior cortical bone.
- Cleaning in particular of crust is very important
- Minimise the chance of cross contamination by the patient or health worker in your cleaning resume.
- Virtually all patients will get erythema around the pin sites this is likely not infected but a normal reaction.
- The most likely bacteria accounted is Staphylococcus Aureus

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