Cannulated Schanz Pin: A Novel Concept for Intraosseous Antibiotic Delivery

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Abstract

Infection control and prevention is the first step in any orthopaedic procedure because its treatment can be challenging and complicated. Complex bony architecture, precarious blood supply and presence of biofilm make eradicating infection a difficult task. Local antibiotic delivery in such cases has proved successful as it provides high concentration of antimicrobial agents and prevents systemic toxicity that is associated with systemic antibiotic administration. Of all the options available at present for local delivery, the most commonly used is antibiotic loaded bone cement. However only heat stable antibiotics can be used with cement and studies show that amount of drug eluted from the cement decreases with time. We have attempted to address these drawbacks and make local administration of antibiotics simpler by a novel method which could be used for treatment of established infections as well as prevention of infection in open fractures. This method could allow use of sensitive and specific antibiotic in addition to providing fracture stability.

Keywords: Infection, intraosseous antibiotic delivery, cannulated schanz pin

Introduction:

Bone infection remains a significant problem for both orthopaedic surgeons and patients[1]. More so, because of its dreadful effects (both physical as well as psychological), notoriously lengthy treatment and increasing financial burden[1]. The associated uncertainty and anxiety can challenge almost everyone involved in management. Preventive measures therefore remain topmost priority. The magnitude of transition from Lister's antisepsis to the present day ultra clean operating theatres is a reflection of our dedicated efforts to curb infection[2]. However even with the best efforts, infection tops the list of complications of most orthopaedic procedures[3]. This widespread recognition of infection as a dreadful complication continues to produce numerous strategies and various modalities aimed for its prevention and management. Current management of established infection promotes the use of antibiotics mixed with cement in the form of either cement beads or intramedullary antibiotic coated rods[4]. This is so, because many studies have documented significant clinical improvement with this form of local antibiotic delivery[5, 6, 7, 8]. Recent literature also supports intermittent irrigation and suction to remove necrotic material and proteolytic enzymes in septic joints[9]. This modality also reduces microbial load and their toxic by-products. The present study proposes a novel concept of local antibiotic delivery which could also be used to provide intramedullary lavage while simultaneously providing fracture stability.

Implant innovation:

Since Alfred Rives Schanz first introduced Schanz pins in 1924, they have been successfully used world over in a wide range of orthopaedic conditions[10]. Our concept of antibiotic delivery utilises this pin as a tool to achieve the goal by creating a path for antibiotic to be instilled inside and flowing out in the medullary canal. So we modified the pin. The inflow channel was created in a pin of 5 mm diameter and thread length of 40 mm by drilling a 0.8 mm drill hole from the shank, through the body, threaded part and just short of the tip of the pin. The outflow ducts were created with similar size linear fenestrations in the threaded part of the pin (Figure 1 and 2). Pin function was tested by drilling it across a bone model. An arthroscope was introduced in the medullary canal to visualize outflow (Figure 3). The pin was placed in a manner that the outflow fenestrations faced the arthroscope. Normal saline was injected via syringe needle inserted in the hole over the exposed end of pin (Figure 4). Successful outflow through the ducts was confirmed by arthroscope (Figure 5). In a clinical scenario, we propose that minimum two pins, one above and one below the site of infection or fracture in open injuries, be used along with standard external fixator assembly. The holes in threaded part of these two pins should be facing each other so that maximum drug concentration is available at infection site. Providing linear marking on the shaft of pin in line with the threaded part can help to achieve this position of the pin (Figure 6).

Mechanical tests:

Since we have altered the physical structure of the normal schanz pin, some changes in the mechanical

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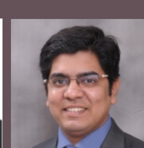
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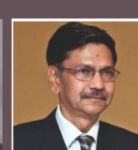
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Figure1: Cannulated schanz pin

Figure2: End on view of schanz pin drilled in bone

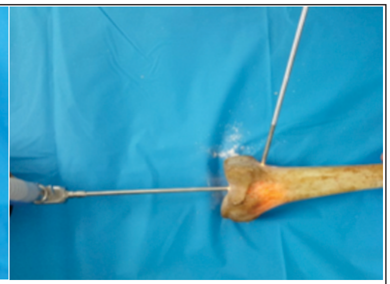

Figure3: Arthroscopic visualisation of pin

properties are expected. This is concerning especially in the threaded part. To compare changes in strength of a normal and cannulated pin, mechanical tests are being done.

Discussion:

Infection in orthopaedics can be devastating as it has the potential to ruin every nearby structure and disturb its functions permanently. Consequently a major part of surgical energy is channelled to prevent and treat infection. In recent times treatment strategies have tilted in favour of local administration of antimicrobial agents as it allows high drug concentrations in otherwise inaccessible areas[11,12]. Studies show that bacterial elimination increases with increasing antimicrobial concentration and therefore a lot of research is focussed on improving the local delivery of antibiotics[13]. Of all the carriers' available today antibiotic loaded bone cement (ALBC) and cement beads are the most widely used. They are non-biodegradable and therefore need to be removed once their action ceases. Biodegradable carriers on the other hand can be left in vivo permanently. Plaster of Paris pellets, calcium sulphate, calcium phosphate & cancellous bone come in this category[14]. ALBC is the gold standard for delivery materials[15] but there are some areas of concern. The selection of antibiotics is limited as only heat stable antibiotics can be used. The maximum drug concentration is restricted to 1 cm adjacent to the delivery depot[16,17]. The solubility of antimicrobial agents is thousands of times less in PMMA than in fluids such as water, saline or plasma[15]. Incomplete elution might lead to subtherapuetic concentrations which in turn may give rise to resistant strains. Resistant strains might grow on ALBC surfaces[18]. Aminoglycosides are the commonly used antibiotics with PMMA. They exhibit time dependant killing of gram positive organisms which are primary pathogens in most cases of osteomyelitis [19]. Therefore induction of resistant strains is possible as antibiotic elution slows down over time. We believe that most of these shortcomings can be addressed by this simple modification in the Schanz pin. It will not only increase the range of antibiotics that can be used but also allow the use of sensitive and specific antibiotic.

Another advantage could be flexibility in adjusting the amount and duration of dosages. Since the technique is simple even paramedical staff can be trained to use it. A major advantage could be using it as a dynamic pin in the external fixator assembly for primary management of open fractures wherein it could serve the dual purpose of providing stability along with infection control. An extended use could be as intraosseus irrigation system by slight modifications in the size and number of fenestrations. A futuristic use can be in tumours if small diameter flexible tubes are passed in through the pin inserted well proximal or distal to the tumour. It may be possible to deliver chemotherapeutic agents via the flexible catheters. To the best of our knowledge such a modification has not been reported in literature so far. Cannulated screws have been modified to allow voids to be filled with cement[20]. Intraosseus drug delivery system has been reported in cardiopulmonary resuscitation[21]. We accept that altering the structure of a mechanical device will lead to changes in its physical properties. Creating a track by drilling holes will reduce the strength of the pin, especially in the threaded part. However, load transmission through the pins is less compared to other orthopaedic implants mainly because weight bearing loads are avoided in most of the scenarios where these pins are used. Precise measurements regarding these changes will be known after further mechanical evaluation. Since the present study provides a theoretical concept, recommendations on antibiotic dosages and duration of treatment could be convincing only after further clinical studies are done. However, we propose that antibiotic instillation should be at least twice a day to start with so as to prevent holes getting clogged. Similarly, clinical improvement along with normalisation of

Figure 4: Saline injection in the pin

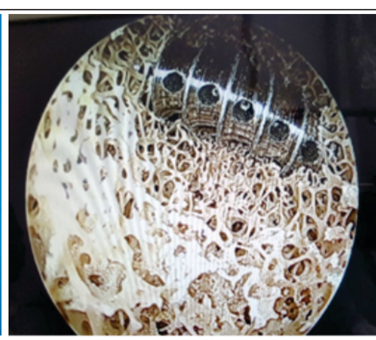

Figure 5: Arthroscopic view of pin

Figure 6: Schanz pin with linear marking along holes on the shaft

lab markers like CRP and ESR, can guide in deciding the duration of treatment.

Conclusion:

We believe that the modification proposed herein can add value to the search for a better material to deliver antimicrobial agents locally. Infection remains a major orthopaedic problem where even a marginal help can have profound impact because functions and lives are at stake. The present study relates to development of a concept and actual efficacy can only be judged after further clinical studies.

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