The antibacterial effect of 2-octyl cyanoacrylate (Dermabond®) skin adhesive

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Abstract

Dermabond® is a tissue adhesive commonly used for wound or surgical incision closure. Its use has previously been associated with a reduction in wound infection, and it has been thought to act as a physical barrier to bacteria accessing the wound. This study aimed to establish whether the Dermabond® adhesive demonstrated any intrinsic antimicrobial properties. Solidified pellets of Dermabond® were placed on standardised Agar plates cultured with a variety of pathogens. Inhibition of growth was demonstrated against Gram-positive bacteria. Culture swabs taken from the inhibition rings demonstrated no growth, suggesting that Dermabond has a bactericidal mechanism of action.

Based on the design of this study, the results suggest that Dermabond® demonstrates bactericidal properties against Gram-positive bacteria. Its use for wound closure following surgical intervention may reduce postoperative wound infection by Gram-positive organisms.

Introduction

Surgical site infection (SSI) following orthopaedic surgery can be devastating for the patient, and occurs in approximately 1% of patients undergoing total hip replacement (THR), and 0.5% undergoing total knee replacement (TKR). Half of these affect deep tissues or the underlying joint. The rates are even higher in trauma patients, with 1.62% of patients with a fractured neck of femur and 1.47% patients undergoing open reduction and internal fixation of a long bone fracture developing an SSI (Elgohari et al, 2010).

Risk factors for developing SSI are related to both patient and surgical factors. Patient-related factors include coincident remote site infection, colonisation, diabetes, cigarette smoking, systemic steroid use, obesity, extremes of age, poor nutritional status and perioperative transfusion of blood products. Surgical-related factors include skin asepsis, duration of operation, antimicrobial prophylaxis, operating theatre environment, sterilisation of instruments, and surgical

technique (Mangram et al, 1999); 5.8% of patients with an SSI will die as a result of the infection (de Lissovoy et al, 2009). The average length of stay for orthopaedic patients without infection is five days, which increases to 12 with SSI (de Lissovoy et al, 2009).

The most common pathogen reported as causing an SSI following orthopaedic surgery is *Staphylococcus aureus*, which accounts for 39% of infections, of which 58% are meticillin sensitive, and 42% meticillin resistant. Following TKR coagulase-negative *Staphylococci* (CNS) is the most common infective pathogen, comprising 30% of infections. Other common pathogens are *Enterobacteriaceae* (18.8%), *Enterococcus* spp. (8.0%), *Pseudomonas aeruginosa* (3.6%), *Pseudomonas* spp. (3.3%), *Streptococcus* spp. (2.8%), anaerobic bacilli (1.4%), anaerobic cocci (1.3%), *Acinetobacter* spp (0.4%), and fungi (0.3%) (Elgohari et al, 2010).

Wound closure technique has been studied as a potential means of reducing SSI. A meta-analysis revealed that using sutures rather than staples significantly reduced the incidence of postoperative infection following orthopaedic surgery (Smith et al, 2010). The use of 2-octyl cyanoacrylate tissue adhesive is commonplace in plastic and cardiac surgery, and investigations showed that it was associated with a decrease in infection rates (Scott et al, 2007; Basaran et al, 2008). It was suggested that the use of tissue glue might act as a physical barrier to micro-organisms (Khurana et al, 2008; von Eckardstein et al, 2011), and it had even been labelled as a sealant for this very purpose (Wilson, 2008). There have also been suggestions that the tissue adhesive might itself have antimicrobial properties (Eiferman and Snyder, 1983). This study set out to investigate whether 2-octyl cyanoacrylate, Dermabond® (Ethicon Inc, Somerville, NJ, USA) has intrinsic antibacterial properties against common SSI causing organisms and might therefore be used to reduce the incidence of postoperative infection.

Method

A custom mould was machined from a block of aluminium (Figure 1). Standardised pellets of Dermabond® were created by dropping the glue into the mould and allowing it to set. In surgical practice the glue

is applied to the skin in liquid form, which then solidifies. Only the solidified form was investigated in this study for prevention of wound infection, as the skin should be free from bacteria when the glue is applied. Some wound infections may occur intraoperatively due to contamination, but in order to standardise the pellet volume, only solidified glue pellets were used, rather than applying liquid adhesive directly to the plates.

The pellets were placed directly on standardised agar dishes containing methicillin-resistant *Staphylococcus aureus* (MRSA), Oxford *Staphylococci*, Group G *Streptococci*, *Enterococcus faecalis*, coagulase-negative *Staphylococcus* (CNS), *Escherichia coli*, *Pseudomonas aeruginosa* and *Candida albicans*. This was to simulate placing the glue directly onto the skin rather than onto an interface such as filter paper. Each petri dish was divided into quadrants, with a pellet placed in three of the quadrants, and the fourth left as a control. The agar dishes were incubated at 37 degrees centigrade for 10 days, and were examined at day 1 and day 10. A swab was taken at day 1 and day 10 from the inhibition ring, if present, and each cultured on agar plates at 37 degrees centigrade for 24 hours.

Results

Dermabond® inhibited growth of Gram-positive organisms, with constant inhibition rings being displayed at day 1 and day 10. An example

Figure 1. Photograph showing custom mould used to create pellets

of inhibition of growth is shown in Figure 2. Table 1 demonstrates the extent of the radial inhibition. No antimicrobial activity was demonstrated against *E. coli*, *P. aeruginosa* or *C. albicans*. Culture swabs taken from the inhibition rings at day 1 and day 10 of the Gram-positive bacteria demonstrated no growth after 24 hours.

Discussion

This study demonstrates that Dermabond® has antimicrobial properties with regards to Gram-positive bacteria. The inhibition rings around the Dermabond® pellets persisted following 10 days of culture. Swabs taken from these inhibition rings then produced no further culture, suggesting that Dermabond® has a bactericidal mechanism of action.

The adhesive property of cyanoacrylate was first recognised in the late 1950s (Coover et al, 1959). The initial shorter chain cyanoacrylates were found to cause inflammatory reactions (Quinn et al, 1997; Trott, 1997) which have been reduced with longer chain formulations. Dermabond® (2-octyl cyanoacrylate) is one of the new generation adhesives which polymerises through an exothermic reaction when in contact with fluid, leading to a strong, flexible bond. It is indicated for use in holding easily approximated skin edges of wounds from surgical incisions and thoroughly cleansed trauma-induced lacerations. It may also be used in conjunction with, but not in place of, deep dermal sutures. Dermabond® had demonstrated superiority over subcuticular sutures (Krishnamoorthy et al, 2009) and staples (Miller and Swank, 2010) with regard to closure time, cosmetic appearance and patient satisfaction, without an increase in wound dehiscence (Eggers et al, 2011), and with a reduction in infection rates (Dohmen et al, 2009). The antimicrobial property is particularly relevant to orthopaedic surgery where surgical site infections can have such a devastating consequence. Of particular interest is the antimicrobial property of the adhesives.

The antimicrobial property of Dermabond® has been demonstrated in vitro. The adhesive provided an effective barrier to microbial penetration by Gram-positive and Gram-negative motile and non-motile species (Bhende et al, 2002). Other studies demonstrate the barrier properties of Dermabond® and found it to be an excellent barrier to bacteria with the exception of *P. aeruginosa* (Narang et al, 2003). Clinical studies have demonstrated reduced infection rates associated with its use (Toriumi et al, 1998; Ong et al, 2002).

The purpose of this study was to demonstrate any antimicrobial efficacy of Dermabond® against pathogens commonly associated

Figure 2. Photograph showing no inhibition of growth of a Gram-negative bacteria (A) and inhibition of growth of a Gram-positive bacteria (B) around the pellets of Dermabond®

Table 1. Size of inhibition ring around pellet after 10 days incubation

Micro-organism	Inhibition ring
Meticillin-resistant <i>Staphylococcus aureus</i>	+++
Coagulase-negative <i>Staphylococcus</i>	++
Oxford <i>Staphylococcus</i>	+++
Group G <i>Streptococcus</i>	+++
<i>Escherichia coli</i>	–
<i>Pseudomonas aeruginosa</i>	–
<i>Candida albicans</i>	–

with orthopaedic infections. The results show that Dermabond® has antimicrobial properties against Gram-positive organisms. It is thought that this is due to the strong electronegative charge on the cyanoacrylate monomer that reacts with the positively charged carbohydrate capsule of Gram-positive organisms (Mizrahi et al, 2010). Although 2-octyl cyanoacrylate had no effect on Gram-negative bacteria, 2-ethyl cyanoacrylate has been shown to be cytotoxic to *E. coli* (Romero et al, 2009).

This study has some limitations. There is no comparison of the effectiveness of Dermabond® with standard antimicrobial compounds. The relative size of the inhibition ring therefore cannot be compared. This would be a useful investigation, in order that the efficacy can be established. Tissue glues in their liquid form have been shown to

exhibit higher antimicrobial activity against Gram-positive organisms and *E. coli* (Romero et al., 2009), which may be relevant in surgical practice if the wound has become contaminated during the surgical procedure, rather than afterwards.

Dermabond® use is not without complication. It has been known to cause a localised inflammatory reaction following its use for wound closure for patellofemoral joint replacement in a patient with a history of atopic eczema. Blisters formed around the incision site four weeks postoperatively, and on close inspection it was noted that Dermabond® was still present on the skin. There was improvement following removal of the Dermabond® (El-Dars et al, 2010). Similar lesions have been seen following bilateral mastopexy (Perry and Sosin, 2009). Complications have also resulted from misplacement of Dermabond® in the eye and mouth, but this was following surgery in close proximity to these structures (Jagannathan and Hallman, 2010).

Conclusion

Dermabond® is a commonly used tissue adhesive that demonstrates bactericidal properties against Gram-positive bacteria. We propose that its use for wound closure following procedures at risk from infection by Gram-positive bacteria may reduce postoperative wound infection. This would be best assessed with a randomised control trial.

Declaration of conflicting interest

The author declares that there is no conflict of interest.

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