

Infection Rates and Healing Using Bone Wax and a Soluble Polymer Material

Tadeusz Wellisz MD, Yuehwei H. An MD, Xuejun Wen MD, PhD,
Qian Kang MD, Christopher M. Hill VMD, Jonathan K. Armstrong PhD

Received: 17 June 2007 / Accepted: 29 October 2007
© The Association of Bone and Joint Surgeons 2008

Abstract The effects of using a newly available water-soluble polymer bone hemostatic material in a contaminated environment were assessed in a rabbit tibial defect model. Infection rates and healing of polymer-treated bone were compared with the infection and healing of bone wax-treated bone and untreated controls after a bacterial challenge. Defects created in 24 rabbit tibias were treated with the polymer or bone wax, or left without a hemostatic agent. The defects were inoculated with *Staphylococcus aureus* ATCC-29213 (2.5×10^4 colony-forming units). After 4 weeks, all defects treated with bone wax were infected and osteomyelitis had developed, and none had evidence of bone healing. In the polymer and control groups, two defects in each group (25%) had osteomyelitis

develop. The remaining six defects in each group (75%) showed no osteomyelitis and exhibited normal bone healing. The polymer-treated defects had a considerably lower rate of osteomyelitis and positive bone cultures compared with the bone wax-treated group. There were no differences between the polymer-treated and control groups in the rates of osteomyelitis, positive cultures, or bone healing. The use of a soluble polymer as an alternative to bone wax may decrease the rates of postoperative bone infections.

Introduction

Bone wax, which largely is composed of beeswax, is widely used for bone hemostasis. Unadulterated beeswax was used for amputation hemostasis during the US Civil War. The development of modern bone wax has been attributed to Horsley in 1892 [18, 30]. Currently available formulations of bone wax have not changed much and are comprised of water-insoluble beeswax softened with paraffin and/or isopropyl palmitate [33]. Bone wax has no inherent hemostasis quality; its effect is to tamponade the vascular spaces in the bone. Although effective in stopping bone bleeding, bone wax has numerous troublesome adverse effects [41]. Once applied to bone, bone wax remains at the site indefinitely. Bone wax is known to increase infection rates, interfere with bone healing, and elicit chronic inflammatory reactions [33]. Continued use of bone wax for bone hemostasis, despite its known adverse effects, may be partly the result of the absence of a suitable alternative.

A new synthetic bone hemostasis material made of water-soluble alkylene oxide copolymers recently became commercially available [41]. The use of a water-soluble

synthetic wax for bone hemostasis comprised of similar alkylene oxide copolymers was first described by Wang et al. [40]. These copolymers have a long history in the medical and pharmaceutical fields [13, 40]. They are considered inert because they are eliminated from the body unchanged without being metabolized [10, 16, 21]. Because these copolymers are hydrophilic, they stick well to wet surfaces and thus are well suited for bone hemostasis.

Our animal study was designed to determine the behavior of these two bone hemostasis materials in a contaminated environment. Tibial bone defects received a bacterial challenge after they were either treated with the polymer material or bone wax or left untreated as a control. The first objective of this study was to determine if the use of the polymer material affected the infection rates; the second objective was to determine if the polymer material affected healing of bone defects in a contaminated environment.

Materials and Methods

Cortical bone defects created in a rabbit tibial defect model were treated in one of three ways. The edges of the defects in the first group of animals were coated with a commercially available blend of water-soluble alkylene oxide copolymers (Ostene; Ceremed, Inc, Los Angeles, CA). The U.S. Food and Drug Administration (FDA) has cleared this material for use as an implant and for control of bleeding from bone surfaces. The second group received a coating of bone wax, a beeswax-based hemostat (Bone Wax; Ethicon, Inc, Somerville, NJ). The defects in the third group were used as controls and were not treated with a hemostatic agent.

All procedures were approved by the Institutional Animal Care and Use Committee at the Medical University of South Carolina. Twenty-four female New Zealand White rabbits (2.75 ± 0.025 kg) were randomly assigned to one of three groups ($n = 8$ per group). Buprenorphine (0.02 mg/kg) was administered before surgery; the rabbits were anesthetized using 30 mg/kg ketamine, 5 mg/kg xylazine, and 1 to 3 mg/kg atropine intramuscularly and maintained on isoflurane after intubation. Surgery was performed using standard aseptic techniques. Animals from each group were included at each laboratory session with the same operators performing all surgeries. The rabbit's right hind limb was shaved and the skin cleaned with a solution containing 7.5% povidone-iodine and 70% isopropyl alcohol. Without the use of a tourniquet, a 2.0-cm anteromedial incision was made to access the proximal tibia. A cortical window measuring 4 mm \times 12 mm was created at the anteromedial facet of the proximal tibia using

a 4.0-mm drill bit and a microoscillating saw under constant irrigation. In the study groups, 0.25 g of material was applied to the edges of the cortical bony defects. An inoculum of *Staphylococcus aureus* strain ATCC-29230 (2.5×10^4 colony-forming units in 0.1 mL saline) was introduced into the intramedullary canal through the defect. The organisms had been grown overnight in tryptic soy broth at 37° C assuring confluent growth, washed twice in phosphate-buffered saline, and resuspended in a balanced salt solution. The plate count method was used to confirm consistent bacterial inoculum load for all defects. The wound was closed in layers using monofilament sutures and the incision was covered with sterile dressing. After surgery, the animals were given buprenorphine (0.02–0.05 mg/kg) as needed every 12 hours.

Four weeks after surgery, the animals were euthanized using an intravenous overdose of pentobarbital. Radiographs of the tibias were taken. The tibias were exposed through the original incisions under sterile conditions, and bone was swabbed for bacterial culture and typing. The tibias were harvested and cut into two segments using an oscillating saw through the center of the original cortical defect. The upper part of the bone explant was cultured. Cultures were grown overnight in 5 mL of tryptic soy broth media. A 1-mL aliquot of the culture was removed, centrifuged to remove the growth medium, and diluted by 10^6 with phosphate-buffered saline. One milliliter of the diluted culture was plated on standard agar plates and colonies were counted after 24 hours. Growth was graded as follows: no growth; less than 20 colonies were graded light growth; 20 to 80 colonies were graded moderate growth; and more than 80 colonies were graded heavy growth.

The lower part of the tibial bone and surrounding soft tissue were fixed in 10% buffered formalin, decalcified, and processed for paraffin sectioning. Sections were examined microscopically after hematoxylin and eosin staining. Image scanning of sections was performed using a ScanScope XT System (Aperio Technologies Inc, Vista, CA) at $\times 20$ magnification courtesy of the Tissue Procurement Core Laboratory (UCLA School of Medicine, Los Angeles, CA). All radiographs and sections were viewed independently by two observers (TW, XW) who were blinded to the results.

For the infection and bone healing research questions, the study had three treatment arms: polymer, bone wax, and control. The results for the first question were categorized as either infected or not infected. The results for the second question were categorized as either healing or not healing. Statistical analysis of the data was performed on the 3 \times 2 contingency table using the Fisher-Freeman-Halton exact test [27]. A value of $p < .05$ was considered significant.

Two of the authors (Tadeusz Wellisz, Jonathan K. Armstrong) have a financial interest in Ceremed, Inc. Four of the authors (Yuehwei H. An, Xuejun Wen, Qian Kang, Christopher M. Hill) received grant support from Ceremed, Inc to support this research. Each author certifies that his or her institution has approved the animal protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

T. Wellisz (✉)
Division of Plastic and Reconstructive Surgery, the Department of Neurosurgery, University of Southern California,
536 S Rimpau Blvd, Los Angeles, CA 90020, USA
e-mail: tadeusz@wellisz.com

Y. H. An, X. Wen, Q. Kang, C. M. Hill
Orthopaedic Research Laboratory, Department of Orthopaedic Surgery, Medical University of South Carolina,
Charleston, SC, USA

J. K. Armstrong
Department of Physiology and Biophysics,
Keck School of Medicine, University of Southern California,
Los Angeles, CA, USA

Results

Animals that received the water-soluble polymer and animals in the control group showed a significantly lower incidence of osteomyelitis ($p \leq 0.004$), and positive bone cultures ($p \leq 0.02$), compared with the bone wax-treated group (Fig. 1). The polymer had no effect on the infection rate and rate of positive cultures compared with controls ($p \leq 0.001$). At 4 weeks, all of the animals in the bone wax group (eight of eight) had radiographic evidence of moderate to severe osteomyelitis, including periosteal reaction and bone lysis (Fig. 2). On histologic examination, all of the bone wax group specimens exhibited typical signs of bone infection: development of abscess lesions, destruction of cortical bone, and periosteal reaction. The bone marrow structure was destroyed in all those specimens (Fig. 3). By comparison, six of the eight animals had normal radiographs in the polymer (Fig. 2B) and the control groups (Fig. 2C); the other two animals in each group had radiographic evidence of osteomyelitis together with typical histologic signs of bone infection, including abscesses, and destruction of bone and marrow structures.

Cultures of the swabs and bone segments were positive for the inoculated strain of *Staphylococcus aureus* in 100% of the bone wax-treated specimens. In the polymer group and the control group, cultures from the animals with radiographic evidence of osteomyelitis were positive, and one additional animal of the six with normal radiographs in each group had a positive culture; five animals in each group had no evidence of infection.

The use of the water-soluble polymer did not affect bone healing compared with controls ($p \leq 0.001$). All of the cortical defects in the animals without radiographic

evidence of infection had histologic evidence of bone healing. In the polymer group, five of the cortical defects had been closed by new bone formation (Fig. 4) and one was partially closed. In the control group, four of cortical defects were closed (Fig. 5) and two were partially closed. None of the defects with radiographic verification of infection had evidence of healing in any treatment group.

Discussion

The rabbit tibial model has been used to study proposed treatments for osteomyelitis [1] and provides a practical means to investigate whether the use of a water-soluble bone hemostasis material in a contaminated environment might be less likely to promote the development of osteomyelitis than bone wax, and secondarily whether the polymer material might influence bone healing. Some limitations of this study are that, like with most animal studies, there is no certainty that the findings are predictive of the likely outcome in a human subject. Also, the type of bacteria and the method of application do not necessarily reflect the typical clinical situation.

In several animal studies, bone wax was shown to increase infection rates and impair the ability of bone to clear bacteria [22, 28, 31]. In a rabbit study, the cancellous bone of the iliac crest was inoculated with *Staphylococcus aureus* followed by placement of either bone wax or a steel rod. The authors concluded that bone wax impaired the ability of cancellous bone to clear the infection [22]. In a rat tibia model, the presence of bone wax reduced the amount of bacteria needed to produce *Staphylococcus aureus* osteomyelitis by a factor of 10,000 [28]. In a retrospective clinical study, infection rates after spinal surgery were assessed during a 3-month period [15]. Surgical site infections occurred in six of 42 cases (14.3%) in which bone wax was used and in only one of 72 cases (1.4%) in which it was not used.

There have been no clinical reports or in vivo studies published to date reporting complications or infections with the use of the polymer material evaluated in this study. One in vitro study involving one of the component polymers (poloxamer 188) showed coating silicone wafers with the polymer reduced bacterial adhesion and was more effective than iodine in reducing *Staphylococcus epidermidis* colony counts on silicone surfaces [25]. In our study, the use of the polymer material considerably reduced the infection rate compared with the use of bone wax, and it had no effect on the infection rate compared with the untreated controls.

The propensity to interfere with bone healing is a well-known property of bone wax [41]. In the 1924 edition of

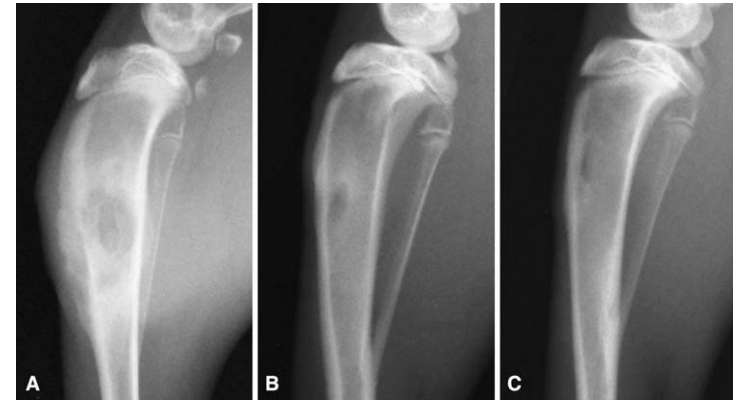


Fig. 2A–C (A) A radiograph taken 4 weeks after surgery shows a bone wax-treated tibia inoculated with *Staphylococcus aureus*. Clear signs of osteomyelitis can be seen, including bone lysis and periosteal reaction. Bone explants cultured in 5% TSB showed heavy growth of *Staphylococcus aureus*. (B) A representative radiograph taken 4

weeks after surgery of a polymer-treated tibia shows no evidence of osteomyelitis and normally healing bone. (C) A representative radiograph of an untreated control tibia also shows no evidence of osteomyelitis and normally healing bone.

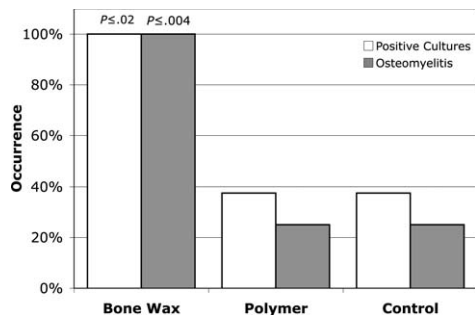


Fig. 1 The application of the water-soluble polymer to a cortical defect significantly decreased the rate of osteomyelitis formation ($p \leq 0.004$) and rates of positive cultures ($p \leq 0.02$) compared with bone wax. There was no difference between the polymer group and the untreated control group in the rates of osteomyelitis, positive cultures, or healing of bone defects ($p \leq 0.001$).

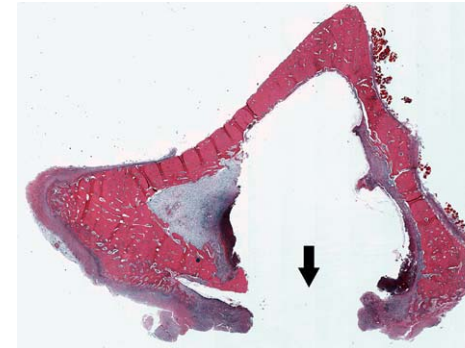


Fig. 3 A cross section of a bone wax-treated tibia at the center of the cortical window shows typical signs of osteomyelitis, including the development of an abscess, the destruction of cortical bone, and periosteal reaction. The cortical window shows no signs of bone healing after 4 weeks (arrow) (Stain, hematoxylin and eosin; original magnification, $\times 5$).

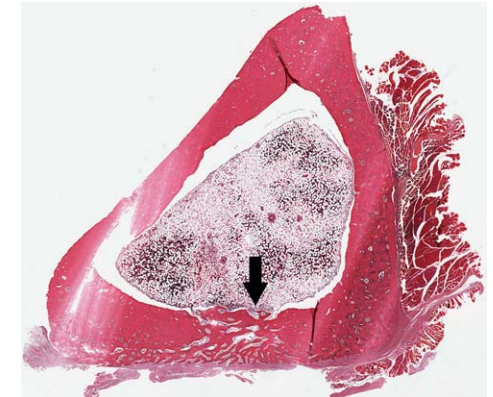


Fig. 4 A cross section of a polymer-treated tibia at the center of the cortical window shows typical normal bone and bone marrow without periosteal reaction. The cortical window is filled with new bone after 4 weeks (arrow) (Stain, hematoxylin and eosin; original magnification, $\times 5$).

Carson's Modern Operative Surgery, the use of bone wax is recommended not for bone hemostasis, but to prevent bone healing and to create a pseudarthrosis as part of an arthroplasty [39]. In various animal studies, bone wax subsequently was shown to inhibit osteogenesis and prevent bone union [2, 5, 8, 11, 12, 14, 19, 20, 29, 32, 36, 40]. Bone wax remains as a foreign body at the site of application indefinitely, and it is known to cause intense foreign body reactions characterized by giant cells, plasma cells,

and fibrous tissue [3, 22, 28, 33, 34]. Similar findings also were reported in humans [8, 35, 37]. Bone wax is believed to interfere with osteogenesis, and osteoblasts have been shown to be absent in the presence of a thin layer of bone wax [2]. Suggested appropriate uses for bone wax are prevention of osteosynthesis and osteophyte formation [2, 35].

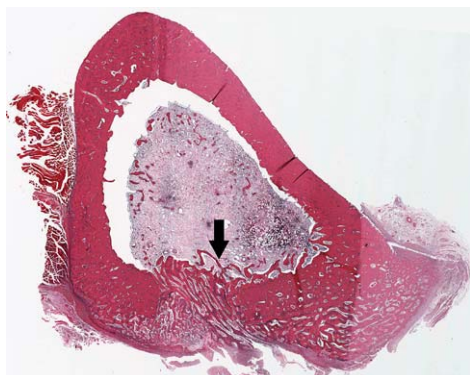


Fig. 5 A cross section of a control tibia at the center of the cortical window also shows normal bone and bone marrow without periosteal reaction. The cortical window is filled with new bone after 4 weeks (arrow) (Stain, hematoxylin and eosin; original magnification, $\times 5$).

The inflammatory reactions to bone wax may be a source of postoperative pain. One report described seven patients with intractable pain after the use of bone wax in foot surgery [4]. Five of the patients were pain-free after the bone containing the inflamed bone wax was resected. Clinical reports describing adverse inflammatory reactions to bone wax are common [3–7, 9, 17, 23, 24, 26, 38]. Reactions consist mainly of pain and swelling, often exacerbated by infection.

The alkylene oxide copolymer material used by Wang et al. showed new bone grew within 10 days into a rat femur defect with the polymer and the untreated controls [40]. In contrast, the defects filled with bone wax showed no bone formation 48 days after implantation. The polymer material dissolved from the site of application within 24 to 48 hours, allowing the early phases of bone healing to occur [40]. The polymer material used in our study dissolves in the body and has been shown not to interfere with bone healing or cause inflammation in a sterile environment [41].

In this study, in the presence of bacterial contamination, the use of the polymer material neither increased infection rates nor interfered with bone healing when compared with untreated controls. All of the defects without radiologic evidence of osteomyelitis had normal bone healing. The use of this polymer material in place of bone wax may be another step toward reducing wound complications and the associated morbidity after bone surgery.

Acknowledgments We thank Drs S. Dry and D. Gui from the Tissue Procurement Core Laboratory, Department of Pathology and Laboratory Medicine, UCLA School of Medicine, Los Angeles, CA, for providing the microscopic images of hematoxylin and eosin-stained sections.

References

- Aimin C, Chunlin H, Juliang B, Tinyin Z, Zhichao D. Antibiotic loaded chitosan bar: an in vitro, in vivo study of a possible treatment for osteomyelitis. *Clin Orthop Relat Res.* 1999; 366:239–247.
- Alberius P, Klinge B, Sjögren S. Effects of bone wax on rabbit cranial bone lesions. *J Craniomaxillofac Surg.* 1987;15:63–67.
- Allison RT. Foreign body reactions and an associated histological artefact due to bone wax. *Br J Biomed Sci.* 1994;51:14–17.
- Anfinsen OG, Sudmann B, Rait M, Bang G, Sudmann E. Complications secondary to the use of standard bone wax in seven patients. *J Foot Ankle Surg.* 1993;32:505–508.
- Angelini GD, el-Ghamari FA, Butchart EG. Poststernotomy pseudo-arthritis due to foreign body reaction to bone wax. *Eur J Cardiothorac Surg.* 1987;1:129–130.
- Ates O, Cayli SR, Gürses I. Bone wax can cause foreign body granuloma in the medulla oblongata. *Br J Neurosurg.* 2004; 18:538–540.
- Bolger WE, Tadros M, Ellenbogen RG, Judy K, Grady MS. Endoscopic management of cerebrospinal fluid leak associated with the use of bone wax in skull-base surgery. *Otolaryngol Head Neck Surg.* 2005;132:418–420.
- Brightmore TG, Hayes P, Humble J, Morgan AD. Haemostasis and healing following median sternotomy. *Langenbecks Arch Chir.* 1975;(suppl):39–41.
- Chun PK, Virmani R, Mason TE, Johnson F. Bone wax granuloma causing saphenous vein graft thrombosis. *Am Heart J.* 1988;115:1310–1313.
- Danielson GK, Dubilier LD, Bryant LR. Use of pluronic F-68 to diminish fat emboli and hemolysis during cardiopulmonary bypass: a controlled clinical study. *J Thorac Cardiovasc Surg.* 1970;59:178–184.
- dos Santos Neto FL, Volpon JB. Experimental nonunion in dogs. *Clin Orthop Relat Res.* 1984;187:260–271.
- Finn MD, Schow SR, Schneiderman ED. Osseous regeneration in the presence of four common hemostatic agents. *J Oral Maxillofac Surg.* 1992;50:608–612.
- Fowler EB, Cuenin MF, Hokett SD, et al. Evaluation of pluronic polyols as carriers for grafting materials: study in rat calvaria defects. *J Periodontol.* 2002;73:191–197.
- Geary JR, Kneeland Frantz V. New absorbable hemostatic bone wax: experimental and clinical studies. *Ann Surg.* 1950; 132:1128–1137.
- Gibbs L, Kakis A, Weinstein P, Conte JE Jr. Bone wax as a risk factor for surgical-site infection following neurospinal surgery. *Infect Control Hosp Epidemiol.* 2004;25:346–348.
- Grindel JM, Jaworski T, Emanuele RM, Culbreth P. Pharmacokinetics of a novel surface-active agent, purified poloxamer 188, in rat, rabbit, dog and man. *Biopharm Drug Dispos.* 2002;23: 87–103.
- Hadeishi H, Yasui N, Suzuki A. Mastoid canal and migrated bone wax in the sigmoid sinus: technical report. *Neurosurgery.* 1995;36:1220–1223 discussion 1223–1224.
- Horsley V. Antiseptic wax [Letter]. *BMJ.* 1892;1:1165.
- Howard TC, Kelley RR. The effect of bone wax on the healing of experimental rat tibial lesions. *Clin Orthop Relat Res.* 1969; 63:226–232.
- Ibarrola JL, Bjorenson JE, Austin BP, Gerstein H. Osseous reactions to three hemostatic agents. *J Endod.* 1985;11:75–83.
- Jewell RC, Khor SP, Kisor DF, LaCroix KA, Wargin WA. Pharmacokinetics of RheothRx injection in healthy male volunteers. *J Pharm Sci.* 1997;86:808–812.
- Johnson P, Fromm D. Effects of bone wax on bacterial clearance. *Surgery.* 1981;89:206–209.

- Katz SE, Rootman J. Adverse effects of bone wax in surgery of the orbit. *Ophthalm Plast Reconstr Surg.* 1996;12:121–126.
- Kothbauer KF, Jallo GI, Siffert J, Jimenez E, Allen JC, Epstein FJ. Foreign body reaction to hemostatic materials mimicking recurrent brain tumor: report of three cases. *J Neurosurg.* 2001;95:503–506.
- Levy ML, Luu T, Meltzer HS, Bennett R, Bruce DA. Bacterial adhesion to surfactant-modified silicone surfaces. *Neurosurgery.* 2004;54:488–490 discussion 490–491.
- Low WK, Sim CS. Bone wax foreign body granuloma in the mastoid. *ORL J Otorhinolaryngol Relat Spec.* 2002;64:38–40.
- Mehta CR, Patel NR. A network algorithm for performing Fisher's exact test in $r \times c$ contingency tables. *JASA.* 1983; 78(382):427–434.
- Nelson DR, Buxton TB, Luu QN, Rissing JP. The promotional effect of bone wax on experimental *Staphylococcus aureus* osteomyelitis. *J Thorac Cardiovasc Surg.* 1990;99:977–980.
- Papay FA, Morales L Jr, Ahmed OF, Neth D, Reger S, Zins J. Comparison of ossification of demineralized bone, hydroxyapatite, Gelfoam, and bone wax in cranial defect repair. *J Craniofac Surg.* 1996;7:347–351.
- Parker R. Aural pyaemia successfully treated by removing putrid thrombus of jugular vein and lateral sinus. *BMJ.* 1892;1:1076–1077.
- Patterson AL, Galloway RH, Baumgartner JC, Barsoum IS. Development of chronic mandibular osteomyelitis in a miniswine model. *J Oral Maxillofac Surg.* 1993;51:1358–1362.
- Robicsek F, Masters TN, Littman L, Born GV. The embolization of bone wax from sternotomy incisions. *Ann Thorac Surg.* 1981;31:357–359.

- Schonauer C, Tessitore E, Barbagallo G, Albanese V, Moraci A. The use of local agents: bone wax, gelatin, collagen, oxidized cellulose. *Eur Spine J.* 2004;13(suppl 1):S89–S96.
- Solheim E, Pinholt EM, Bang G, Sudmann E. Effect of local hemostatics on bone induction in rats: a comparative study of bone wax, fibrin-collagen paste, and bioerodible polyorthoester with and without gentamicin. *J Biomed Mater Res.* 1992;26: 791–800.
- Sorrenti SJ, Cumming WJ, Miller D. Reaction of the human tibia to bone wax. *Clin Orthop Relat Res.* 1984;182:293–296.
- Sudmann B, Anfinsen OG, Bang G, et al. Assessment in rats of a new bioerodible bone-wax-like polymer. *Acta Orthop Scand.* 1993;64:336–339.
- Sudmann B, Bang G, Sudmann E. Histologically verified bone wax (beeswax) granuloma after median sternotomy in 17 of 18 autopsy cases. *Pathology.* 2006;38:138–141.
- Verborgt O, Verellen K, Van Thielen F, Deroover M, Verbist L, Borms T. A retroperitoneal tumor as a late complication of the use of bone wax. *Acta Orthop Belg.* 2000;66:389–391.
- Verrall PJ. Operation on joints. In: Carson HW, ed. *Modern Operative Surgery.* Vol 1. London, England: Cassell & Co; 1924:69.
- Wang MY, Armstrong JK, Fisher TC, Meiselman HJ, McComb GJ, Levy ML. A new, pluronic-based, bone hemostatic agent that does not impair osteogenesis. *Neurosurgery.* 2001;49:962–967 discussion 968.
- Wellisz T, Armstrong JK, Cambridge J, Fisher TC. Ostene, a new water-soluble bone hemostasis agent. *J Craniofac Surg.* 2006; 17:420–425.

The Effects of a Soluble Polymer and Bone Wax on Sternal Healing in an Animal Model

Tadeusz Wellisz, MD*, Jonathan K Armstrong, PhD[†], John Cambridge, PhD[‡], Qian Kang, MD^{††}, Yuehuei H. An, MD^{††}, Xuejun Wen, MD, PhD^{††}, Qian Kang, MD^{††}, Christopher M. Hill, VMD^{††}, Timothy C Fisher, MB, ChB[†]

Objective: The objective of this study was to compare the effects of a soluble polymer hemostatic material to bone wax on sternal bone healing. Although effective as a bone hemostasis agent, bone wax is known to inhibit bone healing, increase infection rates, and elicit chronic inflammatory reactions.

Methods: Median sternotomies were performed on 20 New Zealand White rabbits, and sufficient polymer (Ostene; Ceremed, Inc, Los Angeles CA) or bone wax (Bone Wax; Ethicon, Inc, Somerville NJ) was applied to achieve bone hemostasis. After 6 weeks, sternal healing was assessed using x-rays, histology, and mechanical strength testing.

Results: X-rays revealed normal bone healing in the polymer-treated group and radiolucent areas indicating non-union in the bone wax group. Histology showed normal bone healing and marrow structure in the polymer group, with the absence of new bone formation and fibrotic scar tissue in the bone wax group. Mechanical strength testing showed that polymer-treated sternal segments were twice as strong as those treated with bone wax. The polymer-treated sternal bones had a significantly higher flexural strength (2.53 ± 0.43 vs. 1.29 ± 0.37 Mpa; $P < .001$) and Young's modulus ($.315 \pm .056$ vs. $.146 \pm .031$ Mpa; $P < .001$) compared to those treated with bone wax.

Conclusions: The application of a polymer hemostatic material to the sternum resulted in significantly stronger union compared to the use of bone wax. The use of the soluble polymer in place of bone wax may help reduce the occurrence of post-operative sternal complications.

Sternal non-union has been estimated to occur in 2% to 8% of the patients undergoing cardiac surgery.[1] Post-operative mediastinitis with sternal dehiscence is a dreaded complication.[2] The incidence of sternal non-union without a concomitant infection is estimated to be 0.2% to 5%.[3] Clinical manifestations of late sternal non-union can range from feelings of chest motion, clicking and chronic discomfort, to respiratory embarrassment due to the cycle of pain, tachypnea and hypoventilation.[1]

Bone wax, which is made of softened beeswax, has been thought to contribute to complications following sternotomy.[4] Several authors have warned against using bone wax for sternal bone hemostasis.[4-6] Although effective in stopping bone bleeding, bone wax is never cleared from the operative site and is known to inhibit bone healing, increase infection rates, and elicit chronic inflammatory reactions.[7, 8] A recommended use for bone wax in orthopedic surgery is the prevention of osteosynthesis.[9] The continued use of bone wax in cardiac surgery despite its known adverse effects may be in part the result of the absence of a suitable alternative.

A synthetic bone hemostasis material, made of water-soluble alkylene oxide copolymers, has recently become available.[7] The use of alkylene oxide copolymers for bone hemostasis was first described by Wang et al.[10] These copolymers have a long history in the medical field, and they have been used as an additive in cardiopulmonary bypass pump oxygenators. [11] They do not interfere with coagulation and are considered inert, as they are eliminated from the body unchanged without being metabolized.[11-13] Because these copolymers and they are hydrophilic and stick well to wet surfaces, they are well suited for bone hemostasis.

Our study was designed to compare the effects of the two bone hemostasis materials on sternal bone healing in an animal model. The objective of this study was to determine if the use of the polymer would improve the strength of sternal bone healing compared to the use of bone wax.

MATERIALS AND METHODS

Twenty female New Zealand White rabbits (3.75 ± 0.25 kg) were randomly divided into two equal groups of 10 animals. They underwent median sternotomy with the application of either synthetic polymer (Ostene; Ceremed, Inc, Los Angeles CA), or bone wax (Bone Wax; Ethicon, Inc, Somerville, NJ). Rabbits were anesthetized using ketamine (30 mg/kg), xylazine (5 mg/kg), and atropine (1 - 3 mg/kg) intramuscularly and maintained on isoflurane after intubation. Surgery was performed using standard aseptic techniques. A 5-cm midline chest incision was made (Fig 1A), and a circular saw was used to divide the lower three segments of the sternum (Fig 1B). Equal amounts of the polymer or bone wax were applied to cover the cut bone surface, and hemostasis was assessed. 2-0 monofilament sutures were used to secure the sternal halves, and the incision was closed in layers. Animals were sacrificed after 6 weeks using IV pentobarbital. All animals received humane care in compliance with the Guide for the Care and Use of Laboratory Animals. Each sternum was harvested for radiographic, histological, and mechanical analysis.

Standardized lateral radiographs of the sternum were taken under the same conditions, using the same x-ray intensity and duration, from the same constant object-to-film-to-x-ray-source distance, and with the same batch ultra-high-contrast mammography film. Each fresh specimen was sectioned, and the uppermost treated sternal segment was fixed in 10% neutral buffered formalin and processed for routine undecalcified sectioning. The specimens were embedded in Spurr's media and cut using slow speed diamond saw. Sections were ground to a thickness of 50 μ m and stained with Sanderson's rapid bone stain, staining bone a red color.

The lower portion of each treated segment was used for mechanical strength testing. The mechanical strength of each sternal segment was measured on a MTS Synergie 100 material tester (Eden Prairie, MN) using three-point testing with a 0.2 mm/sec crosshead speed. Statistical analysis of the measured flexural strength and Young's modulus was performed using a t-test.

RESULTS

During the surgery, equivalent bone hemostasis was achieved using bone wax and the alkylene oxide copolymer. At the time of sacrifice 6 weeks post-surgery, x-ray radiographs of two groups show differences in bone fusion. In the polymer group the two halves of each sternum were consistently fused (Fig 2A). In contrast, in the bone wax-treated segments, every sternum exhibited areas of radiolucency indicating sternal non-union (Fig 2B).

Histological analysis of the segments treated with the polymer showed consistent bone healing. Each segment showed new bone formation, as evidenced by regener-

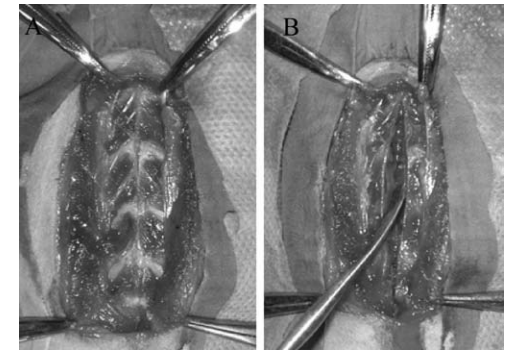


Fig 1 (A) The surgical procedure for rabbit median sternotomy model is shown. (B) The lower three segments of the sternum were divided, and either the polymer or bone wax was applied to the cut bone surface.

ated bone trabeculae, and normal bone marrow structure with a lack of fibrosis (Fig 3A). In contrast, analysis of the bone wax-treated bone showed each segment to contain residual bone wax with minimal bone marrow. Each segment had healed with fibrotic scarring, with little evidence of new bone formation (Fig 3B).

Mechanical testing (Fig 4A) revealed that the sternums treated with the polymer were significantly stronger than those treated with bone wax ($P < .001$). The sections treated with the polymer had approximately twice the flexural strength and Young's modulus compared to those treated with bone wax. The flexural strength (Fig 4B) of the polymer treated sternums (2.53 ± 0.43 Mpa) was significantly greater than the bone wax treated group (1.29 ± 0.37 Mpa, $P < .001$; Fig 5). The Young's modulus of the polymer treated sternums ($.315 \pm .056$ MPa) was also significantly greater than that of the bone wax group ($.146 \pm .031$ MPa; $P < .001$; Fig 6).

COMMENT

Bone wax, which is made of softened beeswax, is widely used for sternal hemostasis in cardiac surgery. Beeswax without softeners was used for amputation hemostasis during the US Civil War. The development of sterile softened beeswax has been attributed to Horsley in 1892.[14] Since that time, bone wax formulations have not changed much, and current formulations are composed of beeswax softened with paraffin and/or isopropyl palmitate.[15] Bone wax has no inherent hemostasis quality; its effect is to tamponade the holes and spaces in the bone. Although effective in stopping bone bleeding, bone wax remains at the site indefinitely and has a number of adverse effects. [4, 16-20] The three major categories of adverse effects of bone wax reported are: inhibition of bone healing, increased infection rates, and inflammatory

From the *Division of Plastic and Reconstructive Surgery, the Department of Neurosurgery, and the [†]Department of Physiology and Biophysics, Keck School of Medicine, University of Southern California, Los Angeles, CA, and the ^{††}Orthopaedic Research Laboratory, Department of Orthopaedic Surgery, Medical University of South Carolina, Charleston, SC.
Address correspondence to Dr Wellisz, 3643 Lenawee Ave, Los Angeles CA, 90016.
© 2007

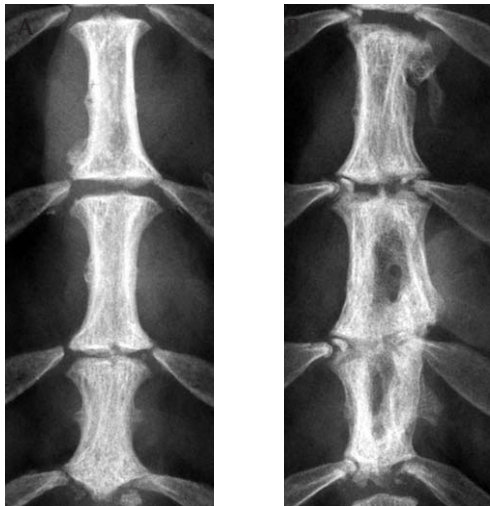


Fig 2 (A) A radiograph taken 6 weeks after surgery of a sternum in which the soluble polymer was used for hemostasis. Bone fusion occurred consistently in every animal. (B) A radiograph taken 6 weeks after surgery in which the sternal segments were treated with bone wax. All bone wax treated segments exhibited areas of radiolucency indicating non-union.

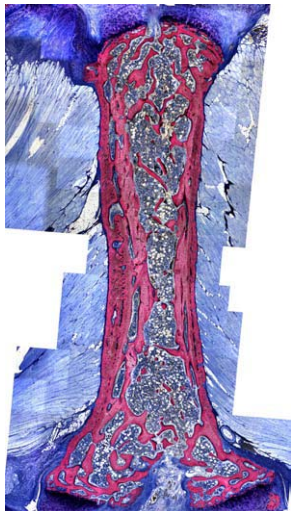


Fig 3 (A) The polymer treated sternum (Horizontal Section). The bone is stained red. New bone has been formed within normal bone marrow. Intact cartilage is present between the sternal segments. (Sanderson's stain, Original magnification 5x).

reactions.

Bone wax has long been known to interfere with bone healing.[5, 8, 21-26] In the 1924 edition of Carson's Modern Operative Surgery, the use of bone wax is recommended not for bone hemostasis, but for preventing bone healing and for the creation of a pseudoarthrosis.[27] In 1969, Howard and Kelley demonstrated that bone wax prevents bone healing in an animal model and concluded that bone wax is contraindicated in areas where bone fusion is desired.[24] In a canine iliac crest model, defects filled with bone wax showed intense foreign-body reactions characterized by giant cells, plasma cells, fibrous tissue, and a lack of bone formation.[23] Alberius et al. showed that bone wax interfered with osteogenesis in cranial bone, and that osteoblasts were completely absent in the presence of a thin layer of bone wax.[21] In a rat tibial defect model, where bone wax was applied for 10 minutes and then removed and the bone curettaged, inhibition of bone regeneration and marked inflammation still occurred.[25] In the clinical setting, autopsy studies have demonstrated persistent sternal non-union and chronic inflammatory reactions with the presence of residual bone wax up to 10 years following surgery.[5, 28]

Bone wax is known to increase infection rates and impair the ability of bone to clear bacteria.[18, 29-31] Bone wax was shown to lower bacterial clearance from

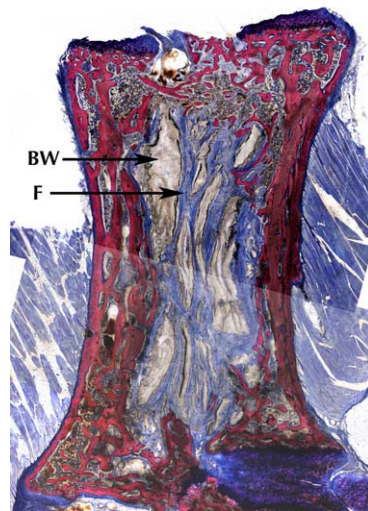


Fig 3 (B) Bone wax treated sternum (Horizontal Section). The bone is stained red. Bone wax is still present at the site (BW), with fibrotic scar in the area of the bone wax (FS). There is scant new bone and minimal normal bone marrow. Intact cartilage is present between the sternal segments. (Sanderson's stain, Original magnification 5x).

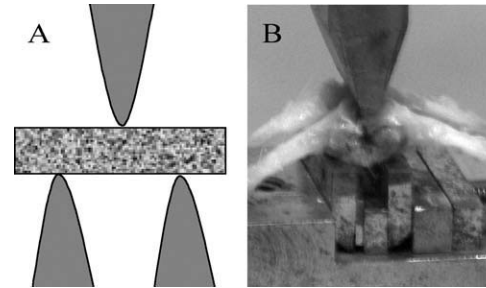


Fig 5 (A) Schematic representation of the three-point testing used to assess the strength of the healed sternum. (B) One segment of sternum undergoing three-point testing.

cancellous bone and to significantly impair the clearance of a standard inoculum of *Staphylococcus aureus* from rabbit iliac crest defects.[29] In a rat tibia model, the presence of bone wax reduced the amount of *Staphylococcus aureus* needed to produce osteomyelitis by a factor of 10,000.[30]

Bone wax is known to remain as a foreign body indefinitely, causing giant cell reactions and inflammation at the site of application. [32-35] In a human study, Sorrentini et al. evaluated the reactions to bone wax in human tibias in 12 patients who had undergone tibial tubercle elevation.[9] The patients underwent re-operation after 5 to 13 months, and bone biopsies were performed. The authors observed a progression from foreign body giant cell reaction with giant cells containing vacuoles filled with bone wax, to the formation of mature fibrous tissue. A number of reports have been published describing adverse inflammatory reactions to bone wax requiring re-operation.[8, 16, 19, 20, 32] Reactions consisted mainly of pain and swelling, often exacerbated by infection. Published reports describe granulomatous reactions to bone wax being mistaken for cancer,[20] causing compression of neural tissue,[19] and compressing vein grafts following coronary artery bypass.[17]

The alkylene oxide copolymer material used by Wang et al. was shown not to interfere with bone healing.[10] New bone grew into rat femur defects within 10 days after treatment with their polymer, as compared to the defects filled with bone wax which showed no bone formation after 48 days. The polymer material dissolved from the site of application within 24 to 48 hours, allowing the early phases of bone healing to occur.[10] The polymer material used in our study dissolves in the body and has been shown not to interfere with bone healing or cause inflammation in animal models.[7] The use of the soluble polymer also significantly decreased the incidence of osteomyelitis compared to that seen with the use of bone

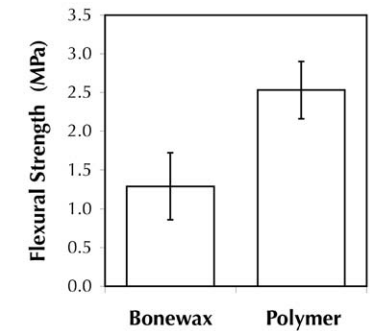


Fig 5 The flexural strength of the polymer treated sternal segments (2.53 ± 0.43 Mpa) was significantly greater than that of the bone wax group (1.29 ± 0.37 ; $P < .001$).

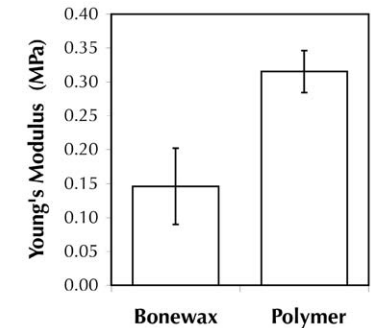


Fig 6 The Young's modulus of the polymer treated sternal segments ($.315 \pm .056$ Mpa) was significantly greater than that of the bone wax group ($.146 \pm .031$ Mpa; $P < .001$).

wax in a tibial defect model.[36]

In our study, the soluble polymer did not demonstrate the interference with bone healing that was observed with the use of bone wax. When the polymer was used, significantly stronger sternal healing occurred as compared to bone wax. The use of this polymer in place of bone wax may help reduce the occurrence of post-operative sternal non-union and its associated complications.

The authors would like to thank Drs S. Dry and D. Gui from the Department of Pathology and Laboratory Medicine, UCLA School of Medicine, Los Angeles, CA for providing the microscopic images of the stained sections.

REFERENCES

1. Robicsek F, Fokin A, Cook J, Bhatia D. Sternal instability after midline sternotomy. *Thorac Cardiovasc Surg* 2000; 48:1-8.
2. Robicsek F. Postoperative sterno-mediastinitis. *Am Surg* 2000; 66:184-92.
3. Olbrecht VA, Barreiro CJ, Bonde PN, et al. Clinical outcomes of noninfectious sternal dehiscence after median sternotomy. *Ann Thorac Surg* 2006; 82:902-7.
4. Robicsek F, Masters TN, Littman L, Born GV. The embolization of bone wax from sternotomy incisions. *Ann Thorac Surg* 1981; 31:357-9.
5. Brightmore TG, Hayes P, Humble J, Morgan AD. Haemostasis and healing following median sternotomy. *Langenbecks Arch Chir* 1975; Suppl:39-41.
6. Harjula A, Jarvinen A. Postoperative median sternotomy dehiscence. *Scand J Thorac Cardiovasc Surg* 1983; 17:277-81.
7. Wellisz T, Armstrong JK, Cambridge J, Fisher TC. Ostene, a new water-soluble bone hemostasis agent. *J Craniofac Surg* 2006; 17:420-5.
8. Angelini GD, el-Ghamari FA, Butchart EG. Poststernotomy pseudo-arthritis due to foreign body reaction to bone wax. *Eur J Cardiothorac Surg* 1987; 1:129-30.
9. Sorrenti SJ, Cumming WJ, Miller D. Reaction of the human tibia to bone wax. *Clin Orthop Relat Res* 1984;293-6.
10. Wang MY, Armstrong JK, Fisher TC, Meiselman HJ, McComb GJ, Levy ML. A new, pluronic-based, bone hemostatic agent that does not impair osteogenesis. *Neurosurgery* 2001; 49:962-7.
11. Danielson GK, Dubilier LD, Bryant LR. Use of Pluronic F-68 to diminish fat emboli and hemolysis during cardiopulmonary bypass. A controlled clinical study. *J Thorac Cardiovasc Surg* 1970; 59:178-84.
12. Fowler EB, Cuenin MF, Hokett SD, et al. Evaluation of pluronic polyols as carriers for grafting materials: study in rat calvaria defects. *J Periodontol* 2002; 73:191-7.
13. Jewell RC, Khor SP, Kisor DF, LaCroix KAK, Wargin WA. Pharmacokinetics of RheothRx injection in healthy male volunteers. *J Pharm Sci* 1997; 86:808-12.
14. Horsley V. Antiseptic wax [Letter]. *Br Med J* 1892; 1:1165.
15. Schonauer C, Tessitore E, Barbagallo G, Albanese V, Moraci A. The use of local agents: bone wax, gelatin, collagen, oxidized cellulose. *Eur Spine J* 2004; 13 Suppl 1:S89-96.
16. Anfinsen OG, Sudmann B, Rait M, Bang G, Sudmann E. Complications secondary to the use of standard bone wax in seven patients. *J Foot Ankle Surg* 1993; 32:505-8.
17. Chun PK, Virmani R, Mason TE, Johnson F. Bone wax granuloma causing saphenous vein graft thrombosis. *Am Heart J* 1988; 115:1310-3.
18. Gibbs L, Kakis A, Weinstein P, Conte JE, Jr. Bone wax as a risk factor for surgical-site infection following neurospinal surgery. *Infect Control Hosp Epidemiol* 2004; 25:346-8.
19. Patel RB, Kwartler JA, Hodosh RM. Bone wax as a cause of foreign body granuloma in the cerebellopontine angle. Case illustration. *J Neurosurg* 2000; 92:362.
20. Verborgt O, Verellen K, Van Thielen F, Deroover M, Verbist L, Borms T. A retroperitoneal tumor as a late complication of the use of bone wax. *Acta Orthop Belg* 2000; 66:389-91.
21. Alberius P, Klinge B, Sjogren S. Effects of bone wax on rabbit cranial bone lesions. *J Craniomaxillofac Surg* 1987; 15:63-7.
22. dos Santos Neto FL, Volpon JB. Experimental nonunion in dogs. *Clin Orthop Relat Res* 1984;260-71.
23. Finn MD, Schow SR, Schneiderman ED. Osseous regeneration in the presence of four common hemostatic agents. *J Oral Maxillofac Surg* 1992; 50:608-12.
24. Howard TC, Kelley RR. The effect of bone wax on the healing of experimental rat tibial lesions. *Clin Orthop Relat Res* 1969; 63:226-32.
25. Ibarrola JL, Bjorenson JE, Austin BP, Gerstein H. Osseous reactions to three hemostatic agents. *J Endod* 1985; 11:75-83.
26. Sudmann B, Anfinsen OG, Bang G, et al. Assessment in rats of a new bioerodible bone-wax-like polymer. *Acta Orthop Scand* 1993; 64:336-9.
27. Verrall PJ. Operation on Joints. In: Carson HW, ed. *Modern Operative Surgery*, Vol. 1. London: Cassell & Co.; 1924:69.
28. Sudmann B, Bang G, Sudmann E. Histologically verified bone wax (beeswax) granuloma after median sternotomy in 17 of 18 autopsy cases. *Pathology* 2006; 38:138-41.
29. Johnson P, Fromm D. Effects of bone wax on bacterial clearance. *Surgery* 1981; 89:206-9.
30. Nelson DR, Buxton TB, Luu QN, Rissing JP. The promotional effect of bone wax on experimental *Staphylococcus aureus* osteomyelitis. *J Thorac Cardiovasc Surg* 1990; 99:977-80.
31. Patterson AL, Galloway RH, Baumgartner JC, Barsoum IS. Development of chronic mandibular osteomyelitis in a miniswine model. *J Oral Maxillofac Surg* 1993; 51:1358-62.
32. Allison RT. Foreign body reactions and an associated histological artefact due to bone wax. *Br J Biomed Sci* 1994; 51:14-7.
33. Papay FA, Morales L, Jr, Ahmed OF, Neth D, Reger S, Zins J. Comparison of ossification of demineralized bone, hydroxyapatite, Gelfoam, and bone wax in cranial defect repair. *J Craniofac Surg* 1996; 7:347-51.
34. Katz SE, Rootman J. Adverse effects of bone wax in surgery of the orbit. *Ophthal Plast Reconstr Surg* 1996; 12:121-6.
35. Solheim E, Pinholt EM, Bang G, Sudmann E. Effect of local hemostatics on bone induction in rats: a comparative study of bone wax, fibrin-collagen paste, and bioerodible polyorthoester with and without gentamicin. *J Biomed Mater Res* 1992; 26:791-800.
36. Wellisz T, Cambridge J, An YH, Wen X, Armstrong JA. Infection rates and healing using bone wax and a soluble polymer material. *Clin Orthop Relat Res*; In Press.

DE

Ostene®

MATERIAL ZUR KNOCHENHÄMOSTASE
LÖSLICH IN WASSER
ENTHÄLT KEIN BIENENWACHS

BESCHREIBUNG

OSTENE® ist ein wasserlösliches, chirurgisches Implantatmaterial und dient zur Kontrolle von Blutungen aus Knochenoberflächen und wirkt dabei als mechanische Barriere. OSTENE® ist eine sterile Mischung aus wasserlöslichen Alkylenoxid-Copolymeren, gewonnen aus Ethylenoxid und Propylenoxid.

ANWENDUNGSGEBIET

OSTENE® wird als ein wasserlösliches, Implantatmaterial zur Kontrolle von Blutungen aus Knochenoberflächen verwendet. Um die gewünschte Konsistenz von OSTENE® zu erhalten, wird es unter sterilen Kautelen erwärmt.

WIRKUNGSWEISE

OSTENE® bewirkt eine lokale Hämostase des Knochens indem es als mechanische Barriere wirkt. Es besitzt keine biochemische Wirkung.

GEGENANZEIGEN

1. Flächen mit aktiven oder latenten Infektionen.
2. Verwendung des Produktes zur strukturellen Stärkung des Knochens.

WARNHINWEISE UND VORSICHTSMASSNAHMEN

1. OSTENE® wird in steriler Form bereitgestellt und ist für den einmaligen Gebrauch vorgesehen. Das Produkt darf NICHT RESTERILISIERT WERDEN. Geöffnete, ungenutzte oder beschädigte Packungen müssen vernichtet werden. NICHT VERWENDEN wenn die Packung nicht mehr steril ist.
2. OSTENE® sollte nicht übermäßiger Hitze ausgesetzt werden. Bei Raumtemperatur lagern und vor direkter Hitze und Sonnenlicht schützen.

HINWEISE FÜR DIE ANWENDUNG

OSTENE® lässt sich am besten bei Körpertemperatur verarbeiten und sollte unter Anwendung steriler Techniken erwärmt werden bis die gewünschte Konsistenz erreicht ist. Die ungeöffnete Folie kann in eine warme, sterile Lösung getaucht und das Material kann mit trockenen, durch Handschuhe geschützten Fingern, geknetet werden. Die ungeöffnete Packung kann auch in einem Wärmeschrank bei einer Temperatur von 43°C (110°F) oder darunter, erwärmt werden. OSTENE® verhält sich mehr wie Gummi als Wax. Bei Anwendung zur Kontrolle von Blutungen aus dem Knochen wird OSTENE® in den blutenden Knochen gedrückt oder über die blutende Oberfläche verteilt, je nachdem wie es aufgrund der chirurgischen Gegebenheiten oder der Vorliebe des Chirurgen angezeigt ist.

STERILITÄT

OSTENE® ist durch Elektronenbestrahlung sterilisiert. Das Produkt sollte mit Hilfe antiseptischer Methoden direkt vor Verwendung aus der sterilen Verpackung entnommen werden. OSTENE® DARF UNTER KEINEN UMSTÄNDEN RESTERILISIERT WERDEN.

GARANTIE

Alle Produkte sind garantiert frei von Material- und Verarbeitungsdefekten. Keine Garantie wird für die unsachgemäße Verwendung des Produktes – zu Zwecken, die nicht in der Gebrauchsanleitung stehen – gewährleistet.

EN

Ostene®

BONE HEMOSTASIS MATERIAL
WATER - SOLUBLE
CONTAINS NO BEESWAX

DESCRIPTION

OSTENE® is a water-soluble surgical implant material and it provides for control of bleeding from bone surfaces by acting as a mechanical barrier. OSTENE® is a sterile mixture of water-soluble alkylene oxide copolymers, derived from ethylene oxide and propylene oxide.

INDICATIONS

OSTENE® is indicated for use as a water-soluble implant material and for use in the control of bleeding from bone surfaces. OSTENE® should be warmed to desired consistency using aseptic techniques.

ACTIONS

OSTENE® achieves local hemostasis of bone by acting as a mechanical barrier. It does not act biochemically.

CONTRAINDICATIONS

1. Sites with active or latent infections.
2. The use of the product to lend structural support to bone.

WARNINGS AND PRECAUTIONS

1. OSTENE® is provided sterile for single use only. DO NOT RESTERILIZE. Discard any open, unused, or damaged packages. DO NOT USE if there is a loss of sterility of the device.
2. OSTENE® should not be subjected to excess heat. Store at room temperature away from direct heat, including sunlight.

INSTRUCTIONS FOR USE

OSTENE® works best at body temperature and should be warmed to desired consistency using aseptic technique. The unopened foil packet may be immersed into a warm sterile solution and the material may be manipulated with dry gloved fingers. The unopened packet may also be placed in a warming cabinet at temperatures at or below 43°C (110°F). OSTENE® handles more like a gum than a wax. For use in the control of bone bleeding, OSTENE® may be pressed into bleeding bone and may be worked across the bleeding surface as indicated by the surgical circumstances and the preference of the surgeon.

STERILITY

OSTENE® is sterilized using electron beam irradiation. Removal from the sterile package using aseptic techniques should only take place immediately before use. OSTENE® MUST NOT BE RESTERILIZED BY ANY METHOD.

WARRANTY

All products are warranted to be free from defects in material and workmanship. No warranty is made for any purpose other than in the product specifications and labeling.

FR

Ostene®

HEMOSTATIQUE OSSEUX
SOLUBLE DANS L'EAU
NE CONTIENT PAS DE CIRE D'ABEILLE

DESCRIPTION

OSTENE® est un dispositif médical implantable hydrosoluble et permet de contrôler les hémorragies à la surface des os en agissant comme une barrière mécanique. OSTENE® est un mélange stérile composé de copolymères d'oxyde d'alkylène solubles dans l'eau. Ces polymères sont dérivés d'oxyde d'éthylène et d'oxyde de propylène.

INDICATIONS

OSTENE® est indiqué pour une utilisation en tant que dispositif médical implantable hydrosoluble dans le contrôle des hémorragies à la surface des os. Réchauffez OSTENE® jusqu'à la consistance désirée en utilisant une technique aseptique.

MODE D'ACTION

OSTENE® permet une hémostase osseuse locale en agissant comme une barrière mécanique. OSTENE® n'a pas d'action biochimique.

CONTRE-INDICATIONS

1. Sites à infection active ou latente
2. Utilisation du produit pour supporter la structure osseuse.

PRECAUTIONS D'EMPLOI

1. OSTENE® est présenté en doses individuelles stériles. NE PAS RE STERILISER. Jeter toute dose ouverte, non utilisée ou endommagée. NE PAS UTILISER si le produit n'est plus stérile.
2. OSTENE® ne doit pas être sujet à des températures élevées. Conserver à température ambiante, à l'abri d'une source directe de chaleur, tel que le soleil.

INSTRUCTIONS D'UTILISATION

OSTENE® s'utilise mieux à température corporelle et doit être réchauffé à la consistance désirée en utilisant une technique aseptique. L'emballage stérile non ouvert peut être immergé dans une solution stérile chauffée et le matériau peut être manipulé avec des gants chirurgicaux. L'emballage stérile non ouvert peut également être placé dans une enceinte thermostatée à une température ne dépassant pas 43°C (110°F). La consistance d'OSTENE® se rapproche plus d'une gomme que d'une cire. Pour le contrôle d'une hémorragie à la surface des os, OSTENE® peut être pressé dans l'os qui saigne ou positionné sur la surface osseuse hémorragique selon les circonstances opératoires et les préférences du chirurgien.

STERILITE

OSTENE® est stérilisé par irradiation. Ne retirer de l'emballage stérile qu'en conditions aseptiques et juste avant son utilisation. OSTENE® NE DOIT PAS ETRE RE STERILISE PAR AUCUNE METHODE.

GARANTIE

Tous les produits sont garantis d'être exempts de défauts dans ses matériaux et sa fabrication. Il n'y a aucune garantie pour toute autre utilisation que celle spécifiée sur l'emballage.

IT

Ostene®

PRODOTTO EMOSTATICO IDROSOLUBILE
PER EMOSTASI OSSEA
NON CONTIENE CERA D'API

DESCRIZIONE

OSTENE® è un materiale chirurgico impiantabile solubile in acqua che agisce controllando il sanguinamento dalle superfici ossee agendo come barriera meccanica. OSTENE® è una miscela sterile di copolimeri idrosolubili di alchilene, derivati dell'ossido di etilene e ossido di propilene.

INDICAZIONI

OSTENE® è indicato come materiale impiantabile solubile in acqua per l'utilizzo nel controllo del sanguinamento da superfici ossee. Per raggiungere la consistenza desiderata, OSTENE® deve essere riscaldato in condizioni asettiche.

AZIONI

OSTENE® induce emostasi locale dell'osso agendo come barriera meccanica. Non svolge azione biochimica.

CONTROINDICAZIONI

1. Zone con infezioni attive o latenti
2. Uso del prodotto allo scopo di offrire supporto strutturale.

AVVERTENZE E PRECAUZIONI

1. OSTENE® è in confezione sterile monouso. NON RISTERILIZZARE. Eliminare confezioni aperte, non utilizzate o danneggiate. Non utilizzare in caso di perdita di sterilità del dispositivo.
2. Tenere lontano da eccessive fonti di calore. Mantenere a temperatura ambiente, lontano da fonti dirette di calore, inclusi i raggi solari.

ISTRUZIONI PER L'USO

OSTENE® si utilizza meglio a temperatura corporea e dovrebbe essere riscaldato per raggiungere la consistenza desiderata utilizzando tecniche asettiche. Il blister metallico chiuso può essere immerso in una soluzione sterile riscaldata e il materiale può essere manipolato con le dita utilizzando guanti asciutti. Il blister chiuso può essere anche scaldato in un riscaldatore a temperatura uguale o inferiore a 43°C (110°F). OSTENE® alla manipolazione si comporta più come gomma che come cera. OSTENE® può essere premuto nell'osso sanguinante e può essere utilizzato sulla superficie sanguinante come richiesto dalle circostanze chirurgiche e a seconda delle preferenze del chirurgo.

STERILITÀ

OSTENE® è sterilizzato mediante irradiazione a elettroni accelerati. Rimuovere dalla confezione sterile solo immediatamente prima dell'uso, servendosi di tecniche asettiche. NON RISTERILIZZARE OSTENE® CON NESSUN METODO.

GARANZIA

Tutti i prodotti sono garantiti privi di difetti, sia nel materiale, sia nella preparazione. Il prodotto è garantito solo se usato secondo le prescrizioni scritte sull'etichetta.



0086



gd medical ag | schwerzistrasse 6 | CH-8807 freienbach (sz)
telephone +41 (0)55 420 33 55 | fax +41 (0)55 420 33 56 | info@gdmedical.ch | www.gdmedical.ch