Orthopaedic utilization of Woundclot®

Examples of effective management and optimization of Hemostasis during Orthopaedic surgical procedures

WOUNDCLOT®
Advanced Bleeding Control™

Core Scientific Creations Ltd.
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WoundClot® Hemostatic Gauze is an FDA cleared, next generation hemostatic gauze engineered to be effective in the management of mild, moderate, and severe bleeding. WoundClot® is also effective in the temporary management of severe bleeding during surgical procedures as well as postoperative and donor-site bleeding. WoundClot® is also a CE Class III Surgical Implantable device, for sizes up to 4" x 4" (10 cm x 10 cm).

MECHANISMS OF ACTION

When WoundClot®'s patented regenerated cellulosic structure contacts blood, it converts into a thick, tenacious, expanding gel, adhering to wound surfaces, creating pressure to effectively control bleeding.

- WoundClot® does not require the application of manual pressure to be effective.
- WoundClot® will absorb up to 2,500% its size and weight in fluid.
- WoundClot® remains actively absorbent for up to 24 hours.
- WoundClot®'s gel formation, enables the concentration of platelets, red blood cells, and clotting factors, creating an environment conducive to clotting.
- WoundClot® affects the coagulation process by transforming Plasma Thromboplastin Antecedent (PTA) (XI) and Hageman (XII) factors from inactive to active (XIIa).
- WoundClot® has a high safety profile and is hypoallergenic and non-reactive in humans. WoundClot® can be used anywhere on the body and requires little to no training to utilize effectively.
- WoundClot® can be easily removed without causing rebleeding.

Introduction

//ORTHOPAEDIC UTILIZATION OF WOUNDCLOT®

TOTAL KNEE AND TOTAL HIP REPLACEMENTS ARE TYPES OF TOTAL JOINT ARTHROPLASTY SURGERY. ARTIFICIAL JOINT IMPLANTS REPLACE THE ACTUAL DAMAGED KNEE OR HIP.

Marked degenerative arthritic changes in the knee or hip, typically associated with impaired function and progressive pain, tend to mark a patient as an appropriate candidate for total joint arthroplasty.

The usual age range for total knee replacement is between 50 and 80. The average age for a total hip arthroplasty is 65.4; for a knee, 66.4. 87 percent of knee replacements are done for osteoarthritis. 70 percent of hips are replaced due to osteoarthritis, with 10 percent for femoral neck fractures.[1]

Despite its risks and potential complications, which will be outlined below, the procedure remains popular due to the endurance of modern prostheses. In 2015 alone, in the United States, nearly 58,000 primary hip replacement and 88,000 knee replacement surgeries were performed, along with 6,700 hip revisions and 9,100 knee revisions. These numbers are doubled from 2013.[1] Each total knee replacement is performed at an approximate cost of $20,000.[2]

This data underscores the large number of Americans who have benefited from these procedures. Given the success of total hip and knee replacement in improving function and quality of life of individuals with severe arthritis, this number is projected to grow substantially in the next few years, based on the aging of the "baby boomers", an increasing proportion of obese population, increased rates of advanced arthritis treatment, and a high demand for increased mobility and improved quality of life. Joint replacement will be the most common elective surgical procedure in the coming decades.[3,4] The number is expected to increase five-fold by 2030.[4,5]

Notwithstanding the potential benefits, total joint arthroplasty involves many risks. Surgical risk is not only based on the complexity of the procedure, but is directly affected by the patient's clinical condition. This is particularly accentuated in the elderly, which comprise the majority of knee and hip arthroplasty patients. With advanced age, there is often increased severity of the condition requiring surgery, coexisting diseases, and reduction in the individual's functional state. [6] For example, given that more than 90% of patients with hip fracture are older than 65, most do have preexisting medical comorbidities. Despite surgical and medical advances, the morbidity and mortality associated with hip fractures remain elevated.[7] There is greater mortality during the first post-operative week. Deaths on the first day tend to be associated with problems from the surgical procedure itself, whereas those during the first week are more often related to clinical complications from the surgery (embolism, infarction, pneumonia, et cetera).[6]

Some of the most common complications of total knee arthroplasty include: Periprosthetic infection, polyethylene wear, osteolysis, aseptic loosening, instability or dislocation (requiring revision surgery), periprosthetic fracture, patellar fracture and extensor mechanism rupture.[8]

One serious complication of total joint arthroplastic surgery is the development of deep vein thromboses (DVT). Blood clots (thrombi) can form in any of the deep veins of the leg, i.e., the calf veins, femoral vein or popliteal vein, or even the deep veins of the pelvis.[9] While the risk following any general surgery is 15-40%, [10] there is a noteworthy rise in risk after total hip or knee procedures reported to be between 46% and 84%.[10] Orthopedic patients are more vulnerable to DVT due to the involvement of several prothrombic processes: coagulation activation from tissue and bone injury,

venous injuries, heat generated due to cement polymerization, intra-or post-surgery reduction in venous emptying, and immobilization.[11] Perioperative thrombotic complications are a major cause of morbidity and mortality.[12] A major preventive treatment is anticoagulant administration.[12]

The significant risk posed by DVT must be considered against the competing risk of peri- and post-operative bleeding or hemorrhage.[6,12] There is a delicate balance between thrombotic and bleeding events in the perioperative period following orthopedic surgery. [12]

Extensive soft tissue dissection with vascular transection along with multiple bone cuts and drilling result in characteristically substantial bleeding.[13] The risk of this bleeding is greater in patients with coagulopathy issues (generally due to deficiencies of coagulation factors), low platelet counts or use of drugs that interfere with the aggregation of platelets. Therefore, use of medications such as aspirin, dipyridamole, ticlopidine and clopidogrel should be suspended for at least a week prior to this elective surgery.[5]

Hemotherapy is frequently used in orthopedic surgery, either to prepare for the surgical procedure, or during or after it. This is because of the large quantities of blood that are lost due to bone trauma and the difficulties of achieving hemostasis in osseous tissue.

However, it is increasingly acknowledged that red blood cell infusion leads to diminished post-surgical immunity, thus making the patient more susceptible to infection. Additionally, infection rates are higher among patients who received transfusions.[5]

Oberweis et al.[12], found that surgical procedure type, cancer, coronary artery disease and chronic obstructive pulmonary disease were all independent predictors of major bleeding. Subjects with a major bleeding event had a significantly longer length of hospital stay versus those without a major bleeding event.

In a study of 101 total knee replacements, Sehat et al.[3] found a mean total loss of approximately 1500 ml, plus a substantial hidden loss of 765 ml, mainly due to bleeding into the tissues and residual blood in the joint.

Prasad et al.[13] found significantly more perioperative blood loss in male patients than in females. Tourniquet time and duration of surgery both demonstrated a positive correlation with perioperative blood loss. BMI did not show any correlation with perioperative blood loss.

Bleeding, if not controlled, will lead to anemia, and it is known that patients with anemia have a notably higher risk of surgical complications and death.[5]

The prevalence of perioperative anemia, due to intraoperative bleeding, ranges from 24-44%; it is a strong negative prognostic indicator, as it is usually associated with underlying comorbid conditions and decreased physiologic reserve. Severe anemia (Hb < 8 mg/dL) is associated with increased postoperative mortality and poor functional recovery.[6]

Due to the typical extensive bleeding in total knee or total hip replacement surgery, a drain is standardly inserted in order to drain out the postoperative blood; evidence has supported the use of a surgical drain with respect to decreasing dressing changes, ecchymosis and hematoma formation.[14] Hematoma can retard rehabilitation, reduce range of motion, and result in painful aching and even infection.

Temporary drain clamping is one of several methods devised to reduce bleeding after surgery. The drain is clamped for several hours after surgery to form a tamponade before opening. It has been observed that intermittent

clamping was associated with less blood loss than conventional drainage. Temporary clamping allows for the establishment of an interim tamponade effect, reducing blood loss. The most critical time zone for forming the tamponade is approximately 3–4 hours post-operation, when most bleeding occurs. There is no consensus regarding optimal clamping time following the surgery.[15]

However, if clamping is applied for too long, bleeding cannot be removed after tamponade formation. The clamping then becomes a cause for blood accumulation, leading to hematoma formation and pain. When the pressure of the hematoma increases, the accumulated blood can infiltrate into the tissues surrounding the knee joint. Edema formation in the periphery of the knee joint induces further pain.[15]

Yet, if the clamping is removed too soon, the tamponade cannot form, and reduction of bleeding is not achieved. Drainage also carries a risk of increasing bleeding when removing the tamponade and thus providing a subsequent route of infection.[15]

A patient with a drained wound is also more likely to require blood transfusion.[16] With major perioperative blood loss, blood transfusion is commonly required.[17] Nearly one-third of total knee patients postoperatively need one to three units of blood.[16] Chen et al found that 38% of patients required perioperative allogenic transfusion.[7] Prasad et al found that the incidence of blood transfusion was significantly higher in patients with rheumatoid knees as their pre-operative hemoglobin value was low.[13]

Blood transfusion is associated with serious complications, including infection, transfusion-related reactions and fluid overload.[4] 20% of all transfusions result in some adverse effect. A major concern is HIV transmission, occurring in 1-2% of transfusions. There are also many transfusion complications with allogenic blood, with a reported mortality rate for mismatched transfusions of approximately 10%, due to shock, renal failure and bleeding.[13] Transmission of infectious diseases and increased likelihood of postoperative infection also should be considered. More serious complications such as multiple organ failure and death can occur.[17] Even autologous transfusion is not risk-free, as the patients tend to be older and less healthy, increasing the potential for complications during donation, including bacteremia and decreased hemoglobin levels post-operatively, as well as potential wastage of blood and unnecessary expenses.[13] Additionally, there is significant increase in length of hospitalization for these patients, adding to already substantial costs.[4]

Due to growing concern regarding the risks of transfusion, the preservation of blood during orthopaedic procedures is important; paramount is the reduction of blood loss during and after the surgery.[16] 10% of hospital readmissions following total knee arthroplasty are for bleeding.[8]

WoundClot® has been used over the past two years for a variety of applications in the Department of Orthopedics A at Galilee Medical Center in Nahariya, Israel, including total hip and total knee replacement surgery, periprosthetic fracture repair, as well as for various types of war trauma that have become a recent hallmark of the hospital.

WoundClot® Surgical gauze is a Class III bio-absorbable non-compressional hemostatic dressing. When it comes in contact with blood, a gel is formed which is designed to absorb bleeding without breaking down. The liquid absorption capability of WoundClot® is over 2500% of its own weight.

This ability to absorb and maintain a stable membrane allows for the pooling

of active coagulation factors in significant quantities to be sequestered in the membrane. The coagulation factors attach to the surface tissue and the membrane in the presence of a unique molecular group incorporated into the product. This dramatically reduces the flow of blood from the wound. In turn, this process also increases adherence of the membrane to the tissue, ensuring its stability on the wound site.

Once the platelets interact with WoundClot®, this initiates the intrinsic clotting pathway. WoundClot® affects the coagulation process by transforming Hageman factor (XII) from inactive to active (XIIa), and activating Plasma Thromboplastin Antecedent (XI) for a longer duration when compared to other common hemostats.

Herein are presented 3 orthopedic medical procedures performed by Dr. Shtarker* at Galilee Medical Center utilizing WoundClot®:

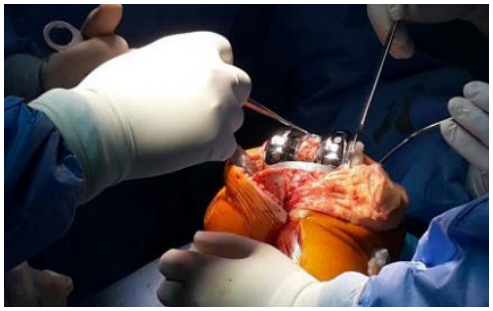
Case 01

//TOTAL KNEE REPLACEMENT

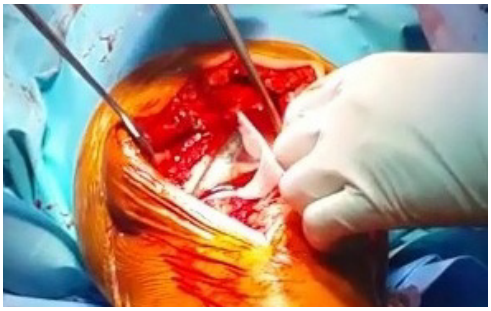
A 64-year-old construction company superintendent complained of severe pain in his right knee that limited function and caused sleep problems. Radiographs demonstrated markedly advanced right knee osteoarthritis. Nonoperative modalities such as activity modification, ambulatory aids, injections, ibuprofen and Tylenol had failed to ease his discomfort. He then underwent total knee arthroplasty.

At surgery, following the insertion and cementing of the prosthetic distal femur and proximal tibia (Figure 1A), 2 packages of 5 cm x 5 cm gauze were placed behind the tibial component of the prosthesis in order to prevent the typical oozing from the posterior capsule (Figure 1B). The WoundClot® was left in situ due to its bioabsorbability. With WoundClot®, no drainage was needed.

Following surgery, the patient had excellent range of motion and walking ability by the second postoperative day. After two nights in the hospital, the patient was discharged home with outpatient physical therapy, and continued to progress with his recovery over the subsequent months.



A. *Note the metallic femoral condyles articulating with metallic tibial plateau.*



B. *Insertion of WoundClot® gauze laterally, posterior to superior tibia (tibial plateau prosthesis).*

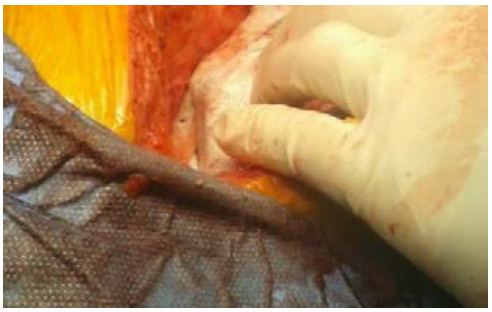
Case 02

//TOTAL HIP REPLACEMENT REVISION Transfusion declined

A 78-year-old woman underwent surgery for revision of a previous total hip replacement. Her femoral diaphysis had fractured and required repair, along with the proximal femoral prosthesis replacement. She had virtually no remaining acetabulum, which had to be rebuilt. The femur fracture was repaired with metal cable, and a new prosthesis was implanted. Six sheets of WoundClot® Surgical (10 cm x 10 cm) were used to reduce surgical and post-surgical bleeding. The case was especially noteworthy with respect to WoundClot® as the patient was a Jehovah's Witness, and refuses blood transfusions on religious grounds.

A. *Initial insertion of sections of WoundClot® into wound.*

B. *Retraction of soft tissue to permit accurate placement of product.*



C. *Manual smoothing of gauze onto surgical site.*

D. *Manual smoothing of gauze onto surgical site.*

E. *WoundClot® gauze in situ, with site ready for suturing.*

Case 03

//SOFT TISSUE TRAUMATIC INJURY

An obese, uncompensated diabetic man in his late 50's suffered a severe crush injury to his upper right thigh when he was run over by a motor vehicle. He sustained no fractures, but rather major soft tissue injury, primarily to the medial and posterior aspects of his thigh and the inguinal region. A fairly large area of exposure resulted, 30-40 cm, with severe bleeding from surrounding tissue.

In the operating room, initial surgical debridement was done, along with primary hemostasis using electric cauterization. There was still marked diffuse bleeding from the crushed muscle and subcutaneous fat. 5-6 large strips of WoundClot® Surgical (10 cm x 10 cm) were laid upon the exposed soft tissue prior to skin closure (Figure 3); hemostatic drainage was initiated. The WoundClot® was left inside. WoundClot®, as a primary therapy, proved to be a definitive stop bleed treatment for this patient.

Following successful plastic surgery, no complications whatsoever were reported. No infection ensued, no skin necrosis and, significantly, no transfusion was required.

A. *Gaping open wound of anterior thigh offered severe bleeding.*

B. *First large sheet of WoundClot® gauze being placed into wound site.*

Discussion

The cumulative experience gained using WoundClot® Hemostatic Gauze in orthopedic surgery reveals advantages in many aspects related to the surgical procedures, patient comfort and healing, and even cost benefits.

Simplicity of use is only one of the features and advantages of WoundClot®. The surgeon places the WoundClot® gauze on the wet wound surface without any need for further compression on the injured tissues. The product immediately begins to absorb blood as it converts to a gel consistency. The stability of the gel amplifies its enhanced blood coagulation capabilities resulting in the rapid formation of a natural and stable clot. Due to the bioabsorbable nature of the product, it can be left in the body, where it is resorbed during healing. The wound can then be stitched closed.

Patient comfort and his/her clinical post-operative state are major factors to consider when utilizing medical devices. Prior to WoundClot®, the surgeons would have to use hemovac drainage, often collecting half a liter of blood. With WoundClot®, however, the standard care protocol has been changed and drainage is no longer required. By eliminating the need for drainage, the orthopedic department of the Galilee Medical Center has markedly improved patient healing and comfort, reduced costs and most importantly, significantly reduced or eliminated the risks and complications described earlier.

Additionally, due to its prolonged gel stability and hemostatic performance, WoundClot® has eliminated or reduced the need for blood product transfusion, along with its inherent risks. In orthopaedic surgery, patients who have received allogenic blood have a 1.5- to 3.5-fold increased risk for perioperative major infection. This includes wound infection, pneumonia, sepsis, and urinary tract infection. In hip or knee replacement surgery, if an infection develops, there can be serious consequences: prolonged hospital stays, removal of the artificial joint, and the possibility of permanent damage to patient mobility. Other risks of transfusion include unknown long-term effects on the patient's immune system, human error (transfusing incompatible or tainted blood products) and transfusion-related acute lung injury. By reducing or even eliminating the need for transfusion, WoundClot® significantly reduces potential patient morbidity and mortality.

Dr. Shtarker summarizes his ongoing surgical experience with WoundClot® hemostat:

"WoundClot® has proven very effective, yielding us much better results since we started using it. I have found it much more effective than Surgicel and Surgicel Fibrillar. With respect to safety, we have encountered no issues, no side effects, no complaints or problems," observes Dr. Shtarker. "My department is very happy to be partnering with Core Scientific Creations in the development of further research into the benefits and clinical value of this exciting product here at Galilee Medical Center."

About

Dr. Haim Shtarker

Director of Dept. Orthopaedy A. and Pediatric Orthopaedics at Galilee Medical Center, Nahariya

Dr. Haim Shtarker is the Director of the Department of Orthopedics A and the Unit of Pediatric Orthopedics at Galilee Medical Center in Nahariya, Israel, a 700-bed teaching hospital affiliated with the Bar Ilan University Faculty of Medicine.

Dr. Shtarker attended medical school in Chelyabinsk, Russia; his residency in Orthopedic Surgery was completed at Galilee Medical Center. He was a Fellow in Pediatric Orthopedics at the Royal National Orthopaedic Institute in London, UK, and a Fellow in Pediatric Orthopedics and Orthopaedic Oncology at Dallas Medical City, Dallas, Texas. Dr. Shtarker served as President of the Israeli Pediatric Orthopaedic Society from 2010-2012.

He is the author of numerous peer-reviewed manuscripts and book chapters. Dr. Shtarker is a senior member of the Israeli Orthopaedic Board and currently serves as Treasurer of the Israeli Orthopaedic Association.

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