Autologous bone plugs in unilateral total knee arthroplasty.

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Autologous bone plugs in unilateral total knee arthroplasty

Nicole M Protzman, Nicholas J Buck[1], Carl B Weiss[1]

Abstract

Background: The purpose of this study was to compare blood loss, declines in hemoglobin (HgB) and hematocrit (HcT) levels, and required homologous transfusions for patients who either had the femoral intramedullary defect left open or filled with an autologous bone plug during total knee arthroplasty (TKA). We hereby present our results of autologous bone plugs in unilateral TKA.
Materials and Methods: A retrospective chart review was performed on 55 patients diagnosed with osteoarthritis (OA) who had undergone unilateral TKA. Twenty six patients had the femoral defect filled with an autologous bone plug and 29 did not. Lateral releases and patella replacements were not performed. Drained blood was reinfused when appropriate.
Results: Mean blood loss and mean blood reinfused were similar for the plugged (loss: 960.8 ± 417.3 ml; reinfused: 466.7 ± 435.9 mL) and unplugged groups (loss: 1065.9 ± 633.5 ml, $P = 0.38$; reinfused: 528.4 ± 464.8 ml, $P = 0.61$). Preoperative HgB (14.3 ± 1.4 g/dL, $P = 0.93$) and HcT levels (42.2 ± 4.6%, $P = 0.85$) were similar across plug conditions. HgB and HcT levels declined similarly for the plugged (2.7 ± 1.2 g/dl and 7.9 ± 4.0%) and unplugged groups (3.0 ± 0.9 g/dl, $P = 0.16$ and 9.0 ± 2.6%, $P = 0.16$), respectively. Of patients, one in the plugged group and none in the unplugged group required homologous transfusions ($P = 0.5$).
Conclusion: The autologous bone plug does not appear to reduce the need for homologous blood transfusions following unilateral TKA.

Key words: Blood loss, bone plug, hemoglobin, total knee arthroplasty, transfusions

Introduction

Total knee arthroplasty (TKA) is associated with substantial blood loss and blood transfusions.[1] Plugging the femoral canal during TKA has been suggested as a means of reducing blood loss and consequently, blood transfusions. However, conflicting results have been reported throughout the literature.[2-4] The purpose of the present study was to compare blood loss, declines in hemoglobin (HgB) and hematocrit (HcT) levels, and required homologous transfusions in patients who presented with osteoarthritis (OA) and either had the femoral intramedullary (IM) deficit left open or filled with an autologous bone plug during TKA. Based on previous studies, we hypothesized that postoperative blood loss would be lower for patients who received the bone plug,[3] postoperative reductions in HgB and HcT levels would decrease less for the plugged patients,[4] and the percentage of postoperative blood transfusions would be lower for the plugged group.[4]

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Materials and Methods

A retrospective chart review was performed to identify consecutive patients who presented with OA and were treated with a primary TKA between April 2008 and October 2011. The same senior surgeon performed all surgical operations (C.B.W.). The patients were separated in two groups. Patients treated before January 2010 underwent the TKA and did not receive the IM bone plug (unplugged), whereas patients treated after January 2010 underwent the TKA and received the IM bone plug (plugged). The confidentiality and privacy of individuals were ensured and maintained. Data were abstracted into a coded and secure database. The Western Institutional Review Board (WIRB) approved the protocol and waived the informed consent. According to the WIRB Regulatory Affairs Department, this research project met the conditions for exemption under 45 CFR 46.101(b×4).

Diagnosis at the time of the procedure was severe OA, which was unresponsive to conservative treatments for all patients. All nonsteroidal, antiinflammatory medications, including aspirin, were discontinued 5 days prior to surgery. Patients included in the analysis underwent TKA without lateral release or patellar replacement. The same protocol was used for each patient.

Operative procedure

The patients were operated under spinal epidural anaesthesia, and a tourniquet.

A midline skin incision was made through the skin and subcutaneous tissue. The extensor mechanism was carefully opened and retracted laterally. Soft tissues were gently elevated along the medial and lateral plateaus to allow for placement of retractors. No lateral retinacular releases were performed. Patella resurfacing was not performed. A distal femoral drill hole was made, and the IM alignment guide was inserted in the knee. The sizing guide and a 3° external rotation device were placed. To make notch cuts for the posterior stabilized component, a 4-in-1 femoral cutting guide was used. After the femoral component was completed, attention was turned to the tibia. The extramedullary guide was assembled and appropriate alignment was obtained. The femoral and tibial trials were placed. Full range of motion without evidence of varus or valgus instability was noted. Flexion and extension gaps were verified. Following cementation of the tibial and femoral trays, the polyethylene spacer was inserted. A standard cemented NexGen LPS-Flex Fixed Bearing Knee prosthesis (Zimmer, Warsaw, IN, USA) was used on all knees. Following copious irrigation, a ¼ inch hemovac was brought in through a separate stab wound in the proximal and lateral aspects of the knee. Subcutaneous tissue was closed with a 2-0 Vicryl. The skin incision was closed with staples. Continuous closed suction drainage was hooked up once the tourniquet was released. All hemovacs (Stryker, Kalamazoo, MI, USA) were discontinued 18-24 h postoperatively or as ordered by the physician. The foot of the bed was placed in the Trendelenburg position with 6 inch elevation. Deep vein thrombosis (DVT) prevention was achieved using thrombo-embolic deterrent stockings (Carolon, Rural Hall, NC, USA), foot pumps, and subcutaneous Fondaparinux. All patients received DVT prophylaxis in accordance with Coordinated Health's existing protocol. All patients received 2.5 mg of Fondaparinux subcutaneously every 24 h, which commenced within 6-8 h following surgery and was continued for 7-10 days. Each patient was educated by trained nursing staff to self administer subcutaneously injected medicines for home use. Written instructions were provided for prescribed thromboprophylaxis medications. Patients were instructed to report any abnormal bleeding. The protocol was identical for both groups of patients except that in the patients who underwent TKA after January 2010, an autologous bone plug was inserted into the femoral opening.

The same physician assistant (N.J.B.) was responsible for creating the bone plug for each plug patient. During the posterior stabilizing cut, a piece of bone was removed. This bone was rid of any excess tendon before being cut into the shape of an hour glass. Each hour glass was created slightly larger than the circumference of entry hole created by the IM alignment rod. This ensured proper closure of the femoral canal. The bone plug was inserted into the femoral medullary opening of the femur.

The Stryker CBC II Blood Conservation System (Stryker, Kalamazoo, MI, USA) is a closed system used postoperatively to collect, filter, and reinfuse wound blood. There is a fat retention valve designed to filter lipid particles from salvaged blood. The system was connected to the wound drain for 24 h or as ordered by the physician. Trained nursing staff performed the reinfusion after 4 h of blood collection or if there was 400 ml of blood in the canister. Every four hours, blood was reinfused until there was less than 200 ml of blood in the canister. As per the guidelines of the American Association of Blood Banks, the total blood reinfused did not exceed 1700 ml of blood. Following removal of the Stryker pump, a Jackson Pratt drain was hooked up and utilized. Drains were removed 24 h postoperatively.

Criteria for blood transfusion were independent of the postoperative day. Reportedly, a patient can become symptomatically anemic when HgB levels drop below 10 g/dL. Symptoms include, but are not limited to tachycardia, hypotension, orthostatic hypotension, dizziness, weakness, a change in mental status, and shortness of breath.[5] If the patient presented with symptomatic anemia, which was interfering with normal function, blood was transfused.[6] The doctor used sound clinical judgment to assess whether a blood transfusion was necessary.[7]

Intraoperative blood loss, postoperative drainage, the quantity of reinfused blood, and the total volume of packed red blood cells that each patient received were recorded. HgB and HcT values were recorded preoperatively and postoperatively at 6:00 am on the first, second, and third days. Required transfusions and volume of packed red blood cells received were recorded on each postoperative day.

Patient demographics were compared with the plugged and unplugged groups. The Fisher exact test was used to compare the number of males and females as well as the number of right and left operative limbs across the plug conditions. Age and body mass index were compared across the plug conditions using unpaired *t*-tests. The independent variables were plug-usage (plugged and unplugged) and day (preoperative, day of surgery, and postoperative days 1, 2, and 3). The dependent variables were mean surgical duration, blood loss, blood reinfused, and declines in HgB and HcT levels from preoperative levels. Missing values were replaced with the series mean when appropriate. Two-factor ANOVAs (plug-condition, day) with repeated measures on day were used to compare blood loss and declines in HgB and HcT levels. When appropriate, paired and unpaired *t*-tests with Bonferroni corrections were used as posthoc tests of differences among pairs of means. The Fisher exact test was used to compare the number of required reinfusions and transfusions across the plug conditions. The significance level for all statistical tests was set at $P = 0.05$. Data are reported as means ± SD (standard deviation) within the text and means ± SE (standard error) within figures.

Results

Fifty five consecutive adults (68.5 ± 10.9 years; 32 men) were included in the study. The initial 29 patients (July 2008 to October 2009) comprised the unplugged group, and the latter 26 patients (February 2010 to October 2011) comprised the plugged group. Patient demographics were similar across the two groups ($P \geq 0.21$) [Table 1].

The duration of the surgery was similar for the plugged (60.8 ± 6.6 min) and unplugged groups (65.3 ± 12.4 min, $P = 0.1$). Mean blood loss was similar for the plugged (960.8±417.3 mL) and unplugged groups (1065.9±633.5 ml, $P = 0.38$) [Figure 1]. A main effect of day was found for blood loss ($P < 0.001$). Significantly, more blood loss occurred on the day of surgery (882.7 ± 423.9 ml) compared with the following postoperative day (121.7 ± 249.2 ml, $P < 0.001$). There was no significant day-by-plug interaction ($P = 0.81$). There was a similar number of patients in the plugged ($n = 17$) and unplugged groups ($n = 22$, $P = 0.2$) that received blood reinfusions. The mean quantity of blood reinfused was also similar for the plugged (466.7 ± 435.9 ml) and unplugged groups (528.4 ± 464.8 ml, $P = 0.61$) [Figure 2]. Preoperative HgB levels were similar for the plugged (14.3 ± 1.8 g/dl) and unplugged groups (14.3 ± 1.1 g/dl, $P = 0.93$). A main effect of day indicated

Table 1: Patient demographics

Measurement	Plugged	Unplugged	*P* value*
Number of subjects	26	29	NA
Age (years)	68±11	69±11	0.64
Gender (male/female)	15/11	17/12	0.2
Operative limb (left/right)	14/12	16/13	0.2
Body mass index (kg/m^2)	32±4	31 ± 5	0.35

Means ± SD. *$P<0.05$ compared across conditions

that the decline in HgB levels increased over time ($P < 0.001$) [Figure 3]. The decline in HgB levels was similar for the plugged (2.7 ± 1.2 g/dl) and unplugged groups (3.0 ± 0.9 g/dl, $P = 0.16$). There was no day-by-plug interaction for the decline in HgB levels, indicating that the decline in HgB was similar for the plugged and unplugged groups across days (plugged groups × day, $P = 0.52$). Preoperative HcT levels were similar for the plugged (42.0 ± 6.0%) and unplugged patients (42.3 ± 2.9%, $P = 0.85$). A main effect of day indicated that the decline in HcT levels increased over time ($P < 0.001$) [Figure 4]. The decline in HcT levels was similar for the plugged (7.9 ± 4.0%) and unplugged groups (9.0 ± 2.6%, $P = 0.16$). There was no day-by-plug interaction for the decline in HcT level, indicating that the decline in HcT was similar for the plugged and unplugged groups across days (plugged groups × day, $P = 0.91$). The total number of blood transfusions was similar for the plugged (1) and unplugged groups (0, $P = 0.5$).

Discussion

TKA is associated with appreciable blood loss. During TKA, IM rods cause damage to cancellous bone and IM vasculature.[8,9] Ruptured vessels bleed into the medullary canal. Through the communication created by the alignment rod, blood can then flow from the medullary

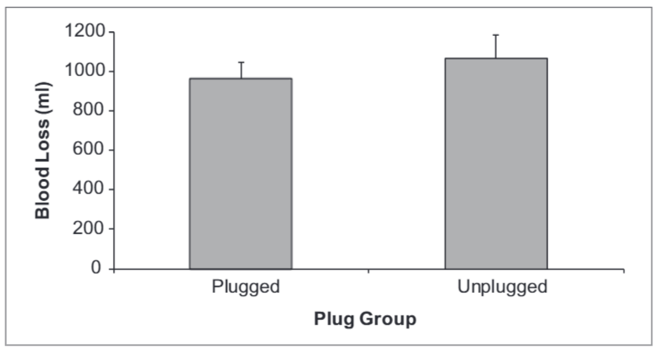

Figure 1: Bar diagram showing blood loss. The mean blood loss for the plugged and unplugged groups had no significant difference

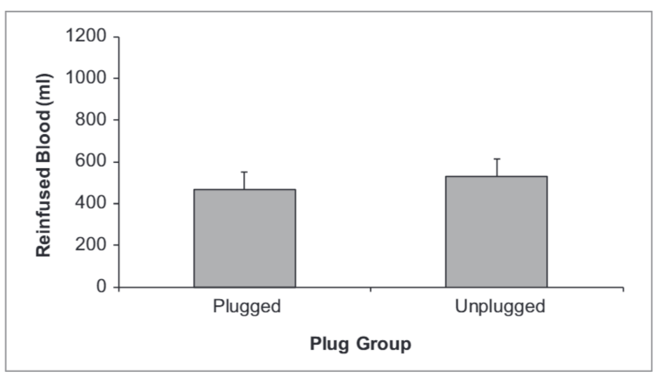

Figure 2: Bar diagram showing reinfused blood. The mean quantity of blood reinfused had no significant difference for the plugged and unplugged groups

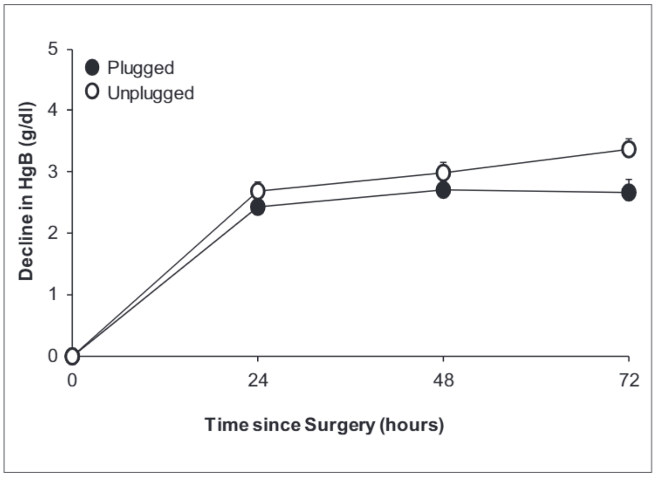

Figure 3: A line graph showing the decline in HgB. The decline in HgB levels increased over time and for the plugged and unplugged groups had no significant difference

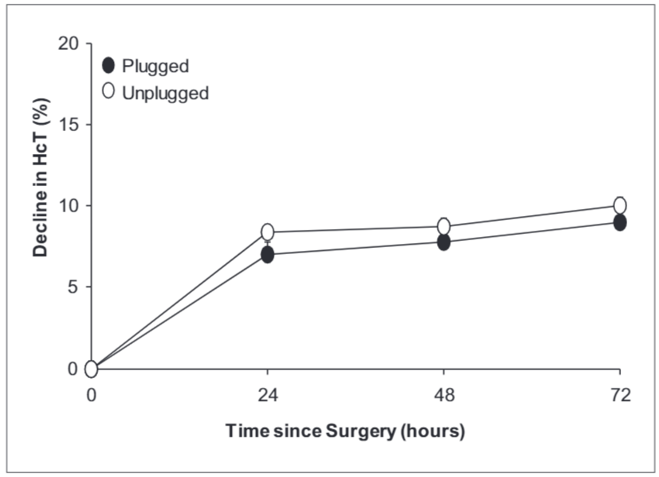

Figure 4: A line graph showing the decline in HcT. The decline in HcT levels increased over time and had no significant difference for the plugged and unplugged groups

canal into the joint cavity, potentially increasing blood loss. Substantial bleeding may lead to more red blood cell transfusions.[1] Reportedly, 39% of patients require blood transfusions. Besides being an expensive and sometimes scarce resource, homologous blood transfusions carry small, but significant health risks, such as immunosuppression and disease transmission.[1,10] Given the associated complications, various methods have been employed to reduce blood loss.

Closing the femoral defect with cement[2] or autologous bone[3,4] has the potential to prevent bleeding from the inside of the femoral shaft, and thus, decrease the need for postoperative transfusions. It has been shown that the addition of the bone plug reduces blood loss[2,3] and required allogenic blood transfusions.[4] Although previous studies have investigated whether plugging the femoral IM hole during TKA influences the need for postoperative blood transfusion, conflicting results have been reported.[3,4]

Kumar *et al*.[3] inserted an autologous bone plug in the femoral defect during TKA to compare the blood loss and transfusion requirements with and without the plug. Adhering to previous protocol,[10] patients who were diagnosed with OA and rheumatoid arthritis were included, and surgical releases were performed on an as-needed basis. As was shown when the IM canal was filled with an acrylic cement plug,[2] the autologous bone plug reduced overall blood loss.[3] However, blood transfusions were unaffected. In a subsequent study by Ko *et al*.,[4] more restrictive inclusion and exclusion criteria were implemented. Only patients diagnosed with OA were included, and lateral releases were not performed. Conversely, there was a similar amount of blood loss for the plugged and unplugged conditions. However, the unplugged group required a greater percentage of blood transfusions.[4] Interpretation of these findings is difficult because of the differing inclusion and exclusion criteria.[3,4] For this reason, we sought to determine whether or not a bone plug inserted into the IM canal decreases blood loss, declines in HgB and HcT levels, and required postoperative homologous blood transfusions.

As opposed to previous studies,[2,3] the present study found that blood loss was similar for the plugged and unplugged patients. Inclusion and exclusion criteria, however, were specific to patients diagnosed with OA, and surgical releases were not performed. By restricting the inclusion criteria to patients diagnosed with OA and excluding patients requiring surgical release and patellar resurfacing, the heterogeneity of the patient population was reduced, and the variability in blood loss was decreased. This study confirmed that insertion of an autologous bone plug into the femoral canal during TKA does not influence postoperative blood loss.[4]

Blood transfusion requirements are not typically dictated by total blood loss, but rather by a drop in HgB level. Drainage output fails to address extravasation of blood into tissues, residual blood, and hemolysis.[11,12] Consequently, drainage output only accounts for one-third of the total blood loss.[13] In the present study, the decrease in HgB and HcT and the number of required blood transfusions were similar across plug conditions. In fact, only 1 of our 55 patients (1.8%) required a homologous blood transfusion. This contradicted the findings of Ko *et al*.[4] who found a larger decline in HgB levels and a greater percentage of blood transfusions for patients who did not receive a bone plug. These controversial findings may reflect differences in the measures implemented to reduce blood loss.

Several studies have shown that reinfusion of wound blood collected following TKA effectively treats blood loss and eliminates the transmission of infectious diseases.[14-19] For this reason, reinfusion of wound blood has become a standard of care. The approximate cost of the blood conservation system utilized at our institution is $750.00. However, previous studies did not reinfuse suction drainage.[3,4] In addition, our physician implemented additional intraoperative measures to reduce blood loss. Implants were fixated with cement,[20-24] and although controversial, the tourniquet was released after wound closure.[13,20,25-28] It appears as though the additional measures taken to reduce postoperative blood loss and required transfusions outweighed the influence of the bone plug.

Our study had several limitations. One of which was a small sample size. To fully evaluate the ability of the bone plug to reduce the need for postoperative blood transfusions, a greater sample of patients requiring blood transfusions following TKA is necessary. Second, the study was designed as a retrospective chart review. Nevertheless, the study controlled for external influences. The surgeon, surgical technique, and prosthesis for both groups were identical. Addtionally, the groups were not randomized. To fully evaluate the method of plugging the femoral defect, a prospective, randomized study with a larger sample of patients requiring transfusion should be conducted. In a procedure, such as bilateral TKA, which has been shown to result in greater blood loss and require more transfusions,[17] differences across the plugged and unplugged patients may be amplified. If so, the bone plug may be effective in reducing transfusion requirements following bilateral TKA. Additional research is necessary to investigate the usefulness of inserting the bone plug within the femoral canal during bilateral TKA.

In conclusion, the autologous bone plug has the potential to offer a cost-effective, safe, and efficient means of reducing the requirement for blood transfusions. However, our results showed similar reductions in HgB and HcT levels as well as a similar percentage of blood transfusions for the plugged and unplugged patients following unilateral TKA. Even though the differences were not significant, the unplugged patients lost slightly more blood and had greater reductions in HgB and HcT levels.

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