

Bone wax reduces blood loss in unicompartmental knee arthroplasty for osteoarthritis

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Research Article

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Abstract

Background: Unicompartmental knee arthroplasty (UKA) offer less trauma, faster recovery in the treatment of osteoarthritis of knee. Bone oozing in UKA may result in hematoma and complications after operation.

Methods: Visible blood loss and total blood loss were evaluated. Hb level of the patient postoperation was recorded. Circumference of knee was measured after operation. Visual analog scale (VAS) score were used and severe pain rate was calculated. Other complication such as wound healing, hemoarthrosis, infection, deep vein thrombosis (DVT), and transfusion were recorded.

Results: Bone wax group had less total blood loss (215.55.3±50.6 ml in group A, 236.74±48.5ml in group B; P = 0.023) The mean circumference of knee increased 2.73cm (range 1.5-4.1cm) in group B and 1.65cm (range 1.2-3.4cm) in group A at 3 days postoperation and the difference was significant (p<0.001). The rate of severe pain occurred was significantly lower in group A than in group B (8.6% vs 22.4% p=0.040). Patients in bone wax group were more satisfied with UKA (89.7% in group A, 74.1% in group B p=0.030). There was no infection occurred and blood transfusion was not performed in any patient. 2 patients in group A and 7 patients in group B underwent knee cavity aspiration due to hemoarthrosis. There was 1 patient experienced delayed wound healing in both groups and 1 DVT in group B.

Conclusion: Use of bone wax can reduce blood loss in UKA, and it do not increase the rate complications at short-term follow-up. More degradable bone waxes with good biocompatibility should be further investigated.

Introduction

Osteoarthritis of knee which is caused by cartilage degeneration lead to knee pain, mobility impairment of knee, and reduced quality of life in the elderly [1]. Arthroplasty is a common treatment for severe osteoarthritis, including total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA). Medial compartment of the knee is more frequently affected in patients with osteoarthritis and thus medial UKA is alternative surgical methods in most of osteoarthritis [2, 3]. Compared with TKA, UKA offer less trauma, faster recovery, and better preservation of physiological structure and function. Simultaneously, bone stock preservation and good survivorship facilitates the possible future revision surgery.

Although it is less incisive in UKA, postoperative oozing may cause hematoma, lead to complications such as knee pain, delayed wound healing, and infection. Therefore, hemostasis is very important and should be paid attention to in surgical procedure. It is easier to stop bleeding with electrocautery in soft tissue. However, removal of osteophytes and open of femoral medullary cavity during the operation may cause bone oozing, which is difficult to stop bleeding, thus may result in hematoma postoperation [4].

Bone wax, which is largely composed of beeswax, is recommended to be widely used in hemostasis of bleeding bone. Local application of bone wax results in the mechanical occlusion of medullary spaces in cancellous bone, blocking vessels in the transected bone and allowing clotting [5]. However, the use of bone wax is still controversial because of possible complications [6-8].

It is reported that the use of bone wax significantly reduced blood loss, preserved Hb levels, and decreased the risk of transfusion in TKA [9]. As far as we know, there was no literature report on the effect of using bone wax for UKA. Therefore, this study was designed to determine the hemostatic effect and safety of bone wax applied in UKA.

Patients And Methods

Study design and patients

The prospective case control single center study was conducted at Affiliated Hospital of Xuzhou Medical University, approval by the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University. Informed consent was obtained from all patients.

This study was conducted in compliance with the principles of the Declaration of Helsinki. We analyzed 116 patients with medial knee osteoarthritis who underwent UKA in the period between April 2020 and April 2021 to analyze the effect of bone wax in reducing blood loss following UKA. Patients were randomly subdivided into two groups: bone wax applied group (group A) and control group without using bone wax (group B). There were 58 patients in both groups. All patients had knee pain, which did not improve after conservative treatment for more than 3 months. Physical examination and radiographs were performed to confirm the diagnosis of medial osteoarthritis of knee. Magnetic resonance imaging (MRI) was also prescribed to assess the degree of cartilage degeneration in lateral compartment and the integrity of cruciate ligament. Patients with serious liver, heart or renal disease, poorly controlled hypertension, coagulation dysfunction, bilateral UKA, or revision UKA were excluded [10].

Surgical and perioperative management

The cemented mobile Oxford medial UKA was used in all patients. The same standard surgical procedures were applied in both groups and the operations were performed by the same surgical team, specialized in knee arthroplasty. Tranexamic acid (1g) was administered intravenously 15 min preoperation. Tourniquet was applied in all patients. In the group A, after the implantation of the prosthesis, the bone wax was applied to the bone oozing site of osteotomy surfaces, nail holes and the opening of the femoral medullary cavity that were not covered by the prosthesis or cement. Bone wax was not applied in the group B. Drainage was not applied in both groups. Compression bandage and ice of the surgical site for 24 hours postoperation were applied. Low molecular-weight heparin was used 12 h after surgery. Patients were encouraged to start early weight-bearing on the second day with the help of a walker. Oral celecoxib (0.2g/d) was routinely applied postoperation.

Blood loss

Visible blood loss and total blood loss were evaluated. Visible blood loss was assessed by measuring the blood loss during operation and the increase in the weight of the dressings. [11]

Total blood loss was calculated with formula reported previously according to weight, height, and the change of hematocrit [12, 13]. Hb level of the patient preoperation and 3 days postoperation were recorded. Homologous blood transfusion was not performed unless the hemoglobin level <70 g/L or symptoms of anemia presented

Swelling of the knee

Swelling of the knee was assessed. Circumference 1 cm proximal to the base of the patella of the extended knee was measured with the patient in supine position to monitor articular effusion on 6h, 12h, 1d, 3d, 6d postoperation [14]

Severe pain rate

Visual analog scale (VAS) score were used and the pain levels were divided into four categories to evaluate the pain, (0: no pain, 1-3: mild pain, 4-6: moderate pain, and 7-10: severe pain). The rate of severe pain was calculated in both groups.

Patient satisfaction

To evaluate patient satisfaction, all patients were asked questions to determine their overall satisfaction with the pain and function of their operated knee at discharge. And the result was classified as five-level scale: "very satisfied", "satisfied", "neutral", "dissatisfied", or "very dissatisfied".

Other complications

The occurrence of other complications was also recorded. Both groups were monitored for wound healing, hemoarthrosis, infection, deep vein thrombosis (DVT), transfusion, and any other complications.

Statistics

Measurement data such as blood loss, Hb level and circumference of knee were expressed as ($\bar{x} \pm s$). Pain level and patient satisfaction are expressed as rate, and t-test and chi-square test are used for statistics. $P < 0.05$ indicates statistical significant difference. Statistical tests were performed using SPSS version 19 for Windows.

Results

Characteristics and preoperative baseline data of patients

133 patients were assessed and 17 Patients were excluded according to the exclusion criteria. Finally, 116 patients were enrolled in the study (Fig. 1). Patient characteristics were similar in the two groups (Table 1), The two study groups were comparable regarding gender, age, body mass index (BMI), operation time, pain scores, Hb levels and Hct before surgery.

Table 1
Demographic data for study participants

	GroupA	GroupB	P value
Sex (male:female)	27/31	26/32	0.852
Age (years)	65.28 ± 7.81	66.22 ± 8.20	0.525
BMI (kg/m ²)	22.98 ± 2.16	23.08 ± 2.25	0.721
VAS	5.78 ± 1.26	5.93 ± 1.28	0.512
operation time	58.38 ± 9.00	56.53 ± 8.30	0.254
Preoperative Hb (g/L)	127.43 ± 7.99	126.83 ± 8.70	0.698
Preoperative Hct (%)	40.34 ± 2.33	40.61 ± 2.91	0.584

Postoperative blood loss assessment

Two groups had no significant difference with respect to either the mean postoperative HB (118.31 ± 7.68 g/L in group A, 117.43 ± 7.93 g/L in group B; P = 0.527) or the mean postoperative Hct (group A 35.24 ± 3.92, group B 34.72 ± 3.73 ml; P = 0.468). Visible blood loss were 107.14 ± 25.71 ml (group A), 109.41 ± 29.77 ml (group B) and had no significant difference. The differences were significant with respect to total blood loss (215.55.3 ± 50.6 ml in group A, 236.74 ± 48.5ml in group B; P = 0.023). (table.2)

Table 2
Comparison of blood loss in two groups

	GroupA	GroupB	P value
Postoperative Hb level (g/L)	118.31 ± 7.68	117.43 ± 7.93	0.545
Postoperative Hct (%)	35.24 ± 3.92	34.72 ± 3.73	0.468
Visible blood loss (ml)	107.14 ± 25.71	109.41 ± 29.77	0.660
Total blood loss (ml)	215.55.3 ± 50.6	236.74 ± 48.5	0.023

Swelling of the knee

The mean circumference of knee increased 2.73cm(range 1.5-4.1cm) in group B and 1.65cm (range 1.2-3.4cm)in group A at 3 days postoperation and the difference was significant($p < 0.001$).The difference was also significant at 24h and 6d in the two groups. While there was no significant differences in the two groups at 6h or 12h postsurgery (Fig. 2).

The rate of severe pain occurred and patients satisfaction

The rate of severe pain occurred was significantly lower in group A than in group B (8.6%vs 22.4% $p = 0.040$). When patients were discharged, Patients in bone wax group were more satisfied with UKA (89.7% in groupA, 74.1% in group B $p = 0.030$) (table.3).

Table.3. Severe pain rate and patients satisfaction

	Group A	Group B	<i>p</i> value
Severe pain rate (%)	8.6	22.4	0.040
Satisfied or very satisfied (%)	89.7	74.1	0.030

Other complications

There was no infection occurred and blood transfusion was not performed in any patient. 2 patients in group A and 7 patients in group B underwent knee cavity aspiration due to hemoarthrosis and severe pain that cannot be relieved by oral medications. There was 1 patient experienced delayed wound healingin both groups and 1 DVT in group B (Table.4).

Table.4 the number of complications in two groups

	Group A	Group B
hematoma aspirated	2	7
delayed wound healing	1	1
infection	0	0
blood transfusion	0	0
DVT	0	1

Discussion

As UKA is a minimally invasive procedure, Most of the intra-articular soft tissue structures such as synovium, joint capsule and ligaments are not damaged or removed[15]. There was no significant increase in postoperative intra-articular volume compared with TKA. However, bone oozing may persist

postoperatively, leading to postoperative hemorrhage in the joint cavity. Drainage was not commonly recommended to be applied in UKA in the previous studies [11]. Therefore, hemoarthrosis due to bleeding from the bone may cause increased pressure in the joint cavity, which can lead to severe pain and infection.

Preventing bone oozing may reduce the incidence of hemoarthrosis and thus reduce postoperative complications after UKA. Bone wax in the present study can prevent bone oozing and the result suggested lower total blood loss and hidden blood loss in group A. This finding is similar to previous studies on the use of bone wax in TKA. Shin, K. H. found the use of bone wax significantly reduced blood loss, decreased Hb levels, and the risk of transfusion in TKA [9]. Moo, I. H. reported that the application of bone wax in TKA was safe and effective for reducing total blood loss and maintaining higher hemoglobin levels [16].

The suprapatellar capsule is the largest space in the knee joint cavity, and the swelling of the suprapatellar capsule can reflect the degree of hemorrhage in the joint cavity. In our study, the circumference of knee increased significantly when bone wax was not applied, which suggested more hemoarthrosis occurred. Swelling and hemoarthrosis of knee may cause pain and limited motion in the knee.

As is known, pressure and inflammatory reactions are two important mechanisms caused pain[17]. Our result suggested the rate of severe pain occurred was higher when bone wax was not applied. This may be because high pressures in the joint cavity due to hemoarthrosis lead to severe pain that can not be relieved by oral celecoxib. Aspiration of hemoarthrosis was applied in 7 patients in group B and 2 patients in group A. Pain was relieved in all patients after knee cavity aspiration, which indicated that reducing joint cavity pressure can also reduce pain. Compared with TKA, due to less soft tissue damage, effusion is less likely to penetrate into the tissue space through the damaged soft tissue, thus accumulation of blood is more likely to cause increased pressure in the joint cavity. Therefore, we should pay more attention to hemoarthrosis in UKA.

Although shown to be advantageous in preventing bone oozing, the use of bone wax may cause complications[18, 19]. The use of bone wax on the fracture may have negative effects on bone healing [20]. Alhan, Cem reported that use of bone wax may be associated with increased postoperative sternal dehiscence after cardiac surgery and liberal use of bone wax should be restricted[6]. Foreign body reaction is another important complication that cannot be ignored. In a reported study, bone wax was used in the procedure of elevation of the tibial tubercle in 12 patients. Biopsy specimens of the tissues showed a foreign body giant cell reaction five to 13 months after the operation [21]. Solomon, L. B. found biopsy results showed foreign body-type chronic synovial inflammation in patients undergoing revision surgery whom had bone wax used at the time of original surgery [7].

The present study had short follow-up time and no histological finding to assess the safety of bone wax, so, foreign body reaction of the bone wax was unclear in this study. However, there was no infection or wound healing issues associated with bone wax occurred during the one-year follow-up in our study.

To avoid foreign body reactions, the authors recommend using a small amount of bone wax and removing excess bone wax during surgery. More degradable bone waxes with good biocompatibility should be further investigated[22].

Abbreviations

TKA: Total knee arthroplasty; UKA: Unicompartmental knee arthroplasty; DVT: Deep vein thrombosis, VAS: Visual analog scale;

Declarations

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Authors' contributions

Sifeng Shi did the study, analyzed the data, and wrote the manuscript.

Wenhai Lu and Guochun Zha participated in the operation process and analysis of the data. Qiang Lin participates in the study design and data analysis. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article, and the supplementary file. We do not wish to share the patients' raw data because of patient's privacy.

Ethics approval and consent to participate

This study was approved by the Ethic Committee of the Affiliated Hospital of Xuzhou Medical University. Informed consent was obtained from all patients all patients participate in the study

Consent for publication

Not applicable.

Competing interests

No competing interests.

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Figures

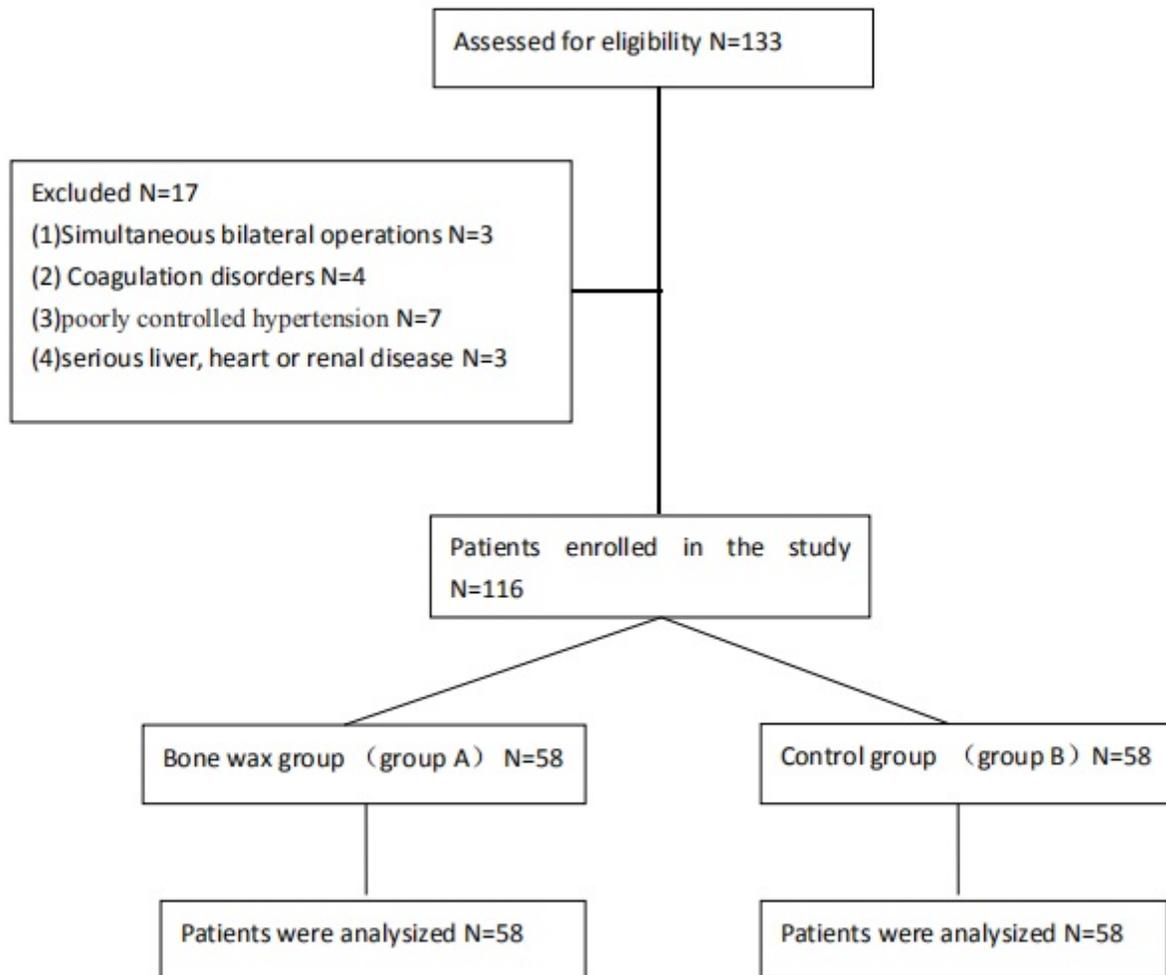


Figure 1

Flowchart of the prospective cohort study

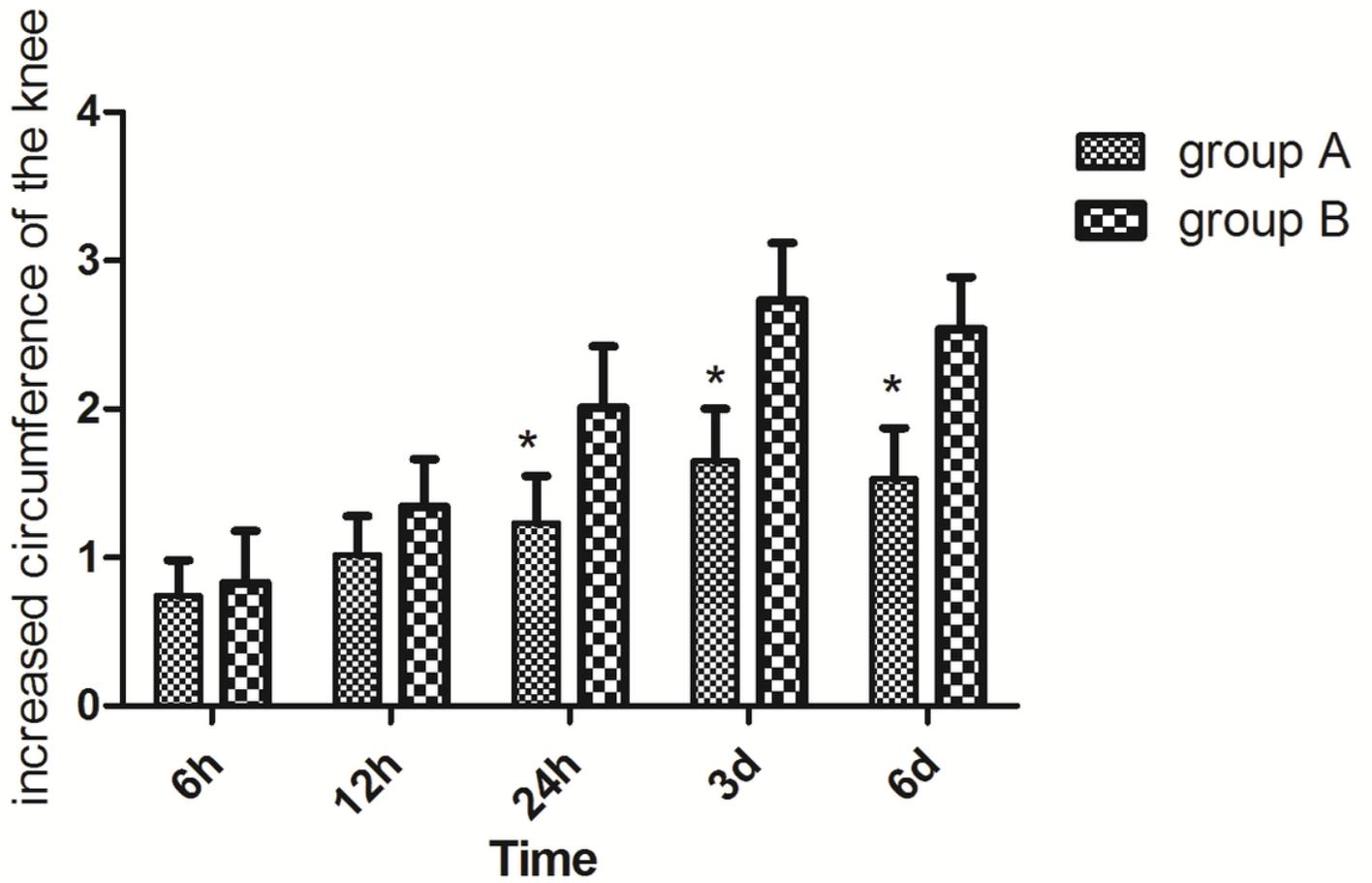


Figure 2

Postoperative increased knee circumference are presented as median and standard deviation * $p < 0.05$