

Bandaging technique after knee replacement

Charalambos Charalambides¹, Marilyn Beer¹, John Melhuish², Robert J Williams³ and Andrew G Cobb¹

¹Orthopaedic Department, Epsom General Hospital, Surrey, ²Cardiff University of Wales College of Medicine, Wound Healing Research Unit, Cardiff Medicentre, Health Park, Cardiff, ³University of Glamorgan, School of Electronics, Pontypridd, UK
Correspondence CC: charalambos.charalambides@whittington.nhs.uk
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Background Firm bandaging of the knee following knee replacement may prevent bleeding into the joint by a tamponade effect. We studied the pressure required to achieve tamponade, and then clinically compared the use of a compression bandage with the use of a standard crêpe bandage, with or without a drain.

Method Transducers were used to measure the pressure achieved on the surface of the knee under different bandages, and within the knee following release of the tourniquet. We prospectively compared 3 series of 50 patients each: (1) with compression bandaging from toes to mid-thigh, (2) with crêpe bandage from mid-calf to mid-thigh alone, or (3) with crêpe bandage and suction drain.

Results The pressure within the joint at which tamponade occurs is 52–62 mm Hg. The pressure on the skin under a properly applied compression bandage is between 28 and 32 mm Hg, and this controls bleeding within the joint. Patients treated with compression bandaging recovered more quickly from the operation, had a shorter hospital stay, and a greater range of flexion on discharge. They had no swelling of the limb, rarely suffered a tense hemarthrosis, and had fewer complications.

Interpretation The use of a compression bandage incorporating the foot and calf following knee replacement surgery, without the use of drains, confers specific advantages over the use of a crêpe bandage alone.

while at the same time avoiding the complication of venous obstruction. It should maintain this tension for as long as there is a likelihood of bleeding.

Setopress bandage is used for the treatment of patients with post-phlebotic syndrome and has been shown to maintain a pressure of 19–50 mm Hg for several days (product information). It meets the performance requirements of a type 3c compression bandage (high compression) as described in the British Standard (1995), and is capable of applying the levels of sustained compression required for the treatment of venous leg ulcers.

Using pressure transducers, Melhuish et al. (2000) demonstrated that sub-bandage pressure measurements ranged from 21 to 67 mm Hg and depend on the bandage tension applied, the number of layers, the surface hardness of the limb, and the radius of the surface being bandaged. The pressure achieved under compression bandages also varies with the bandage used and the experience of the person applying it (Williams et al. 1997). In the United Kingdom, most knee surgeons currently use a cotton crêpe bandage to wrap the knee following knee replacement, even though this has been shown to be ineffective in providing sustained compression (Barbenel and Sockalingham 1990).

We have studied the pressure produced under different types of bandage and the pressure which develops within the joint following knee replacement.

The ideal knee bandage should maintain an appropriate tension to control bleeding within the joint,

Patients and methods

We compared 3 series of 50 consecutive total knee replacement patients. The patients in the later two groups (B and C; see below) were already in the database of our orthopedic department. Our study was prospective and the patients were not randomized.

Intraarticular pressure

Following knee replacement surgery in 5 patients, a 3-mm diameter fenestrated drain tube was placed within the joint and a Setopress bandage (Seton, UK) applied from toes to mid thigh, over a layer of Velband wool (De Puy Johnson and Johnson, USA). A 50% overlap with each turn effectively produced a uniform double layer. The drainage tube was connected to a monitor (Datex Ohmeda Cardiocap III, Hatfield, UK) through an arterial line polythene tube (Portex single monitoring set, Haslingden Rossendale, UK) and the pressure allowed to stabilize. The tourniquet was then removed and the intraarticular pressure recorded at 5-min intervals for 60 min, and compared with the systolic blood pressure. The drainage tube was then connected to a suction bottle.

Three series of knee replacement patients

Group A. 50 consecutive patients undergoing knee replacement surgery by two of the authors (CC and AGC) between July 2001 and December 2001 were treated postoperatively by bandaging the operated leg from toes to mid-thigh with Setopress bandage over a double layer of Velband wool padding. The bandage was applied using the visual tensioning guide incorporated in each bandage: the bandage was tensioned until the rectangular shapes printed onto the surface assumed a square shape. In accordance with the manufacturer's instructions, the bandages were applied in order to achieve a pressure of 35 mm Hg. No drain was used. The bandage was maintained for 48 h, and the limb rested on a pillow under the calf between exercise sessions. A long-leg TED (Tyco Healthcare Reviuth, Cornwall, UK) antiembolism stocking was then applied to the limb for the next 6 weeks. Active quadriceps extension exercises and walking (full weight bearing) were encouraged from the first postoperative day. Analgesia with patient-controlled on-demand

opiate infusion was employed for 24 h, and Diclofenac was given orally for 3 days. Amoxycillin 500 mg TDS (3 times daily) and Flucloxacillin 500 mg QDS (4 times daily) were given orally for 3 days postoperatively, and warfarin given on days 2 to 14 commencing with a loading dose of 10 mg, then adjusting the dose to achieve an international normalized ratio (INR) of 2–3. Patients were assessed frequently during the first 24 h period for any distress associated with the tightness of the bandaging, and for circulation and sensation in the toes. After removal of the bandages at 48 h, the leg was inspected for any evidence of swelling, bruising, or blisters and the knee joint was examined to assess the presence of hemarthrosis according to Tria's method (Tria and Klein 1991). Complications were recorded, as were the time to discharge, the range of flexion at discharge and at 4.5 months postoperatively, the mean change in hemoglobin and units of blood transfused. The criteria for transfusion of blood were a hemoglobin level of less than 9 g/dL on the second postoperative day, and symptoms of anemia.

Group B. 50 consecutive patients undergoing knee replacement surgery by the senior author (AGC) during 1998 were treated postoperatively with a suction drain for 24 h, and a firmly applied crêpe bandage for 3 days. The crêpe was 6 inches wide. It was applied over Velband padding before the tourniquet was released, and extended from mid-thigh to mid-shin with 3–4 layers. On the third day postoperatively, the crêpe was removed and substituted with a long TED anti-embolism stocking. The amount of blood loss in the drain was recorded. Analgesia, antibiotics, anticoagulation and mobilization were as in group A.

Group C. 50 consecutive patients undergoing knee replacement surgery by two of the authors (CC and AGC) during the first half of 2001 (between January and June) were treated postoperatively with no suction drain, but with a firmly applied crêpe bandage as in group B. Analgesia, antibiotics, anticoagulation and mobilization were as in group A.

The three groups were comparable with respect to age and sex (Table 1). All operations were performed under tourniquet control, which was released after bandaging of the limb using exactly the same surgical technique. PFC Sigma cruciate

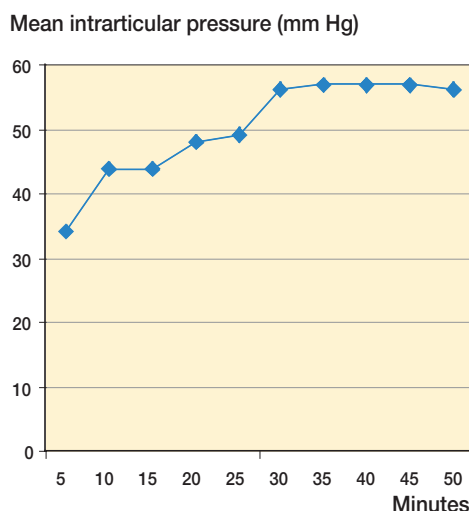


Figure. Measurement of pressure inside the knee cavity.

substituting total-knee prostheses (De Puy, Johnson and Johnson) were used in all groups.

Results

Pressure

Intraarticular knee pressure immediately following release of the tourniquet after knee replacement rose consistently in the 5 patients from an average of 32 (28–35) mm Hg above atmospheric pressure, for 20–25 min before stabilizing at an average of 57 (52–62) mm Hg. The pressure recorded at 60 min was 56 (53–59) mm Hg. There was no significant change in the intraarticular pressure over the second 30-min period following tourniquet release (Figure).

Blood loss and transfusion requirements

The preoperative hemoglobin levels were 13.7 (SD 1.1) g/dL in the Setopress group (A), 13.6 (SD 1.4) g/dL in the drain group (B), and 13.7 (SD 1.4) g/dL in the crêpe group (C). The blood drainage in the drain group (B) was 381 (SD 196) mL (30–700). The postoperative fall in hemoglobin in the three groups was similar. Transfusion for drop in hemoglobin attributable to the knee operation occurred in 0% of group A (Setopress), 8% of group B (drains), 4% in group C (no drains). This difference was not statistically significant ($p = 0.1$, Fisher exact test).

Hospital stay

The hospital stay of the patients with no drain (group C) was longer (8.3 days, SD 4.4) than that of patients with drains (group B) (7.0 days, SD 3.1), but this difference was not statistically significant ($p = 0.9$, Mann Whitney U-test). The stay of the Setopress group (A) was less (6.7 days, SD 2.9) than that of the no-drain group ($p = 0.05$, Mann Whitney U-test).

The average length of stay of the 10 patients who required transfusion was 11.5 days. The difference in the length of the hospital stay between these 10 patients and the other 140 patients who did not require transfusion was statistically significant ($p = 0.01$, Mann Whitney U-test).

Range of movement

The average range of maximum flexion of the operated knee, clinically measured with a goniometer at the date of discharge, was 84 degrees in the Setopress group (A). This was significantly greater ($p = 0.02$) (Mann Whitney U-test) than in the no-drain group (C) (74 degrees). The difference in the range of flexion between groups A and B was not statistically significant. The range of maximum flexion at discharge in the drain group (B) was 76 degrees. There was no difference in range of motion between the three groups at 4.5 months follow-up (104–108°) (Table 1).

Complications

All wounds were dry by 48 h except 3, which appeared to have subcutaneous wound hematomas. 2 were in the crêpe bandage (group C) and 1 was in the drain group (B) (Table 2). 1 of those in group C required surgical drainage of the hematoma 1 week after surgery. A tense hemarthrosis (defined as a visible and firm swelling of the suprapatellar pouch) occurred in 8 knees in group C, 3 in group B and 1 in group A. This latter patient had been unable to tolerate the bandage for more than 24 h and subsequently suffered intraarticular bleeding. In the remainder of group A, there was a small effusion palpable within the knee.

In 3 patients in group A, several small superficial blisters of the skin were detected after removal of the bandage (one on the anteromedial surface of the lower thigh, the other two on the anteromedial surface of the upper shin). 1 patient in group B and

Table 1. Comparison of groups and results

Variables	Group A Setopress bandage alone	Group B Drain with crêpe bandage	Group C Crêpe bandage alone (no drain)
Men/women	20/30	17/33	12/38
OA/RA	46/4	49/1	49/1
Mean age (range)	76 (51–86)	77 (53–99)	74 (58–87)
Mean hospital stay (range)	6.7 (4–24) ^a	7 (4–20)	8.3 (5–25)*
Mean discharge R.O.M.	6–84° ^b	4–76°	5–74° ^b
Mean R.O.M. at 4.5 months	1–104°	2–108°	3–108°
Mean (range) of hemoglobin drop (g/dL)	2.3 (0.2–4.2)	2.3 (0.2–6)	2.2 (1–4.8)
Mean (range) of blood loss in drain (mL)	–	381 (50–700)	–
Patients transfused	2	5	3

^a p = 0.05, ^b p = 0.02 (Mann Whitney U-test)

Table 2. Complications in the three groups

Complications	Group A Setopress bandage	Group B Crêpe with drain	Group C Crêpe (no drain)
Chest infection	1	–	2
Pressure sores	–	1	–
Clinical DVT	–	1	1
Tense hemarthrosis	1	3	8
Subcutaneous hematoma	–	1	2
Wound discharge 24–48 h	–	1	2
Delayed wound healing	–	1	1
Manipulation under anesthetic	3	1	3
Bruising	4	3	3
Blisters	3	1	1
Wound infection	–	–	–
Total of local complications	11/50 ^a	13/50	21/50 ^a

^a p = 0.03, χ^2 test

1 in group C had delayed wound healing until two weeks after surgery.

A clinical diagnosis of deep vein thrombosis was made and was confirmed with a venogram for 1 patient in each of groups B and C. These were treated with anticoagulation and antiembolism stockings and made an uneventful recovery. Manipulation under anesthesia was required in 3 patients in group A, 3 in group C and 1 in group B, when they failed to achieve 90 degrees of flexion or less than 10 degrees of fixed flexion at 6 weeks.

The total number of local complications (of the associated limb) was highest in group C (crêpe

bandage), and lowest in group A (Setopress) (p = 0.03, χ^2 test) (Table 2).

Discussion

Cotton crêpe bandages are used routinely for bandaging the limb following knee replacement, but they have a very short duration of action due to slipping, poor elasticity and poor compression (Raj et al. 1980).

Using pressure transducers, Melhuish et al. (2000) demonstrated that sub-bandage pressure

measurements can range from 21 to 67 mm Hg, and depend on the bandage tension applied, the number of layers, the surface hardness of the limb, and the radius of the surface being bandaged. The pressure achieved under compression bandages also varies with the bandage used and the experience of the person applying it (Williams et al. 1997). We have found that a high-elasticity bandage which maintains compression for at least 48 h provides effective control of intraarticular bleeding in the postoperative period. The tension on the bandage during application is reproducible because of the visual guide (and instructions from the manufacturer). Pressure developed in the knee has been assessed to be consistently sufficient to achieve a tamponade effect. It is well known from arthroscopic surgery that the irrigation fluid pressure which is required to stop hemorrhage into the joint is between 50 and 60 mm Hg. Our measurements of the intraarticular pressure following knee replacement indicate that bleeding into the joint continues until a similar pressure is reached. We have confirmed the manufacturer's advice that the Setopress bandage consistently achieves a pressure under the bandage of 30 mm Hg. In our practice, this pressure has been sufficient to control bleeding following knee replacement, and, in a series of patients bandaged with Setopress, has resulted in fewer complications than in group C. We suggest that in addition to the pressure supplied by the bandage, the tissue elasticity around the knee contributes to development of an intraarticular pressure which may achieve a tamponade effect with only a small volume of blood within the joint.

Our concern that an effective bandage around the knee might impede venous flow within the limb led us to apply the bandage from the toes to the mid-thigh, in a technique similar to that used for patients with venous insufficiency. We have found this technique to be satisfactory, to be well tolerated by the patients in our series, and to result in an overall reduction in the complication rate associated with this type of surgery as compared to group C. The blistering of the skin which occurred in 3 patients may have been the result of movement, and we now advise delay of flexion exercises until the bandage is removed.

Bandaging from toe to mid-thigh may confer an advantage in aiding venous return and reducing the

risk of thrombosis. Further studies are required to establish whether this bandaging technique may have a protective effect. It was certainly noted that following removal of the bandage in every case, there was no swelling in the lower leg, ankle or foot, and the calf felt soft. This observation seems to be associated with the finding that patients bandaged using this technique achieved a greater range of flexion in the knee before discharge and at six weeks, and had a shorter length of stay in hospital. Bandaging with an elastic compression bandage allows faster recovery from the operation, avoiding complications associated with bleeding. It may also reduce the total blood loss and the need for transfusion.

Several authors have argued that a drain is not necessary after knee replacement (Beer et al. 1991, Adalberth et al. 1998, Esher et al. 2003). We have found that the use of a compression bandage incorporating the foot and calf as well as the knee confers specific advantages over the use of a crêpe bandage. We believe that a crêpe bandage alone should no longer be used.

No competing interests declared. The manufacturer of Setopress has had no influence on this study.

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