The Wound Dressing Influenced Effectiveness of Cryotherapy After Anterior Cruciate Ligament Reconstruction: Case-Control Study Comparing Gauze Versus Film Dressing

Yasukazu Yonetani, Ph.D., M.D., Makiko Kurokawa, Hiroshi Amano, Ph.D., M.D., Masashi Kusano, Ph.D., M.D., Takashi Kanamoto, Ph.D., M.D., Yoshinari Tanaka, Ph.D., M.D., and Shuji Horibe, Ph.D., M.D.

Purpose: To compare the clinical effectiveness of cryotherapy after anterior cruciate ligament reconstruction using 2 different wound dressings, conventional postoperative gauze dressings and polyurethane semipermeable transparent film dressings.

Methods: In total, 60 patients who had undergone arthroscopic anterior cruciate ligament reconstruction with an autogenous patellar tendon were assigned to 2 groups. The surgical wound was covered with 5 sheets of gauze with an elastic bandage (control group) in 30 patients and film dressing was used (film group) in the remaining 30 patients. Silicone drainage catheters were inserted at the intercondylar notch, beside the distal outlet of the tibial tunnel for 2 days. After 1 hour of cooling using the device, the knee was chilled with an ice bag every 2 hours until the next morning. The severity of pain was evaluated by the number of times an analgesic, 50 mg of diclofenac sodium suppositories, had to be administered in the 24 hours after surgery. The amount of drainage during the following 2 days, the range of motion at 21 days, the change of hemoglobin concentration at 1 and 7 days, CRP at 1 and 7 days were examined.

Results: The number of patients who used an analgesic was 18 in the control group and 7 in the film group (P = .003). The amount of drainage was 165.2 ± 72.9 mL in the control group and 289.7 ± 77.6 mL in the film group (P < .001). The postoperative CRP value was 0.77 ± 0.65 mg/dL at 1 day in the control group and 0.39 ± 0.42 mg/dL in the film group (P = .009). No statistical difference was seen for hemoglobin concentration at 1 or 7 days, CRP at 7 days or range of motion at 21 days.

Conclusions: In this study, we found that film dressing enhanced the effect of cryotherapy with respect to pain control, wound drainage, and inflammation immediately after surgery compared with traditional gauze dressing with elastic wrap.

Level of Evidence: III, case-control study.

The use of cold therapy (cryotherapy) for acute musculoskeletal injuries has been previously established to reduce cellular metabolism, tissue hypoxia, edema formation, nerve conduction, and secondary pain.1,2 Similarly, cryotherapy has been used for the postsurgical treatment of anterior cruciate ligament reconstruction (ACLR) to control hematoma, hemarthrosis, and pain, and to facilitate the return of function.2–8 While the optimal duration and frequency of cryotherapy are often subject to debate,9 many authors assert that lower temperatures contribute to decreased tissue metabolism, localized vasoconstriction, diminished inflammatory mediator release, hypoxia, and attenuated nerve conduction with a resultant decrease in secondary edema, pain, and spasm.1,10 A review of 8 manuscripts concerning the effect of cryotherapy after ACLR revealed that 4 studies found a positive effect for pain relief, but oral drug administration/bleeding and range of motion (ROM)/duration of the hospital stay were not positively affected except in...
one study.\textsuperscript{10,11} This review concluded the reason for this limited and controversial effect might be due to the use of conventional gauze dressing, which make chilling the knee difficult.\textsuperscript{12}

Recently, polyurethane semipermeable transparent film dressings have been used for accelerating re-epithelialization of partial-skin thickness wounds by providing a moist wound environment.\textsuperscript{13-15} In addition, polyurethane semipermeable transparent film has the advantage of being waterproof and thin when cooling or when warmth is applied. However, studies concerning cryotherapy after ACLR have not adequately investigated or demonstrated the benefits of film dressing when compared with conventional gauze dressing. The purpose of this study was to compare the clinical effectiveness of cryotherapy after ACLR using 2 different wound dressings, conventional postoperative gauze dressings and polyurethane semipermeable transparent film dressings. It was hypothesized that film dressing would produce improved subjective patient outcomes and decreased postoperative bleeding when compared with conventional gauze dressing with bandages.

\textbf{Methods}

Patients who underwent arthroscopic ACLR using an autogenous patellar tendon under standardized general anesthesia were assigned to a control group that used gauze dressing (N = 30) or an experimental group that used film dressing (N = 30) on the surgical wound. The patients were assigned to each group by the timing of exchanging the postoperative dressing from gauze to film. Gauze was used for first 2 years, and film was used for last 2 years. Three surgeons participated in this study. The surgical wound was covered with 5 to 10 sheets of gauze with an elastic bandage in 30 patients (male 17, female 13, average age 23.6 ± 8.1 years) and film dressing (OPSITE Post-Op Visible; Smith & Nephew, Andover, MA) in 30 patients (male 24, female 6, average age 23.9 ± 7.3 years). All study protocols were approved by the local ethics committee. Between the 2 groups, there were no significant differences in age, sex, additional meniscal procedures, or operation time (Table 1).

The pad of the cooling device (Aircast Cryo Cuff, DJO Global, Lewisville TX) was used immediately for 1 hour after operation. After use of the cooling device for 1 hour, chilling of the knee was initiated with an ice bag exchanged every 2 hours until the following morning by the nurses. Subsequently, the patients chilled their knees with an ice bag when they felt the need to themselves. To relieve the pain, diclofenac suppositories were taken as needed without any other analgesic medication during the first day after operation, and 180 mg of loxoprofen sodium hydrate was administered for 5 days from the second day after operation.

| Table 1. Demographic Data of the Patients |
|---|---|---|
| Gauze | Film | \(P\) Value |
| Age | 23.6 ± 8.1 | 24.0 ± 7.3 | .84 |
| Male:female | 17:13 | 24:6 | .053 |
| Meniscus excision | MM: 7, LM: 3 | MM: 5, LM: 1 | .27 |
| | LM + MM: 1 | LM + MM: 1 |
| Meniscus repair | LM: 1 | MM: 1 |

LM, lateral meniscus; MM, medial meniscus.

The severity of the patients’ pain was evaluated based on the number of times that an analgesic, 50 mg of diclofenac sodium suppositories, had to be administered during the 24 hours after the surgery. The amount of postoperative drainage was calculated at 2 days after operation. Change in hemoglobin (Hb) concentration and C-reactive protein (CRP) was examined at 1 day and 7 days after surgery. Passive ROM was evaluated at 21 days following surgery by physiotherapists. Cold-related wound complications, including frostbite or transient nerve palsy, and surgical-site infections were evaluated.

\textbf{Surgical Procedure}

Arthroscopically anatomical ACLR using a central third autologous patella tendon was performed by the transportal technique via the far anteromedial portal. An ACL graft was inserted around the femoral and tibial tunnel with a diameter of 8 to 10 mm and fixed by the ENDOBUTTON (Smith & Nephew) at the femoral side and DSP (double spike plate; Meira Corporation, Aichi, Japan) plate at the tibial side. Silicone drainage catheters were inserted at 2 sites, the intercondylar notch and beside the distal outlet of the tibial tunnel, for 2 days.

\textbf{Postoperative Rehabilitation}

ROM exercise was started after 2 weeks of 5° flexion of the knee immobilization with a brace. Full weight-bearing was gradually allowed after a period of 3 weeks.

\textbf{Statistical Analysis}

The results are presented through a descriptive analysis, using mean and standard deviation. The data were statistically analyzed by a paired \(t\) test and \(\chi^2\) test.

\textbf{Results}

The number of the patients who used an analgesic was significantly decreased in the film group, with 7 patients (23%) in the film group in contrast to 18 patients (60%) in the gauze group (\(P < .01\)). The amount of drainage was significantly increased in the film group, with 289.7 ± 77.6 mL compared with 165.2 ± 72.9 mL in the gauze group (\(P < .001\)), although there was no significant difference in the amount of Hb at 1 or 7 days after operation, as follows, −1.56 ± 0.62 g/dL at 1 day and −1.63 ± 0.87 g/dL at 7 days in the gauze
group and \(-1.80 \pm 0.70\) g/dL at 1 day and \(-0.85 \pm 3.01\) g/dL at 7 days in the film group.

CRP values for 1-day postoperation concerning the film group (0.39 \pm 0.42 mg/dL) were significantly smaller than that of the gauze group (0.77 \pm 0.65 mg/dL) \((P < .01)\).

In contrast to the differences between the groups at 1-day postoperation, no statistical difference was shown, including CRP at 7 days’ postoperation or ROM at 21 days after surgery (Table 2).

### Complications

There were no cold-related wound complications, including frostbite, and transient nerve palsy, and no infection occurred in any patients in either gauze with bandage or film dressing.

### Discussion

In this study, we found that film dressing enhanced the effect of cryotherapy with respect to pain control, wound drainage, and inflammation immediately after surgery. Several in vivo studies have demonstrated the efficacy of conventional ice therapy and commercial cryotherapy systems in reducing skin, intramuscular, and intra-articular temperature in healthy volunteers,\(^{16}\) patients with inflammatory conditions,\(^{16,17}\) and those after ACL reconstruction.\(^{1,3,7,18}\) However, a previous review concluded the reason for limited knowledge and the controversy surrounding the effect of cryotherapy after ACLR might be due to the use of conventional gauze dressing, which makes chilling the knee difficult.\(^{10,11}\) There were 2 possible explanations. First, there is a difference in temperature between the skin and in the knee joint. Ice chips for 30 minutes in arthritic knees decreased skin temperature by 16°C and intra-articular temperature by only 6°C.\(^{16}\) The use of the Aircast Cryo Cuff, DJO device for 1 hour after ACL reconstruction also decreased skin temperature by 12°C and suprapatellar porc temperature by only 2.7°C.\(^{18}\) Second, there is a difference in the skin temperature concerning different dressings, which revealed that thin adhesive dressings (Tegaderm; 3M, St. Paul, MN) did not prevent the decreasing of skin temperature by 17°C, whereas wool and crepe dressings prevented effective cryotherapy due to decreasing the temperature by only 5°C.\(^{19}\) This positive enhancement shown through this research could be due to its waterproof and thin nature, whilst also maintaining a moist wound healing environment and facilitating the prevention of surgical-site infection.\(^{13}\)

The prevention of bleeding and inflammation has been shown previously to be an additional advantage of cryotherapy besides pain relief. However, a review described that cryotherapy had positive effects on pain relief in 4 studies but no effects on oral drug administration/bleeding and ROM/duration of the hospital stay in 7 of 8 studies.\(^{10,14}\) Interestingly, no difference in the amount of Hb between the 2 groups in this study indicated that cryotherapy with film dressing may not decrease the bleeding from bone tunnels after ACLR. Similarly, there was no significant change with respect to post-operative drainage in previous studies of cryotherapy.\(^{10,20}\) Despite no difference in the prevention of bleeding, the film group had a significantly larger amount of drainage and lower CRP within 2 days’ postoperation. These results may be due to the differences not only in the dressing material but also in the use of bandages. The use of bandages in the control group may have caused difficulty with chilling but also nonuniform compression by the cooling device and ice bags compared with the film group, which had no bandages. Therefore, nonuniform compression also may lead to drainage problems. These positive effects associated with film dressing without bandages, such as the RICE (Rest, Ice, Compression, and Elevation) concept, might lead to less hematoma formation as a

### Table 2. Result of Postoperative Cryotherapy Findings

|                      | Gauze \((n = 30)\) | Film \((n = 30)\) | \(P\) Value |
|----------------------|-------------------|------------------|------------|
| Number of patients who received diclofenac sodium | 18 \((60\%)\) | 7 \((23\%)\) | .003       |
| Amount of drainage, mL | 165.2 \pm 72.9 | 289.7 \pm 77.6 | <.001      |
| Difference of Hb to preoperative data, g/dL |                      |                  |            |
| 1 day                | \(-1.56 \pm 0.62\) | \(-1.80 \pm 0.70\) | .166       |
| 7 days               | \(-1.63 \pm 0.87\) | \(-0.85 \pm 3.01\) | .183       |
| C-reactive protein, mg/dL |                      |                  |            |
| 1 day                | 0.77 \pm 0.65     | 0.39 \pm 0.42    | .009       |
| 7 days               | 2.04 \pm 2.24     | 1.17 \pm 1.43    | .077       |
| Range of motion, degrees |                      |                  |            |
| Extension            |                   |                  |            |
| 14 days              | \(-4.5 \pm 4.8\)  | \(-2.8 \pm 3.9\) | .147       |
| 21 days              | \(-0.9 \pm 1.9\)  | \(-1.1 \pm 2.1\) | .722       |
| Flexion              |                   |                  |            |
| 14 days              | 91.3 \pm 20.3     | 85.7 \pm 15.0    | .246       |
| 21 days              | 127 \pm 12        | 122 \pm 12       | .229       |

Hb, hemoglobin.
result of the increased drainage, and may decrease CRP levels and facilitate pain relief, because hematoma formation is associated with inflammation.\textsuperscript{21}

**Limitations**

There were several limitations regarding this research. This series was a case-control study, not a randomized study, due to patient groups being divided by the timing of changing the dressing from gauze to film. To measure the positive effect for pain, a visual analog scale usually is used. In this series, a visual analog scale during the night could not be obtained for all patients because patients without pain slept well during the night, and visual analog scales the next morning showed no significant difference. For these reasons, the ratio of suppository use was examined in this series. The difference of CRP for 1 day was a reasonably low change. However, this difference was a 2 times greater level in the gauze group compared with the film group, even though there was a greater incidence use of suppository use in the film group. In addition, the average level of CRP in the film group showed a nearly normal level as most healthy adults have CRP levels lower than 0.3 mg/dL.

**Conclusions**

In this study, we found that film dressing enhanced the effect of cryotherapy with respect to pain control, wound drainage, and inflammation immediately after surgery compared with traditional gauze dressing with elastic wrap.

**References**

1. Ohkoshi Y, Ohkoshi M, Nagasaki S, Ono A, Hashimoto T, Yamane S. The effect of cryotherapy on intraarticular temperature and postoperative care after anterior cruciate ligament reconstruction. *Am J Sports Med* 1999;27:357-362.
2. Schroder D, Passler HH. Combination of cold and compression after knee surgery. A prospective randomized study. *Knee Surg Sports Traumatol Arthros* 1994;2:158-165.
3. Cohn BT, Draeger RI, Jackson DW. The effects of cold therapy in the postoperative management of pain in patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 1989;17:344-349.
4. Barber FA, McGuire DA, Click S. Continuous-flow cold therapy for outpatient anterior cruciate ligament reconstruction. *Arthroscopy* 1998;14:130-135.
5. Dahlstedt L, Samuelson P, Dalen N. Cryotherapy after cruciate knee surgery. Skin, subcutaneous and articular temperatures in 8 patients. *Acta Orthop Scand* 1996;67:255-257.
6. Edwards DJ, Rimmer M, Keene GC. The use of cold therapy in the postoperative management of patients undergoing arthroscopic anterior cruciate ligament reconstruction. *Am J Sports Med* 1996;24:193-195.
7. Konrath GA, Lock T, Goitz HT, Scheidler J. The use of cold therapy after anterior cruciate ligament reconstruction. A prospective, randomized study and literature review. *Am J Sports Med* 1996;24:629-633.
8. Shelbourne KD, Wilckens JH. Current concepts in anterior cruciate ligament rehabilitation. *Orthop Rev* 1990;19:957-964.
9. Mac Auley DC. Ice therapy: How good is the evidence? *Int J Sports Med* 2001;22:379-384.
10. Raynor MC, Pietrobon R, Guller U, Higgins LD. Cryotherapy after ACL reconstruction: A meta-analysis. *J Knee Surg* 2005;18:123-129.
11. Dambros C, Martinibianco AL, Polachini LO, Lahoz GL, Chamlian TR, Cohen M. Effectiveness of cryotherapy after anterior cruciate ligament reconstruction. *Acta Ortop Bras* 2012;20:285-290.
12. Bleakley C, McDonough S, MacAuley D. The use of ice in the treatment of acute soft-tissue injury: A systematic review of randomized controlled trials. *Am J Sports Med* 2004;32:251-261.
13. Beam JW. Management of superficial to partial-thickness wounds. *J Athl Train* 2007;42:422-424.
14. Poulsen TD, Freund KG, Arendrup K, Nyhuus P, Pedersen OD. Polyurethane film (Opsite) vs. impregnated gauze (Jelonet) in the treatment of outpatient burns: a prospective, randomized study. *Burns* 1991;17:59-61.
15. Weber RS, Hankins P, Limitone E, et al. Split-thickness skin graft donor site management. A randomized prospective trial comparing a hydrophilic polyurethane absorbent foam dressing with a petrolatum gauze dressing. *Arch Otolaryngol Head Neck Surg* 1995;121:1145-1149.
16. Oosterveld FG, Rasker JJ. Effects of local heat and cold treatment on surface and articular temperature of arthritic knees. *Arthritis Rheum* 1994;37:1578-1582.
17. Kaempffle FA. Skin surface temperature reduction after cryotherapy to a casted extremity. *J Orthop Sports Phys Ther* 1989;10:448-450.
18. Glenn RE Jr, Spindler KP, Warren TA, McCarty EC, Secic M. Cryotherapy decreases intraarticular temperature after ACL reconstruction. *Clin Ortop Relat Res* 2004;421:268-272.
19. Ibrahim T, Ong SM, Saint Clair Taylor GJ. The effects of different dressings on the skin temperature of the knee during cryotherapy. *Knee* 2005;12:21-23.
20. Dervin GF, Taylor DE, Keene GC. Effects of cold and compression dressings on early postoperative outcomes for the arthroscopic anterior cruciate ligament reconstruction patient. *J Orthop Sports Phys Ther* 1998;27:403-406.
21. Hoff P, Gaber T, Strehl C, et al. Immunological characterization of the early human fracture hematoma. *Immunol Res* 2016;64:1195-1206.