Comparison of a cryopneumatic compression device and ice packs for cryotherapy following ACL reconstruction

Department of Orthopaedic Surgery
College of Medicine, Hanyang University

Jae-Hyuk Yang, Kyu-Tae Hwang, Myoung Keun Lee, Eunil Cho, Jin Kyu Lee*

Introduction

† ***Cryotherapy***

- ***Decrease edema, pain and inflammation***
- ***Mechanism of action***
  - ✓ ***Vasoconstriction and reduction in secondary hypoxic injury by lowering metabolic demand***
  - ✓ ***Decrease nerve conduction velocity (tissue temperature <15 ℃)***

Gatewood, CT. Knee Surg Sports Traumatol Arthrosc 2017;25:501-516.

Taber C. Phys Ther 1992;72:294-299.

Martimbianco ALC. Phys Ther Sport 2014;15:261-268.

Algafly AA. Br J Sports Med 2007;41(6):365-369.

Introduction

† ***Early rehabilitation following ACL reconstruction***

- ***Pain and knee effusion must be controlled to avoid delay in functional recovery & the quadriceps inhibition phenomenon***

Sonnery-Cottet B. Br J Sports Med 2019;53(5):289-298.

Palmieri-Smith RM. Am J Sports Med 2007;35(8):1269-1275.

† ***Cryotherapy types***

- ***Standard ice packs, crushed-ice bags, and Cold compression devices***

Jawad M. Surg Technol Int 2017;30:415-424.

Martimbianco ALC. Phys Ther Sport 2014;15:261-268.

Introduction

† *Cryotherapy types*

- *Standard ice packs, crushed-ice bags, and Cold compression devices*

† *Cold compression device*

- *Constant temperature + Compression*

Introduction

† ***Purpose of the study***

- ***To evaluate and compare the effectiveness of cryopneumatic compression device with that of standard ice packs***

Hypothesis : cryopneumatic compression device would produce **decreased postoperative pain, less opioid consumption** and decreased **effusion**

Material and Methods

† *Inclusion criteria*

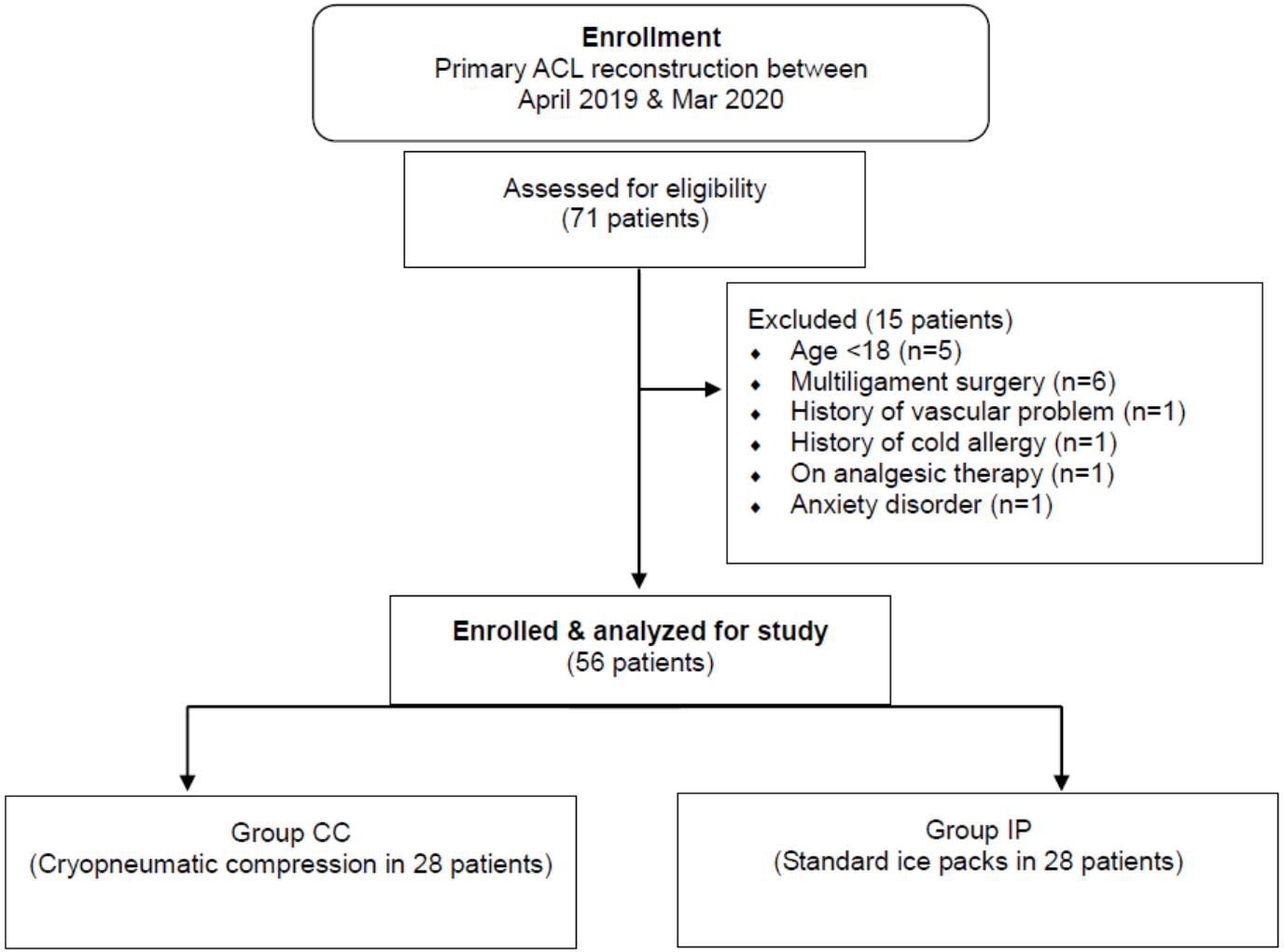
- *Between April 2019 ~ March 2020*
- *Primary ACL reconstruction*

† *Exclusion criteria*

- *Age < 18 years*
- *Multi-ligamentous knee injury*
- *Contra-indications to compressive or cold therapy*
- *History of long-term analgesic therapy*
- *Psychologic problem*

Material and Methods

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) flow chart.



Material and Methods

† *Randomization*

- *Group CC : (28 knees) received cryopneumatic compression(CC) device*
- *Group IP : (28 knees) received standard ice pack(IP) cryotherapy*

† *Cryotherapy protocol*

- *3 times per day*
- *Group CC : 20 minutes per 1 cycle, 10 ℃, compression pressure set at 30mmHg*
- *Group IP : maximum coverage on each knees*

Material and Methods

C.T.C.-7 **(DAESUNG MAREF CO.,LTD.)**

Conventional ice packs

Outcome measures

† ***Pain evaluation***

- ***Postoperative Opioid consumption : PCA + rescue medicine***
- ***Patients reported VAS pain score***

† ***Edema evaluation***

- ***Circumferential measurements performed at thigh(10cm proximal to patella sup. pole), and knee(mid-patella)***

Outcome measures

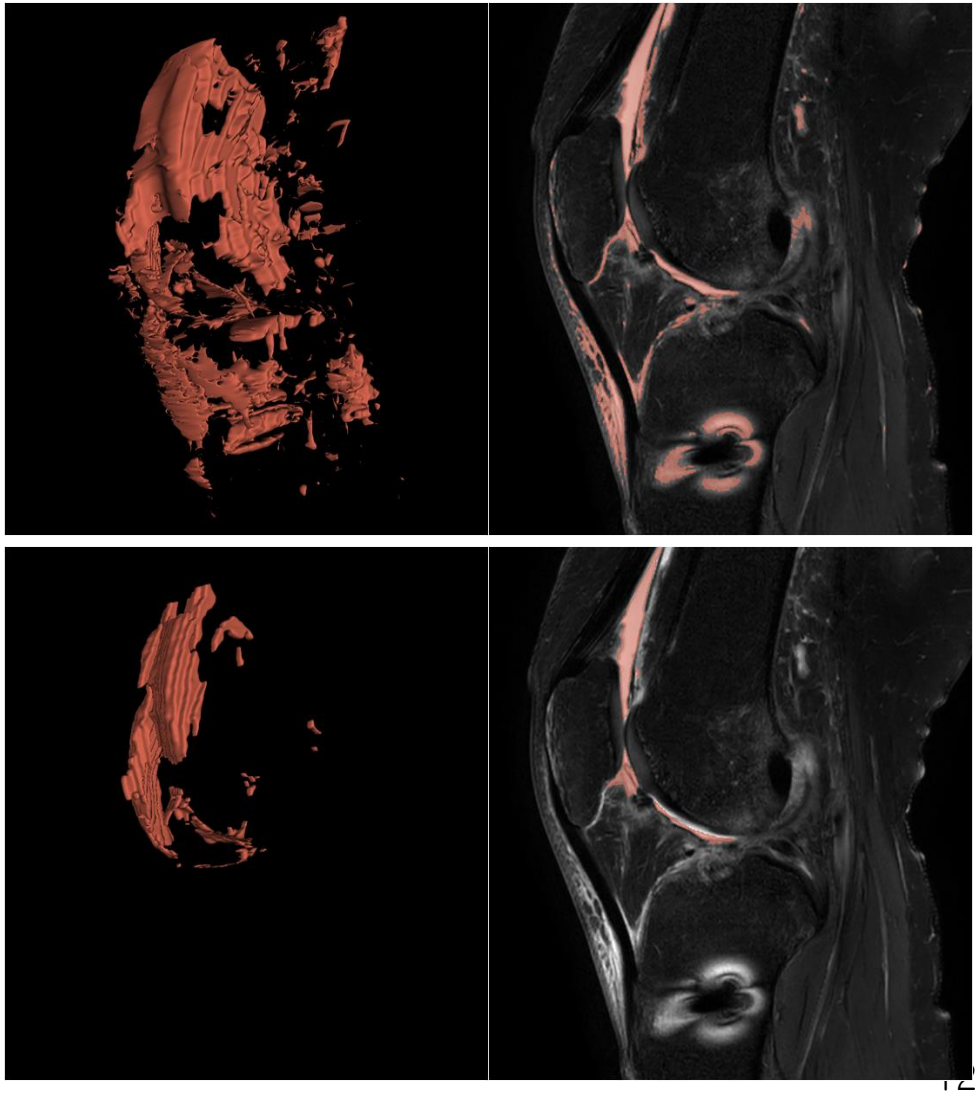
† ***Joint effusion***

- ***Intra-articular bleeding : closed suction drainage (during first 2 days)***
- ***3D MRI reconstrustruction model (MRI obtained at POD 6)***

Outcome measures

† *MRI 3D reconstruction model*

- *AI based algorithm*
- *Threshold based identification of fluid signal on T2-weighted MRI sagittal images*
- *Location of ROI (exclusion of bone and other signals)*
- *3D reconstruct for effusion measurement*



Effusion segmentation by AI

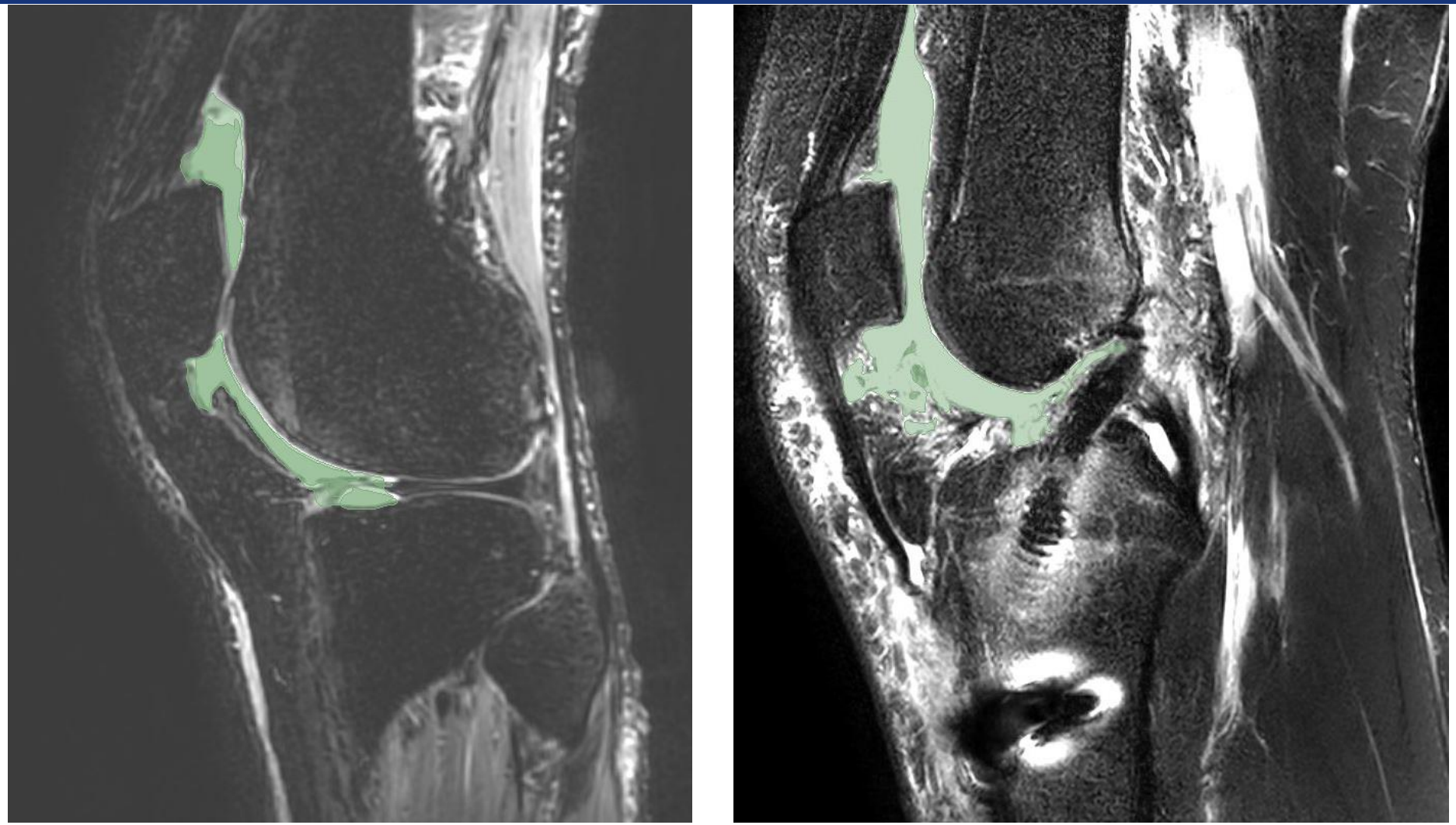


Fig 2. Joint effusion segmentation. Joint effusion segmentation process of sagittal T2-weighted MRI slices obtained from cadaveric (A) and ACL reconstructed (B) knees.

3D reconstructed model by AI

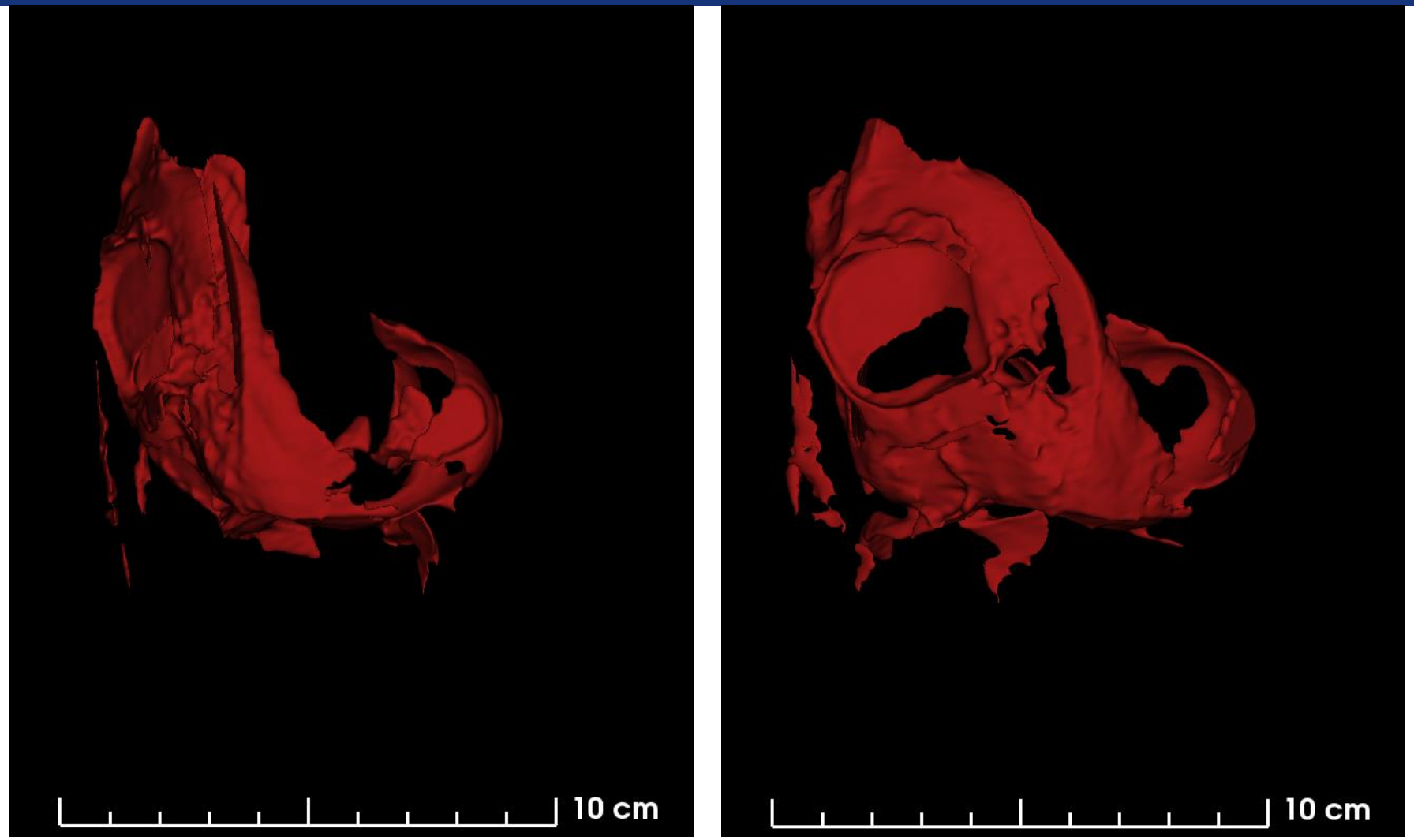


Fig 3. Final three-dimensional MRI reconstructed effusion model. Views from (A) antero-lateral and (B) anterior aspects of the knee

Results

Base characteristics

Variables	CC group (N = 28)	IP group (N = 28)	P-value
Age, years	26 (19-34)	24.5 (21.5-30.5)	0.724
Sex (male)	23 (82.1)	23 (82.1)	1.000
Body mass index	25.5 ± 2.9	26.28 ± 4.3	0.433
Affected side (right)	16 (57.1)	13 (46.4)	0.422
Graft type			
Allograft	1 (3.6)	3 (10.7)	0.611
Hamstring autograft	27 (96.4)	25 (89.3)	
Combined meniscus injury	15 (53.6)	18 (64.3)	0.415

Table 1. Patient characteristics and clinical data.
Note. Non-normally distributed numerical variables are presented as median (Q1-Q3) and were tested by a Wilcoxon rank-sum test. Categorical variables are presented as n (%) and were tested by a Chi-square test or Fisher's exact test.

Results

Pain evaluation - VAS

Variables	CC group (N = 28)	IP group (N = 28)	P-value
VAS preop.	2.0 ± 1.5	2.1 ± 0.9	0.596
VAS (day 4)	2.1 ± 1.4	3.3 ± 1.3	0.001
VAS (day 7)	1.5 ± 1.3	2.0 ± 0.9	0.078
VAS (day 14)	1.3 ± 1.1	1.3 ± 0.8	0.980
ΔVAS (day 4)	0.1 ± 1.4	1.2 ± 1.4	0.007
ΔVAS (day 7)	−0.5 ± 1.7	−0.1 ± 1.2	0.363
ΔVAS (day 14)	−0.6 ± 1.5	−0.8 ± 1.1	0.577

Index : **preop VAS** (mean)

Table 2. Comparison of VAS pain scores between groups.

VAS represents changes in VAS at 4, 7, and 14 days postoperatively relative to preoperative measurements. VAS scores are presented as a least-square mean and were tested by linear mixed model analyses for repeated measures.

Results

Soft tissue Edema - Circumference

Variables	CC group (N = 28)	IP group (N = 28)	P-value
Patella (day 7)	1.1 ± 1.6	1.2 ± 1.5	0.899
Patella (day 14)	0.9 ± 1.8	0.6 ± 1.6	0.508
Thigh (day 7)	−0.4 ± 1.8	0.2 ± 1.5	0.134
Thigh (day 14)	−1.0 ± 2.9	0.1 ± 1.4	0.120

Table 3. Comparison of circumferential measurements (cm) at mid-patellar and thigh levels in the two groups.
Values are given as mean ± standard deviation and represent the difference in circumferential measurements (cm) at 7 and 14 days postoperatively relative to index measurements at **day 4.**

Results

Pain evaluation - Administered analgesics

Variables	CC group (N = 28)	IP group (N = 28)	P-value
Rescue medication	0.6 ± 1.4	0.5 ± 1.0	0.657
Fentanyl -6h	220.9 ± 106.7	208.2 ± 80.5	0.626
Fentanyl -12h	370.6 ± 156.7	352.7 ± 120.0	0.647
Fentanyl -24h	561.1 ± 223.3	584.4 ± 209.0	0.705
Fentanyl -48h	840.6 ± 297.5	987.4 ± 343.6	0.136

Table 4. Comparison of cumulative fentanyl consumption (cc) and rescue medication (ampules) in the groups.
NOTE. Values are given as mean ± standard deviation.

Results

Joint effusion

Variables	CC group	IP group	P-value
Drainage volume	148.2 ± 102.8 (28)	171.3 ± 64.8 (28)	0.324
MRI Effusion (calculated)	47.1 ± 11.9 (21*) *7 Pt. refused Day 6 MRI	51.8 ± 16.0 (22**) **6 Pt. refused Day 6 MRI	0.280
Total Effusion volume	175.2 ± 83.4 (21) <	239.7 ± 78.8 (22)	0.015

Table 5. Comparison of effusion (cc) measured by drainage and 3D MRI reconstruction in the two groups.
NOTE. Values are given as mean ± standard deviation (number of patients assessed).

Discussion

† ***Barber et al. compared continuous-flow cryotherapy with no cryotherapy controls after ACL reconstruction***

- ***Improved VAS, Oral narcotics use, ROM***

Barber FA. Arthroscopy. 1998;14(2):130-135.

† ***Recent systematic review significant reduction in pain scores at 48 hours after ACL reconstruction compared to no cryotherapy***

Martimbianco ALC. Phys Ther Sport 2014;15:261-268.

Discussion

† ***In laboratory studies involving artificial knee joint effusion models, concluded that cryotherapy is effective in reducing swelling or joint effusion***

Hopkins J. J Athl Train 2002;37(1):25-31.

Rice D. Arthritis Rheum 2009;61(1):78-83.

† ***These results of previous clinical studies were in line with our study's data***

Discussion

† ***No previous studies have quantified the effectiveness of cryotherapy on reducing the effusion volume***

Conclusions

† *Application of cryopneumatic compression device was associated with significant reduction in (1)VAS pain scores and (2)Joint effusion during the early postoperative period following ACL reconstruction.*


HANYANG
UNIVERSITY