Comparison of Operative Times Between Pressure and Flow-Control Pump Versus Pressure-Control Pump for ACL Reconstruction

RYAN SIEG, MD; RUSSELL BEAR, DO; M. SHAUN MACHEN, MD; BRETT D. OWENS, MD

abstract

Full article available online at OrthoSuperSite.com/view.asp?rID=43767

Evidence suggests that a pressure and flow-control pump provides better visualization than a pressure-control pump alone. Increased visualization may lead to decreased operative time. We sought to perform a direct comparison in terms of operative times in anterior cruciate ligament (ACL) reconstructive surgery using these 2 automated pump systems.

We retrospectively studied all ACL reconstruction procedures performed at our institution over an 8-month period. During the first 4-month period, a pressure-driven pump was used (HydroFlex Multipurpose Irrigation Pump; Davol, Warwick, Rhode Island). During the second 4-month period, a pressure and flow-control pump was used (FMS Duo+; DePuy Mitek, Raynham, Massachusetts). Procedures that involved multiligament reconstruction or meniscal repair were excluded. Surgical time was defined as the time from incision to skin closure. The data were analyzed with the Student *t* test with significance set at $P<.05$. Forty-four procedures met our inclusion criteria, with 21 surgeries performed using the pressure-control pump and 23 surgeries performed using the pressure and flow system. Mean operative time using the pressure-control pump was 126 minutes (95% CI 118.9, 133.3), while mean operative time using the pressure and flow-control system was 111 minutes (95% CI 104.1, 117.9). This difference was significant ($P=.004$).

These results indicate that the use of pressure and flow-control pump system results in time savings compared with the pressure-control pump.

Drs Sieg, Bear, Machen, and Owens are from William Beaumont Army Medical Center, El Paso, Texas.

Drs Sieg, Bear, Machen, and Owens have no relevant financial relationships to disclose.

Correspondence should be addressed to: Brett D. Owens, MD, Keller Army Hospital, 900 Washington Rd, West Point, NY 10996.

doi: 10.3928/01477447-20090818-09

Fluid pump systems used for arthroscopic surgery have evolved over the years. Gravity pump systems were the first systems used, followed by automated pump systems, some of which control pressure via inflow and others that control pressure and flow independently by controlling inflow and outflow separately. The effectiveness of arthroscopic pump systems has been investigated with measures related to image quality, fluid volume used, intra-articular vs set pressure, and fluid extravasation.[1-7]

There is little in the literature supporting the use of pump systems as they relate to operative time savings.[4] The goal of this study was to perform a direct comparison in terms of operative times in anterior cruciate ligament (ACL) reconstruction using these 2 types of pump systems. Our hypothesis was that the pressure and flow-control system would result in operative time savings compared to the pressure-control pump.

Materials and Methods

In March 2008, our institution changed the type of pumps used during arthroscopy. To assess the time savings associated with this change, we performed a chart review of all ACL reconstructions performed at our institution 4 months prior to and 4 months after this change.

During the first 4-month period, all surgeries were performed using a pressure-control pump (HydroFlex Multipurpose Irrigation Pump; Davol, Warwick, Rhode Island). The pressure-control system has an impeller pump powered by an electronic controller. The input pressure is determined by the user-selected setting on the electronic controller. The controller determines the speed of the impeller pump, which drives the flow of irrigant and determines the resultant static pressure. However, there is no separate control for flow, and one must use wall suction or canisters for suction. Manual adjustments are made to the suction during the procedure to control flow.

During the second 4-month period, a system that controlled for both pressure and flow was introduced (FMS Duo+; DePuy Mitek, Raynham, Massachusetts). In addition to pressure-control, the dual system has an outflow port connected by tubing back to the pump that allows for flow control. Computer-integrated inflow and outflow control helps to maintain constant pressure in the joint. The device also has the capability to increase pressure and flow independently to eliminate debris and control bleeding. It interfaces directly with the shaver to automatically control shaver suction, and thus no wall suction is needed.

Consecutive patients undergoing ACL reconstruction surgery by 3 surgeons (R.B., M.S.M., B.D.O.) were included in the study. All primary and revision reconstructions were included, irrespective of graft choice, as well as cases involving meniscal debridement. However, surgeries requiring other ligamentous procedures or meniscal repair were excluded. Surgical time was recorded as the start of the procedure to the time of skin closure. The data were recorded by the circulating nurse using the surgical scheduling software available at our institution. Surgical times were verified by chart review using the operative start and end times. The data were analyzed with the Student *t* test with significance set at $P<.05$.

Results

Fifty-eight ACL reconstructions were performed in an 8-month period. Fourteen cases were excluded, 7 from each group, leaving a total of 44 cases available for this analysis. A complete listing of patient details is located in Table 1. Twenty-one procedures were performed in the first 4 months using the pressure-control system (group 1), and 23 procedures were performed in the second 4 months using the dual system (group 2).

Mean patient age was 30 years in group 1 and 32 years in group 2. Nineteen primary reconstructions were performed in both groups 1 and 2. Two revisions were performed in group 1, and 4 revisions were performed in group 2. Seven procedures in group 1 and 8 in group 2 involved meniscal debridement. Hamstring autograft was used for 5 procedures in group 1 and 4 in group 2. Allograft was used in 16 procedures in group 1 and 19 in group 2. Surgeon 1 (M.S.M.) performed 10 procedures in group 1 and 7 in group 2; surgeon 2 (R.B.) performed 5 and 7 procedures, respectively; and surgeon 3 (B.D.O.) performed 6 and 9 procedures, respectively.

Average operative time using the pressure-control pump was 126 minutes (95% CI 118.9, 133.3). Average operative time using the dual system was 111 minutes (95% CI 104.1, 117.9). There was an average 15-minute decrease in surgical time ($P=.004$) in favor of the dual system. We also compared the average surgical times separating reconstruction from revision, the type of graft used, the involvement of meniscal debridement, and the surgeon performing the procedure. For each of these comparisons, the use of the pressure-flow pump led to operative time savings ranging from 11 to 17 minutes, as shown in Table 2.

Discussion

We set out to determine whether there was a significant decrease in surgical time for ACL reconstruction using a pump that controls pressure and flow independently compared to a pressure-control system. The results of this study indicate that the pump that independently controls pressure and flow results in time savings compared with the pressure-control pump. This is likely due to the improved visualization provided by the independent control of pressure and flow. Previous authors have compared these 2 types of automated pump systems clinically with regard to visualization; however, neither of these studies set out to measure the amount of operative time savings.[1,4]

Ogilvie-Harris and Weisleder[4] prospectively compared the effectiveness of these 2 types of pumps for multiple types

of arthroscopic procedures. Visualization and technical ease were assessed subjectively via observations of the video monitor and given a score based on the amount of impairment of visualization. They concluded that the adequacy of visualization and technical ease significantly improved with the pressure-flow system compared with the pressure system alone. They also compared surgical times for the 2 pumps based on the duration of surgery. The results of the comparison show that there were an increased number of surgeries lasting <1 hour using the pressure and flow-control unit. They concluded that the increased number of shorter-duration surgeries was due to improved visualization. However, the authors did not provide the operative time data for analysis.[4]

Ampat et al[1] prospectively compared these 2 types of pump systems based on visual clarity, presence of bleeding vessels, and total red blood cell loss for subacromial decompressions of the shoulder in 20 patients. The visual clarity and presence of bleeding vessels were assessed subjectively by the surgeon. Total red blood cell loss was determined by multiplying the volume of fluid used and the cell count in the effluent. There was no significant difference in relation to visual clarity, presence of bleeding, or red blood cell loss, and they concluded that there was no difference between the pumps in straightforward shoulder procedures.[1]

These studies compared visualization based on subjective measures. Tuijthof et al[7] compared a gravity pump to a pressure and flow-control pump (the same pump in our study) based on objective assessment of the quality of the arthroscopic view. Ten routine knee operations using a tourniquet were performed. Four disturbances of the arthroscopic view were described as bleeding, turbidity (caused by synovial fluid and debris), air bubbles, and loose fibrous tissue. Digital videos were analyzed by 2 testers who assessed an equal number of procedures per group. Mean procedure time for each group was ap-

Table 1

Patient Demographics

Patient No./ Sex/Age, y	Surgery	Graft	Debridement	Surgeon	Surgical Time, min
Group 1: Pressure-Control Pump					
1/M/15	PR	A	No	1	154
2/M/18	PR	A	No	1	121
3/M/23	PR	H	Yes	1	156
4/M/23	R	A	No	3	122
5/M/24	PR	A	No	3	126
6/M/25	PR	H	No	2	117
7/M/27	PR	H	No	2	138
8/M/28	PR	A	No	3	111
9/M/28	PR	H	No	2	131
10/M/29	PR	A	No	1	143
11/F/29	PR	A	No	1	119
12/M/32	PR	A	No	3	103
13/M/34	PR	A	No	2	122
14/M/37	PR	A	No	1	111
15/M/38	PR	A	Yes	3	158
16/M/39	PR	A	Yes	1	112
17/M/40	PR	H	Yes	2	123
18/M/43	PR	A	Yes	1	125
19/M/43	R	A	Yes	3	137
20/M/45	PR	A	Yes	1	99
21/M/52	PR	A	No	1	121
Group 2: Dual System Pump					
22/F/20	PR	H	No	2	115
23/F/21	PR	A	Yes	2	131
24/M/22	PR	A	Yes	3	150
25/M/23	R	A	No	2	128
26/F/24	PR	A	No	1	102
27/F/24	PR	A	No	1	100
28/M/24	PR	A	No	3	115
29/M/25	PR	A	No	2	108
30/M/25	PR	A	Yes	1	103
31/M/26	PR	A	Yes	3	115
32/M/26	PR	A	Yes	2	91
33/M/27	PR	A	No	1	109
34/M/28	PR	H	No	2	105
35/F/29	R	A	Yes	3	123
36/M/30	PR	H	No	1	125
37/M/31	PR	A	No	1	95
38/M/36	PR	A	No	3	87
39/M/36	PR	H	No	1	141
40/F/37	R	A	No	3	105
41/M/39	PR	A	No	3	95
42/M/39	PR	A	Yes	3	104
43/M/45	R	A	No	3	115
44/M/60	PR	A	Yes	2	91

Abbreviations: A, allograft; H, hamstring autograft; PR, primary reconstruction; R, revision.

Table 2

Surgical Time

	No. of Surgeries		Average Surgical Time, min			
	Group 1[a]	Group 2[b]	Group 1	Group 2	Time Savings, min	*P* Value
All procedures	21	23	126	111	15	.004
Primary	19	19	126	110	16	.006
Revision	2	4	130	118	12	n/a[c]
Plus debridement	7	8	130	114	16	.156
No debridement	14	15	124	110	14	.009
Hamstring autograft	5	4	133	122	11	.297
Allograft	16	19	123	106	17	.013
Surgeon 1 only	10	7	126	111	15	.103
Surgeon 2 only	5	7	126	110	16	.065
Surgeon 3 only	6	9	126	112	14	.177

[a]*Group 1, pressure-control pump.*
[b]*Group 2, dual system pump.*
[c]*Not enough information to determine* P *value.*

proximately 18.5 minutes for the gravity pump and 17.5 minutes for the dual system. There was a significant reduction in turbidity in favor of the dual system. This was attributed to the continuous flow afforded by the dual system. There were no significant differences found for the other 3 disturbances.[7]

The main limitation of our study is that it was retrospective. Consideration for familiarity and equipment learning when switching to the FMS Duo+ system was not accounted for. Our study was also relatively small in size, although large enough to show a difference in procedure times. A strength of this study is the consideration for the potential differences that may affect surgical time. We were able to document time saving in ACL reconstructions that were independent of surgeon, primary vs revision procedure, graft choice, or presence of meniscal lesions requiring debridement.

While we have seen significant advances in arthroscopic equipment, few investigations exist that compare different pump systems. While improvements in visualization have been noted with dual pressure and flow-controlled pumps, this study is the first known documentation of actual operative time savings related to choice of pump.

References

1. Ampat G, Bruguera J, Copeland SA. Aquaflo pump vs FMS 4 pump for shoulder arthroscopic surgery. *Ann R Coll Surg Engl*. 1997; 79(5):341-344.
2. Dolk T, Augustini BG. Three irrigation systems for motorized arthroscopic surgery: a comparative experimental and clinical study. *Arthroscopy*. 1989; 5(4):307-314.
3. Morgan CD. Fluid delivery systems for arthroscopy. *Arthroscopy*. 1987; 3(4):288-291.
4. Ogilvie-Harris DJ, Weisleder L. Fluid pump systems for arthroscopy: a comparison of pressure control versus pressure and flow control. *Arthroscopy*. 1995; 11(5):591-595.
5. Tuijthof GJ, Dusée L, Herder JL, van Dijk CN, Pistecky PV. Behavior of arthroscopic irrigation systems. *Knee Surg Sports Traumatol Arthrosc*. 2005; 13(3):238-246.
6. Tuijthof GJ, Sierevelt IN, van Dijk CN. Disturbances in the arthroscopic view defined with video analysis. *Knee Surg Sports Traumatol Arthrosc*. 2007; 15(9):1101-1106.
7. Tuijthof GJ, van den Boomen H, van Heerwaarden RJ, van Dijk CN. Comparison of two arthroscopic pump systems based on image quality. *Knee Surg Sports Traumatol Arthrosc*. 2008; 16(6):590-594.