Do Arthroscopic Fluid Pumps Display True Surgical Site Pressure During Hip Arthroscopy?

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Purpose: To report on the accuracy of 5 commercially available arthroscopic fluid pumps to measure fluid pressure at the surgical site during hip arthroscopy. **Methods:** Patients undergoing hip arthroscopy for femoroacetabular impingement were block randomized to the use of 1 of 5 arthroscopic fluid pumps. A spinal needle inserted into the operative field was used to measure surgical site pressure. Displayed pump pressures and surgical site pressures were recorded at 30-second intervals for the duration of the case. Mean differences between displayed pump pressures and surgical site pressures were obtained for each pump group. **Results:** Of the 5 pumps studied, 3 (Crossflow, 24K, and Continuous Wave III) reflected the operative field fluid pressure within 11 mm Hg of the pressure readout. In contrast, 2 of the 5 pumps (Double Pump RF and FMS/DUO+) showed a difference of greater than 59 mm Hg between the operative field fluid pressure and the pressure readout. **Conclusions:** Joint-calibrated pumps more closely reflect true surgical site pressure than gravity-equivalent pumps. With a basic understanding of pump design, either type of pump can be used safely and efficiently. The risk of unfamiliarity with these differences is, on one end, the possibility of pump underperformance and, on the other, potentially dangerously high operating pressures. **Level of Evidence:** Level II, prospective block-randomized study.

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Hip arthroscopy has become a common procedure with indications for various hip pathologies. Although relatively rare, serious complications associated with retroperitoneal, intra-abdominal, and intrathoracic fluid extravasation have been published.[1-11] Appropriate fluid pressure monitoring may help minimize these complications while allowing for adequate visualization.[10,12] This begins with a basic understanding of how pumps measure and display fluid pressure.

Historically, pump designs have been divided into 2 categories, pressure-control and pressure- and flow-control pumps, with the latter being used more in recent times. Within the pressure- and flow-control pumps, there are 2 distinct designs that use differing methods to estimate surgical site fluid pressure.[13] The first design attempts to reflect the surgical site pressure either by direct measurement in the arthroscope cannula or by a computer algorithm that integrates frictional losses and flow rates into the calculation of the displayed pressure. These can be referred to as "joint-calibrated pumps." The second design substitutes a pump for a simple gravity tubing setup in which the pressure, displayed in millimeters of mercury, is equivalent to the hydrostatic pressure produced by an irrigation fluid bag placed at a variable height above the surgical site. For both designs, the height of the fluid bag above the surgical site does not affect pressures; however, the pump itself must be level with the surgical site to avoid additional pressure changes due to hydrostatic forces.

This raises the question of how the displayed pressure relates to the surgical site pressure. Because of their differing designs, these 2 different methods of estimating fluid pressure can lead to a drastically different surgical site pressure compared with the displayed pressure. In turn, this could have implications on fluid extravasation during hip arthroscopy because a surgeon

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Table 1. Demographic Data

Pump	Sex, n		Age, yr*		BMI,
	M	F	Mean ± SD	Range	Mean ± SD
ConMed Linvatec 24K	3	2	41 ± 8	31-49	27 ± 3
Stryker Crossflow	3	2	33 ± 10	22-47	26 ± 4
Arthrex Continuous Wave III	4	1	29 ± 8	25-42	23 ± 2
Medical Vision Double Pump RF	3	2	25 ± 9	18-41	24 ± 4
DePuy Mitek FMS/DUO+	2	3	40 ± 4	36-44	27 ± 3

NOTE. BMI was not statistically different between groups ($P > .05$).
BMI, body mass index; F, female; M, male; SD, standard deviation.
*With respect to age, the following groups were statistically different: ConMed Linvatec 24K and Medical Vision Double Pump RF ($P = .02$), Medical Vision Double Pump RF and DePuy Mitek FMS/DUO+ ($P = .02$), and DePuy Mitek FMS/DUO+ and Arthrex Continuous Wave III ($P = .03$).

may unknowingly expose the surgical site to higher-than-anticipated pressures.[13-15]

The purpose of this study was to report on the accuracy of 5 commercially available arthroscopic fluid pumps to measure fluid pressure at the surgical site during hip arthroscopy. We hypothesized that joint-calibrated pumps would reflect true surgical site pressure more accurately than gravity-equivalent pumps.

Methods

We performed an institutional review board–approved, block-randomized study including patients (5 patients per pump group) undergoing hip arthroscopy for femoroacetabular impingement (FAI) from January to June 2016. Demographic data collected included age, body mass index (BMI), and sex (Table 1). The inclusion criteria were arthroscopy for FAI (acetabuloplasty, labral repair or debridement, and femoroplasty only) and age 18 to 65 years. The exclusion criteria were arthroscopy for hip conditions other than FAI and age younger than 18 years or older than 65 years. Patients (N = 37) provided written informed consent to participate in the study. The 5 arthroscopic fluid pumps included were ConMed Linvatec 24K (LC), Stryker Crossflow (SC), Arthrex Continuous Wave III (ACW), Medical Vision Double Pump RF (MVDP), and DePuy Mitek FMS/DUO+ (DM). The order of pump selection was randomized, and a block randomization scheme was used for patient allocation. Equipment representatives from each company were present during all procedures to ensure correct fluid pump setup and use. Pump pressures were set based on surgeon experience to obtain adequate visualization.

After capsulotomy was complete, a 21-gauge cannulated needle was placed at the location of the traditional anterior portal and introduced into the operative field, where it was directly visualized (Fig 1). The needle was connected to an arterial line pressure-monitoring system (Edward Lifesciences), and the pressure was measured by an anesthesia machine (GE Healthcare Aisys CS[2]). The line pressure was calibrated at the level of the surgical site.[16] The irrigation fluid bag was placed at a standard height of 60 inches above the surgical site. Pressures were set at 40 to 50 mm Hg for the joint-calibrated pumps and 110 mm Hg for the gravity-equivalent pumps. Intermittent pressure increases of 20 mm Hg for 2 minutes were used to improve visualization. The surgical site pressure as measured by the arterial line and the displayed fluid pump pressure were manually and simultaneously recorded at 30-second intervals by research personnel (B.P.). The collection period began after introduction of the needle into the surgical site and continued for the duration of the case.

Statistics

Statistical analyses were performed using Microsoft Excel (Office Professional Plus 2013). Descriptive statistics included age and BMI, as well as displayed pump pressure, surgical site pressure, and duration of surgery in minutes. Mean differences between the displayed pump pressure and the surgical site pressure were calculated for each of the 5 pumps. Because of variability in the overall duration of surgery, data used for statistical comparisons between pumps included measurements for up to the first 30 minutes of each case.

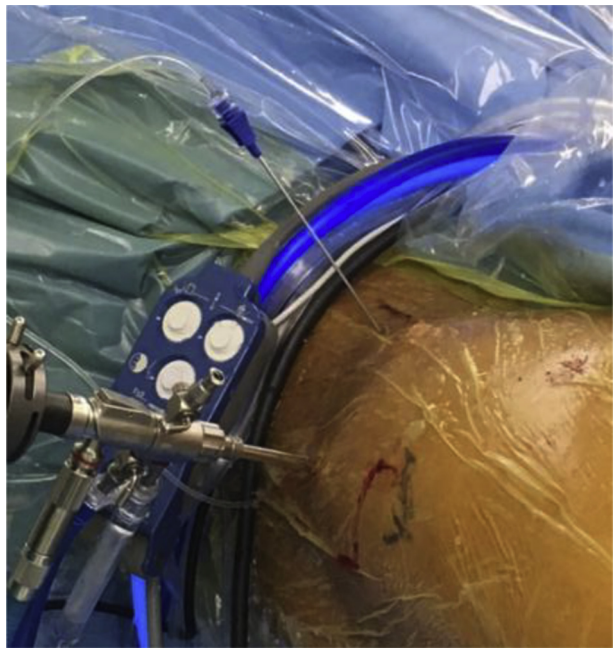

Fig 1. Placement of spinal needle inserted into the operative field through a traditional anterior portal. Patients were positioned supine on a Hana table (Mizuho OSI) with boot traction. The portals used during arthroscopy were anterolateral, mid-anterior accessory, and distal anterolateral accessory. The spinal needle was introduced into the operative field. The needle was connected to an arterial line pressure-monitoring system, and pressure was measured by an anesthesia machine. Line pressure was calibrated at the level of the surgical site.