

Intra-articular Pressure Characteristics of the Knee Joint

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Objectives

Knee joint synovitis and effusion are common findings of painful knees. It is speculated that, in a closed joint space, pressure profiles by infusing fluid could reveal synovial integrity, joint fluid dynamics, and capsular tightness in various pathologic conditions. To explore potential diagnostic utility of pressure profiles, we investigated the relationships between pressure profiles and clinical and radiological parameters.

Subjects and Methods

We reviewed outpatients records from January 2017 to May 2018 and enrolled 22 subjects who underwent intra-articular cortico-steroid injection with real-time pressure monitoring in painful knees. The pressure profiles created by constant-volume-speed injection were analyzed to characterize the injected volume (V200) at 200 mmHg, maximum pressure (Pmax), and ratio (Rpv= Pmax/Vpmax) of Pmax and the volume at the Pmax. The three pressure parameters were related with the results of McMurray's and knee flexion pain tests, Kellgren-Lawrence (KL) grades by plain X-rays, existence of suprapatellar swelling by ultrasonography.

Results

V200 was substantially larger in knees with negative McMurray's test than in the positive ones (33.07 ± 16.14 ml vs 19.47 ± 7.55 ml, $p=0.040$ by Wilcoxon test). Pmax showed significant relationships with KL grade ($r=0.502, p=0.024$, by Spearman's correlation test), and was 132.47 ± 57.96 mmHg and 219.81 ± 99.79 mmHg at negative and positive McMurray's test, respectively ($p=0.075$). Rpv showed significant relationships with the KL grade ($r=0.472, p=0.036$), While the slope of rising section was higher in knees with positive flexion pain test (4.91 ± 2.87) than in those with negative results (3.63 ± 0.63), it gained no statistical significance.

Conclusions

In this explorative study, knees with positive McMurray test, higher KL grades, tend to reveal steeper slope, lower volume at 200mmHg, and higher maximal pressure, which suggests intra-articular pressure profiles can be utilized to evaluate painful knees after further clinical researches with more specific clinical conditions.

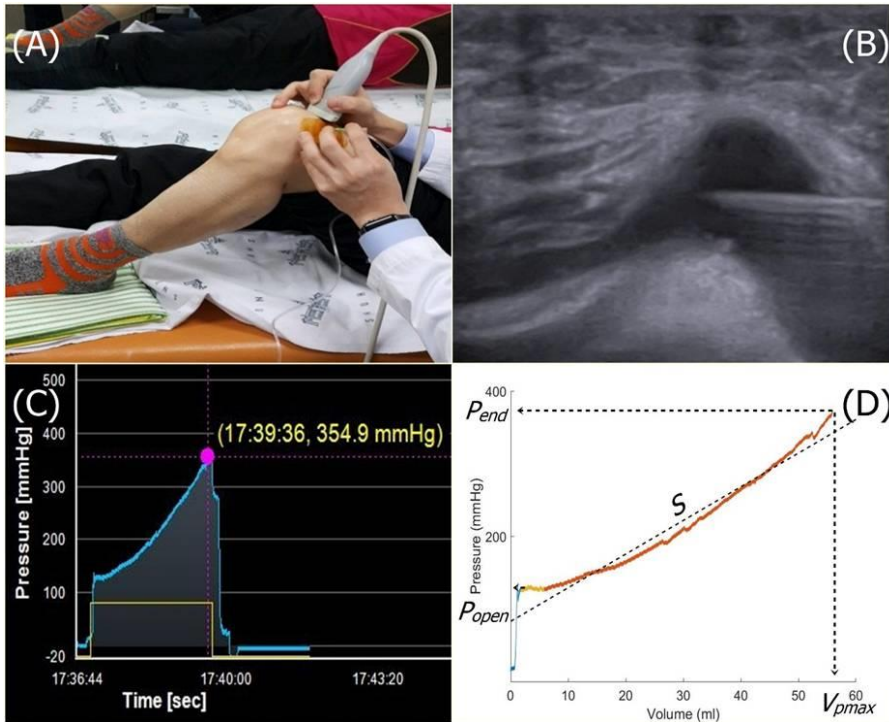


Fig. 1. Insert needle to suprapatellar synovial recess at 90 degrees knee flexion during constant-volume-speed injection (A). The ultrasonography demonstrate exact intra-articular position of needle (B). Generated data from real-time pressure monitor (C) were processed to pressure-volume curve by a MATLAB software (D). The maximum pressure ($P_{max} = P_{end} - P_{open}$), volume (V_{pmax}) at the P_{max} , and slope (S) of rising section (orange curve), were measured.

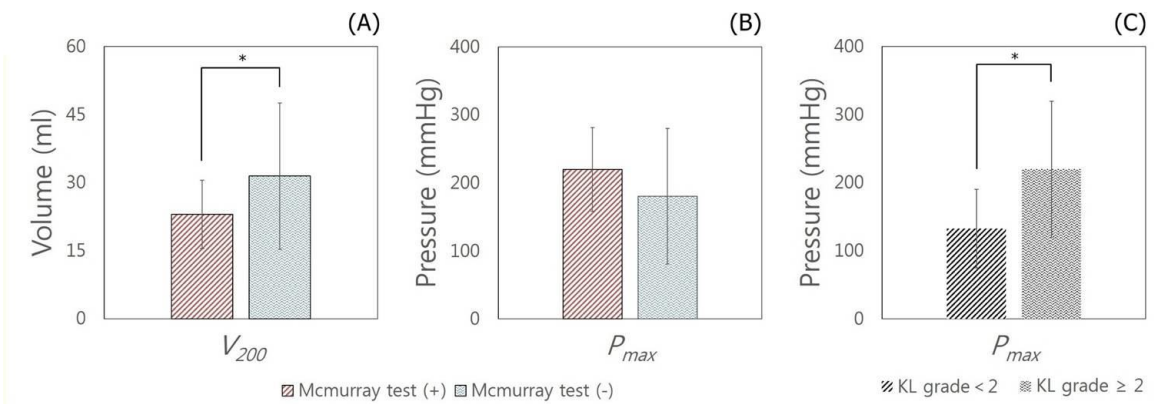


Fig. 2. Comparison of injected volume (V_{200}) at 200 mmHg (A) and maximum pressure (P_{max}) (B). The subjects with positive McMurray's test showed lower V_{200} and higher P_{max} compared with the negative ones. P_{max} also higher at the osteoarthritic knees which more than KL grade 2 (C). * $p < 0.05$

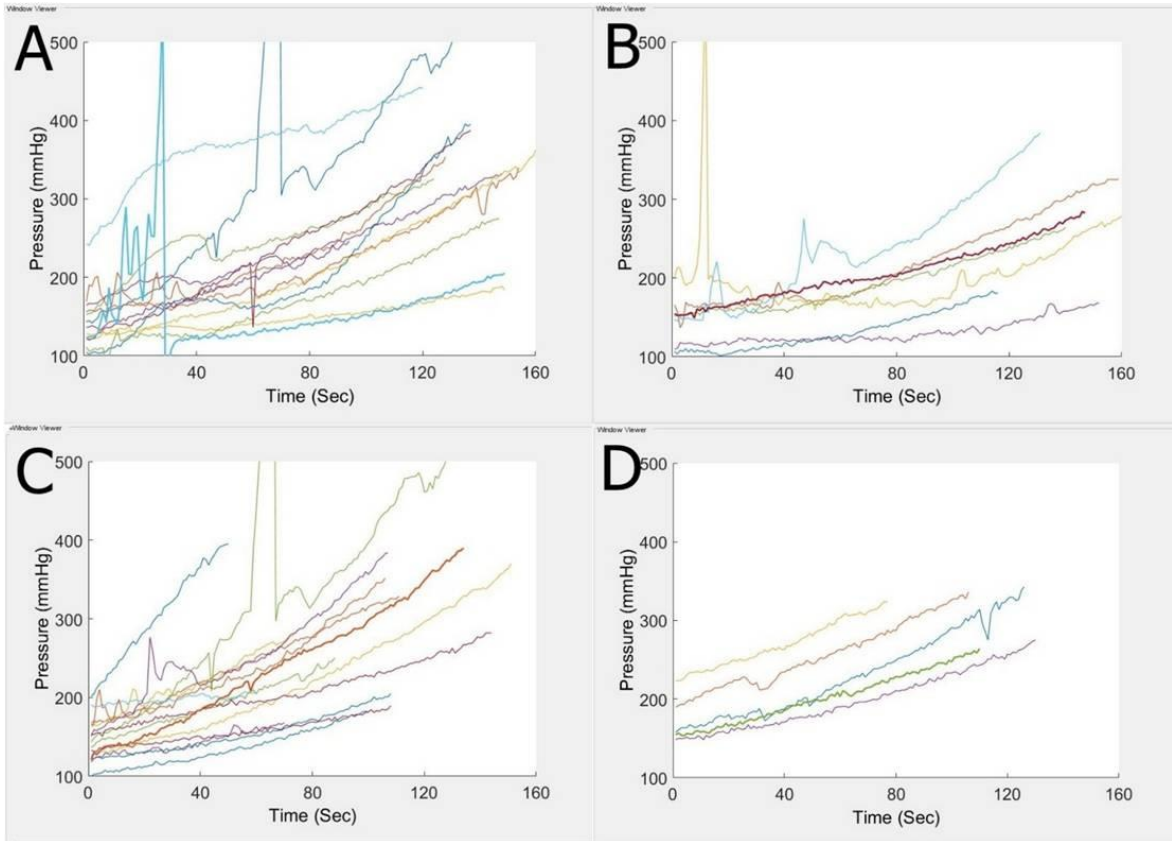


Fig. 3. The upper two stacks of pressure-time graphs show subjects with KL grade more than 2 (A) and under 2 (B). (A) graphs show higher Pmax and Pmax / Vpmax Ratio than (B) graphs ($P < 0.05$). And the both stacks of graphs below, which are rising section of each pressure-time graphs, show subjects with the positive (C) and negative (D) flexion pain test. The mean slope of (C) graphs are higher than (D) graphs, it gains no statistical significance.