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Original Article

Introduction of an easy-to-operate arthroscopic test in detecting and treatment of meniscal instability: "suction drift" test

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Abstract: Objective: To explore the surgical guidance value of "suction drift" in osteoarticular meniscal instability. Methods: The clinical data of 104 patients with significant knee symptoms following surgery were retrospectively analyzed. "Suction drift" was diagnosed in both groups. Depending on the treatment, patients treated with conventional debridement were assigned to group A, and those treated by meniscus suture until the disappearance of the "suction drift" phenomenon were included in group B. All patients were followed up for a minimum of 6 months after surgery. The postoperative Visual Analogue Scale (VAS) score, Lysholm knee score and the occurrence of meniscus-related symptoms were compared between the two groups. Results: After puncture, 78 patients (75.0%) had excessive displacement of the meniscus, with 53 (67.9%) of them being followed-up for at least 6 months. Twenty-five patients in group A and twenty-eight in group B were included in the final analysis (The number of patients with "suction drift" in two groups was tested to be comparable, P>0.05). VAS score was significantly decreased and Lysholm knee score was markedly increased in both groups after treatment, with lower VAS score and higher Lysholm knee score in group B compared with group A. In addition, group A had a significantly higher incidence of meniscus-related symptoms (joint space tenderness, joint clicks, and noose sensation) than group B. Conclusions: "Suction drift" is a quick and easy-to-operate arthroscopic test, which can not only diagnose meniscus instability due to knee osteoarthrosis-induced meniscus degeneration, but also help determine the recovery of meniscus stability after suture, and significantly relieve symptoms.

Keywords: Osteoarthrosis, arthroscopy, suction drift

Introduction

Knee meniscus, a fibrocartilage structure between the tibia and the femur, plays a role in cushioning pressure, transmitting load, making femoral and tibial joints more matched, and synergistically lubricating articular cartilage [1-3]. The meniscus is essential in the protection of tibiofemoral articular cartilage [4, 5] and allows free knee joint movement. Meniscus injuries in young adults mainly result from acute sports injuries and can be associated with anterior cruciate ligament injury [6, 7]; while degeneration of the meniscus is a major cause in older adults [8, 9]. According to epidemiological data, the risk of meniscus degeneration increases with age and may affect 16% of women aged 50-59 and over 50% of men aged 70-90 [10]. Knee meniscus injury can affect knee function and joint stability, and even lead to knee cartilage damage [11, 12]. Thus, exploring and optimizing related detection methods is necessary for reducing the adverse effects of meniscal degeneration and injury on patient clinical outcomes.

Meniscus degeneration usually leads to meniscal extrusion [13], a typical medial meniscus posterior root tear that causes loss of the chondroprotective function of the meniscus and osteoarthritis progression [14-17]. However, magnetic resonance imaging (MRI) has little value in the diagnosis of such a condition [18, 19]. Shin et al. believe that lateral meniscus instability and hypermobility can be confirmed when the meniscus shifts more than 50% dur-

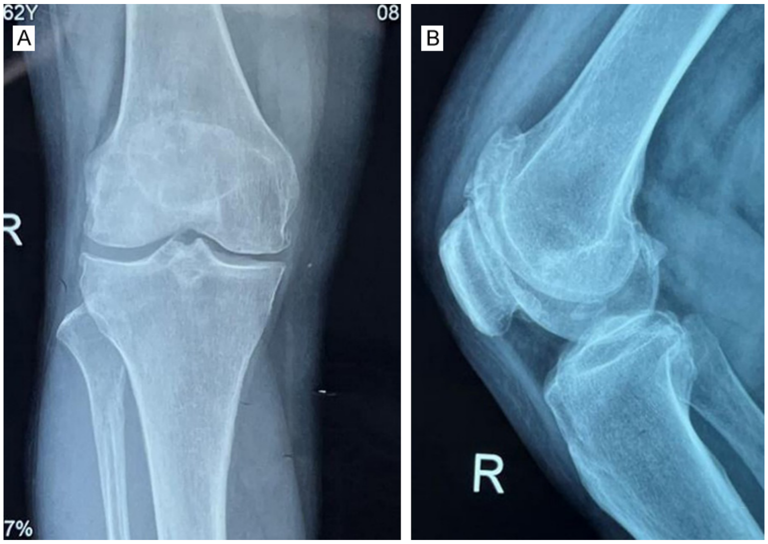

Figure 1. Kellgren-Lawrence grade I-III knee osteoarthrosis. A. Coronal X-ray of right knee. B. Sagittal X-ray of right knee.

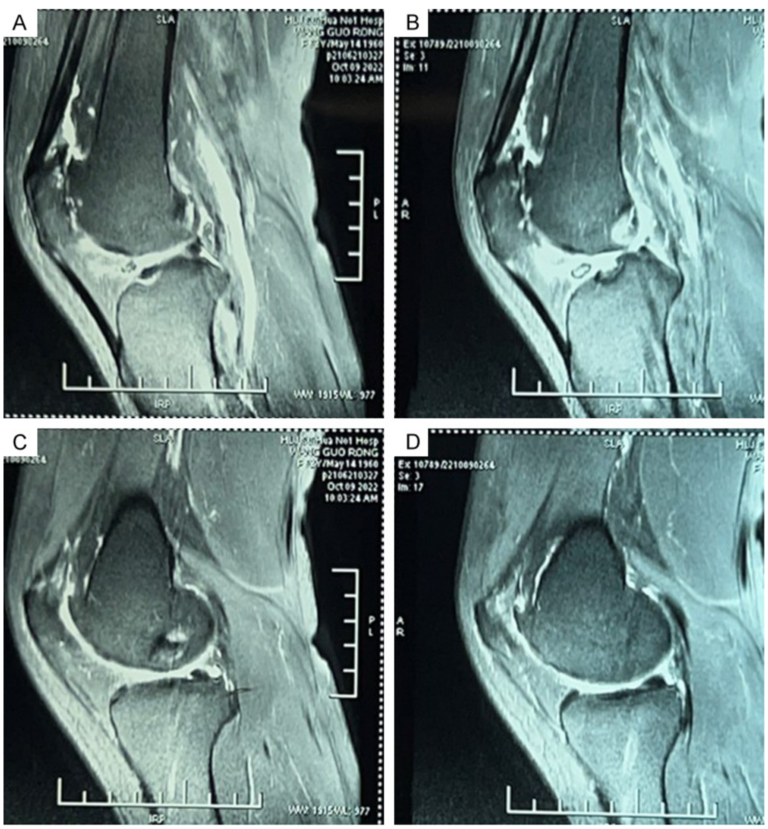

Figure 2. Magnetic resonance imaging of knee joint (no obvious meniscal injury or tear). A. No obvious tear in lateral meniscus. B. No obvious tear in lateral meniscus. C. No obvious tear in medial meniscus. D. No obvious tear in medial meniscus.

ing arthroscopic exploration [20]. However, this method has great limitation and can only determine the lateral meniscus instability caused by the suspension mechanism injury of the posterior lateral meniscus [21], warranting optimization during arthroscopic exploration. “Suction drift” is a meniscal abnormality that can be displaced by the suction function of a shaver, and meniscus instability can be determined when the displacement reached a certain degree. The purpose of this study is to diagnose the medial and lateral meniscus instability caused by knee osteoarthrosis by means of a special sign (“suction drift”) under arthroscopy, and to confirm whether the stability is restored after suture and can be instructive for surgery.

Methods

General information

This study was approved by the ethics committee of the Second Affiliated Hospital of Harbin Medical University. We retrospectively analyzed the clinical data of 104 patients who underwent knee arthroscopy in the Second Affiliated Hospital of Harbin Medical University from June 2016 to June 2019. Among them, 44 were males and 60 were females, aged between 40 and 65, with an average age of 58.6 years old.

Inclusion criteria: Patients diagnosed with Kellgren-Lawrence (KL) grade I-III knee osteoarthrosis (**Figure 1**); Patients with presence of knee osteoarthrosis symptoms such as knee pain, as well as symptoms and signs caused by meniscus lesions such as knee clicks, joint space tenderness, with or without McMurray (+); Patients without obvious meniscal injury or tear detected by MRI (**Figure 2**); Patients who completed 6-week, 3-month, and

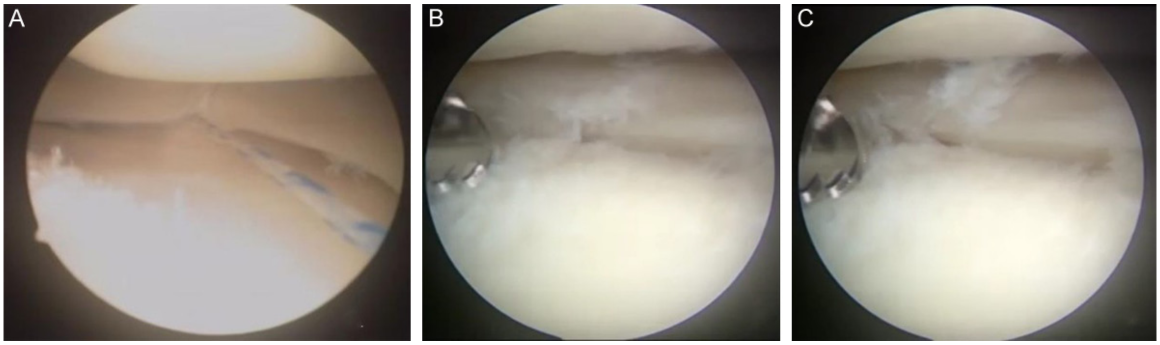

Figure 3. Arthroscopic approach of the knee joint. A. Meniscal suture. B. Meniscus position when the shaver aspirator is closed. C. Meniscus position when the shaver aspirator is opened.

Figure 4. Examination of patellofemoral joint, suprapatellar bursa, and cruciate ligament.

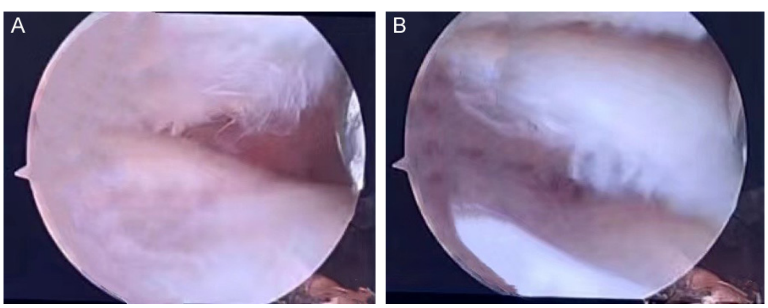

Figure 5. "Suction drift" examination of the meniscus using a shaver. A. Meniscus position when the shaver aspirator is closed. B. Meniscus position when the shaver aspirator is opened.

6-month outpatient follow-ups; Intraoperative confirmation of "suction drift" (forward-oriented movement of the meniscus for more than 3 mm, see *"Suction drift" detection* of *1.2 Arthroscopy methods* for details).

Exclusion criteria: Patients complicated with rheumatoid arthritis or other orthopedic diseases; Patients with contraindications to the intervention used in this study; Patients with incomplete medical records; Patients with immune system disease or infectious disease; Patients with malignant tumors or severe organ dysfunction; pregnant or lactating women.

Depending on the treatment, patients were divided into the following two groups: group A that were treated with conventional debridement of the knee joint without meniscus suture, and group B that treated with additional meniscus suture using the Fast-fix Meniscal Repair System (Smith & Nephew, USA) until the disappearance of the "suction drift" phenomenon (**Figures 3-5**).

Arthroscopy methods

All procedures were performed by the same doctor (Dr. Pan). We propose a quick and easy-to-operate arthroscopic test, named "suction drift", to evaluate potential meniscus instability caused by meniscal degeneration in knee osteoarthrosis. During arthroscopic surgery, all patients underwent arthroscopic surgery in the supine position under general or spinal anesthesia.

Routine exploration of the knee joint was conducted via standard anterolateral and anteromedial arthroscopic knee approaches, covering the patellofemoral joint, suprapatellar bursa, and cruciate ligament.

"Suction drift" detection: Free bodies and cartilage fragments in the knee joint were cleaned, and hyperplastic and diseased synovium were removed. Next, the medial and lateral meniscus were explored carefully. The overall morphology of the meniscus was first observed, and various parts of the meniscus were explored with a hook, with no obvious injury or tear of the meniscus was found. Then, by using the suction function of a shaver, "suction drift" examination on the meniscus was performed. Forward-oriented movement of the meniscus for more than 3 mm was defined as "suction drift" positive, representing meniscus instability.

Treatment methods

Group A received conventional knee debridement: Patients were placed in the supine position for epidural anesthesia. The tourniquet was tied at the root of the thigh, and the anteromedial and anterolateral patellar ligaments were selected as surgical approaches. An arthroscope was implanted, the joint was irrigated, and arthroscopic exploration was performed, followed by the removal of diseased tissue and cartilage and cartilage fragments. Then, the joint surface was trimmed with radio frequency, planer tool and nucleus pulposus, the cartilage was polished, and the loose bodies were removed. The joint cavity was then washed and aspirated. Pressure bandaging and 12 h of ice compress were performed after incision closure. The drainage tube was removed 48 h after surgery.

Group B received additional meniscal sutures: Patients were placed in a supine position with epidural anesthesia. A 1-cm surgical incision was made at the lateral 1 cm and the medial 1 cm of the patellar ligament, which served as a viewing hole and an operation hole, respectively. Then, a knee arthroscope was inserted through the viewing hole to check the damaged meniscus. Thereafter, a meniscus file was inserted through the operation hole, and the damaged wound of the meniscus was planned and trimmed to a shape close to the normal meniscus, followed by the application of negative pressure to remove debris in the patient's knee joint cavity. The appropriate suture method was selected according to the patient's meniscus injury. Then, the patient's knee cavity was flushed with saline, and an indwelling drainage tube was placed. Finally, the surgical incision was closed.

Clinical assessment

The primary outcome measures included the Lysholm Knee Score, Visual Analog Scale (VAS), and meniscus injury-related symptoms in both groups. The Lysholm Knee Score [22] was used for knee function evaluation before and 6 months after surgery, with a score ranging from 0 to 100; higher score suggests better knee function. Patients' pain was assessed before and 6 months after surgery using the Visual analog scale (VAS) [23]. On a 10-point scale, a higher score indicates a higher pain level. Finally, meniscus injury-related symptoms, including knee clicks, noose sensation, and joint space tenderness, were observed and recorded.

Statistical analyses

Quantitative data were expressed as mean ± standard deviation, and count data were described as n (%). A t-test was used to compare the differences in Lysholm and VAS scores between groups A and B, and paired t-tests were performed to identify differences before and after treatment within groups. Meniscus-related symptoms and signs were compared between groups using a chi-square test. Data analysis and visualization were performed using Graphpad Prism 7.0 (GraphPad Software, San Diego, USA). The difference was statistically significant at $P<0.05$.

Results

Comparison of baseline data

After puncture, 78 (75.0%) of the 104 patients had excessive meniscus displacement, with 53 (67.9%) of them being followed-up for at least 6 months. Twenty-five patients in group A and 28 patients in group B were finally included in this study (The two groups were tested and found to have a comparable number of patients with "suction drift", $P>0.05$). The comparative analysis of baseline data between the two groups revealed no significant differences in age,

Table 1. Comparison of baseline data between the two groups

Factors	Group A (n=25)	Group B (n=28)	T value/chi-square value	*P* value
Age (years)	56.68±7.27	57.36±4.99	0.386	0.702
Course of disease (months)	6.14±1.84	5.73±1.90	0.775	0.442
Gender (male/female)	11/14	8/20	1.367	0.242
Site of injury (left knee/right knee)	16/9	13/15	1.646	0.200
Education level (high school and above/below high school)	8/17	5/23	1.427	0.232

Table 2. Comparison of VAS and Lysholm scores

Groups	VAS (points)		Lysholm (points)	
	Before surgery	6 months after operation	Before surgery	6 months after surgery
Group A (n=25)	5.52±1.72	4.16±1.38*	51.46±5.70	66.47±7.47*
Group B (n=28)	5.32±1.72	3.26±1.17*	51.81±7.63	80.92±4.6*
T value	0.411	2.487	0.184	8.236
P value	0.683	0.016	0.855	<0.001

Note: VAS, Visual Analogue Scale. *P<0.05 versus preoperative level.

Table 3. Comparison of meniscus injury-related symptoms between two groups

Factors	Group A (n=25)	Group B (n=28)	Chi-square value	*P* value
Knee clicks	4 (16.00)	1 (3.57)	-	-
Noose sensation	3 (12.00)	1 (3.57)	-	-
Joint space tenderness	2 (8.00)	0 (0.00)	-	-
Total	9 (36.00)	2 (7.14)	6.687	0.010

course of disease, sex, site of injury, and education level between the two groups (all P>0.05, **Table 1**), indicating that the two groups were comparable.

Comparison of VAS and Lysholm scores

The effects of the two treatment methods on knee function and pain levels were assessed separately by using the VAS and Lysholm knee score, respectively. No significant differences were identified between groups in preoperative VAS and Lysholm scores (both P>0.05); postoperatively, the VAS score was reduced and Lysholm knee score was increased in both groups (both P<0.05), with even lower VAS score and higher Lysholm knee score in group B (P<0.05). See **Table 2** for details.

Comparison of meniscal injury-related symptoms

The observation of meniscal injury-related symptoms such as knee space tenderness, joint clicks, and noose sensation in the two groups showed that the incidence of the above symptoms was significantly lower in group B than in group A (7.14% vs. 36.00%, P<0.05). See **Table 3** for details.

Discussion

Normal meniscus anatomy is divided into anterior horn, body, and posterior horn. The anterior and posterior horns anchor the meniscus on the tibial plateau, thereby maintaining the biomechanical stability of the meniscus [24-26]. Injury or degeneration of the meniscus can disrupt this stability, leading to meniscus instability that is difficult to be detected by MRI and corresponding symptoms [27, 28]. In the study of Kramer DE et al. [29], it was also pointed out that MRI was not as effective as clinical examination and difficult to detect for the stability of the discoid meniscus, coupled with the insidious nature of some incomplete discoid meniscus abnormalities, suggesting limited diagnostic value of MRI in meniscal instability.

In this study, meniscus instability was qualitatively assessed by “suction drift” testing. The “suction drift” detection method first determines that there is no obvious meniscus damage and tear through the observation of the overall morphology of the meniscus and the local exploration using a hook, and then determines the meniscus instability by using the suction function of the shaver to test the degree of meniscus displacement. In this study, meniscus instability was determined by meniscus displacement exceeding 3 mm. The results of our study showed that 78 cases (75.0%) of the 104 cases had excessive meniscus displacement after puncture, suggesting that the "suction drift" detection method has potential diagnostic value for meniscus instability in knee arthropathy patients without obvious meniscus injury or tear. The method adopted in the study can clearly diagnose meniscus instability and lay a foundation for further treatment. Jacquet C et al. [30] used the translation of the lateral meniscus over 50% or beyond the equator of the lateral condyle of the femur as criteria for meniscus instability, and performed similar suction tests with the help of the suction of a shaver. They confirmed that this method was superior to exploratory tests in diagnosing lateral meniscal posterior horn instability in patients with anterior cruciate ligament (ACL) injury, similar to our results. In the study of Wang JH et al. [31], it was also reported that the diagnostic value of "suction drift" detection in patients with acute ACL injury and suspected arthrothermohema was significantly higher than that of the Lachman test, mainly because it had a higher test positivity rate. On the other hand, the VAS and Lysholm knee score were used to evaluate the effects of meniscus suture on the knee function and pain level of patients, respectively. Patients in group B were found to have significantly lower post-treatment VAS scores and higher Lysholm knee scores than pre-treatment values and group A, suggesting that meniscus suture can significantly improve knee function and relieve pain in patients with meniscus instability. The evaluation results of meniscus injury-related symptoms showed that the incidence of knee space tenderness, joint clicks and noose sensation was significantly lower compared with group A (7.14% vs. 36.00%), indicating that meniscus suture is conducive to meniscus stability and recovery of normal biomechanical effects, and can prevent the occurrence of related symptoms to a certain extent. After the meniscus suture, the morphology of the meniscus can be stabilized, and the original biomechanical effect of the meniscus can be maintained, contributing to good efficacy. According to Dong YL et al. [32], bone tunnel suture under arthroscopy in patients with posterior lateral meniscus root tears can significantly reduce pain and reduce the risk of postoperative complications, which is consistent with our findings. Another study indicated that meniscus suture in patients with meniscus tears could not only reduce complications, but also promote postoperative functional recovery [33], which supports our study results.

This study has the following advantages: (1) Being simple and easy to perform under arthroscopy, "suction drift" can quickly determine whether the meniscus is stable. (2) When diagnosing the instability of the meniscus, this exploration method also allows examination of the restoration of biomechanical stability of the sutured meniscus, because the recovery of stability leads to better efficacy and has guiding significance for surgery. (3) The method proposed here is different from the "the aspiration test" proposed by Christophe Jacquet et al., and the research object of this study is the instability of the entire medial or lateral meniscus caused by meniscus injury, tear, or degeneration, not limited to the lateral meniscus instability due to the damage of the lateral meniscus posterior angle suspension mechanism.

Of course, there are also some shortcomings: (1) Due to the relatively short follow-up time, the long-term postoperative efficacy needs further research. (2) The sample size is relatively small, so it is necessary to include more cases for further analysis. (3) The diagnostic and surgical guidance value of "suction drift" in osteoarticular meniscal instability has not been specifically analyzed by ROC analysis, warranting supplementary analysis in future studies.

In conclusion, "suction drift" is a quick and easy arthroscopic test, which can not only detect meniscus instability caused by knee osteoarthrosis-induced meniscus degeneration but also detect the restoration of the meniscus stability after suture during surgery, with better efficacy. To our knowledge, "suction drift" sign is the first under-arthroscopic test trying to determine meniscus instability in patients with degenerative osteoarthritis of the knee.

Disclosure of conflict of interest

None.

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