# Evaluation of the Novel Puncture Capsulotomy Technique for Hip Arthroscopy

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## BACKGROUND AND OBJECTIVES

- For patients with femoroacetabular impingement (FAI), hip arthroscopy has become the standard treatment due to faster post-operative recovery, fewer complications, and reduced morbidity with similar efficacy when compared to open procedures.
- Multiple arthroscopic techniques have been developed to enhance surgical field visualization, minimize iatrogenic hip instability, and optimize patient outcomes.
- The most common surgical approaches in hip arthroscopy are interportal capsulotomy and T-capsulotomy. However, these techniques introduce iatrogenic capsuloligamentous instability due to transection of the iliofemoral capsule ligament.
- To avoid iatrogenic injury to the capsuloligamentous structures, the senior author published a novel technique, puncture capsulotomy, that involves preservation of the biomechanics of the hip joint, namely the iliofemoral ligament.
- This approach incorporates careful placement of multiple, small portals in a manner that negates the necessity of an extended capsulotomy while still maximizing visualization.
- Theoretical advantages of this innovative approach include preservation of native hip biomechanics, elimination of anterior dislocation risk, minimal disruption of soft tissues therefore decreasing the risk of heterotopic ossification and eliminating the need for postoperative range-of-motion restrictions.
- The primary aim of this study is to evaluate the mid-term functional outcomes associated with the novel puncture capsulotomy technique in the treatment of labral tears, along with any osseous pathology resulting in femoroacetabular impingement.

## METHODS

- This is a case series of patients undergoing hip arthroscopy with puncture capsulotomy by a single surgeon between December 2013 and May 2019.
- Patients were included in this study if they met the following criteria: 18 years or older, consented to hip arthroscopy performed by the senior author, and completed a minimum of two years of patient-reported outcome measure (PROM) surveys post-procedure.
- Intraoperatively, patients underwent hip arthroscopy via puncture capsulotomy to treat labral tears and any concomitant femoroacetabular impingement.
- Clinical outcome data consisted of patient-reported outcome measures.
- All patients analyzed in this study underwent the same strict postoperative rehabilitation protocol.

### Surgical Technique of Portal Placement

- Under fluoroscopic guidance, the anterolateral portal is created 1cm anterior to the greater trochanter at approximately 15-20° cephalad, parallel to the floor.
- Next, via arthroscopic visualization, the anterior portal is formed. As a guideline for determining the skin location for the anterior portal, a vertical line is drawn at the anterior superior iliac spine and a horizontal line is drawn at the level of the anterolateral portal. The location for the anterior portal is the intersection of these two lines.
- To confirm accurate portal placement, the scope is switched to the anterior portal for visualization of the original anterolateral portal, which can then be adjusted as needed to ensure access to both the central and peripheral compartments, along with avoidance of labrum insult.
- Then, at an equal distance from the anterior and anterolateral portals, the midanterior portal is placed distally. Lastly, at one-third the distance between the anterior superior iliac spine and the anterolateral portal, the Dienst portal is positioned, thus finalizing a quadrilateral arrangement with the other portals on the skin.

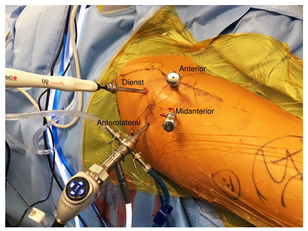


**Figure 1.** Quadrilateral arrangement of portals (right hip in the supine position)

## RESULTS

- This study included a total of 163 hips that met inclusion criteria.
- The study population consisted of 84 (51.5%) female and 79 (48.5%) male hips with a mean age of 37.9 (95% CI: 36.1-39.6) years. The mean BMI was 25.9 (25.2-26.5) kg/m$^2$.
- Preoperative imaging demonstrated that 85 (52.1%) hips had a pincer pathology, while 47 (28.8%) hips had a combined pincer and cam lesion.
- Intraoperatively, 150 (92.0%) hips underwent labral repair and 13 (8.0%) hips underwent labral debridement.
- For FAI, 82 (50.3%) hips underwent an acetabuloplasty while 53 (32.5%) underwent femoroacetabuloplasty.
- 69.3% of hips were Tönnis Grade 1 or worse. The median Outerbridge Grade was 3.

**Table 1.** Prospectively collected PROMs at enrollment, 3-months, 6-months, 12-months and FFU

| | | Mean | 95% CI | | P Value |
|---|---|---|---|---|---|
| **mHHS** | Enrollment | 60.1 | 57.8 | 62.3 | - |
| | 3-months | 75.7 | 73.5 | 77.8 | <0.001* |
| | 6-months | 80.6 | 78.6 | 82.6 | <0.001* |
| | 12-months | 84.9 | 82.9 | 86.9 | <0.001* |
| | FFU | 84.9 | 82.5 | 87.2 | <0.001* |
| **HOS-ADL** | Enrollment | 69.9 | 66.9 | 72.9 | - |
| | 3-months | 79.9 | 77.8 | 82.0 | <0.001* |
| | 6-months | 86.0 | 84.0 | 87.9 | <0.001* |
| | 12-months | 88.9 | 87.0 | 90.8 | <0.001* |
| | FFU | 89.3 | 87.3 | 91.3 | <0.001* |
| **HOS-Sport** | Enrollment | 41.5 | 37.7 | 45.4 | - |
| | 3-months | 41.8 | 37.1 | 46.4 | 0.410 |
| | 6-months | 63.2 | 58.8 | 67.5 | <0.001* |
| | 12-months | 72.0 | 67.9 | 76.1 | <0.001* |
| | FFU | 75.7 | 71.7 | 79.7 | <0.001* |
| **iHOT-33** | Enrollment | 39.6 | 36.8 | 42.4 | - |
| | 3-months | 60.5 | 57.7 | 63.3 | <0.001* |
| | 6-months | 69.4 | 66.4 | 72.4 | <0.001* |
| | 12-months | 74.4 | 71.1 | 77.7 | <0.001* |
| | FFU | 76.1 | 72.7 | 79.6 | <0.001* |
| **VAS** | Enrollment | 6.3 | 5.9 | 6.7 | - |
| | 3-months | 2.8 | 2.5 | 3.1 | <0.001* |
| | 6-months | 2.4 | 2.1 | 2.8 | <0.001* |
| | 12-months | 2.4 | 2.0 | 2.8 | <0.001* |
| | FFU | 2.2 | 1.8 | 2.6 | <0.001* |

* Statistically significant (α = 0.05), reference: Enrollment

Abbreviations: modified Harris Hip Score (mHHS), Hip Outcome Score-Activities of Daily Living (HOS-ADL), Hip Outcome Score-Sports Specific Subscale (HOS-Sport), International Hip Outcome Tool (iHOT-33), Visual Analog Scale (VAS)

- The average final follow-up (FFU) was 30.4 (95% CI: 28.5-32.3) months.
- There were significant improvements in mean enrollment compared to final follow-up scores for the iHOT-33 [39.6 (36.8-42.4) vs. 76.1 (72.7-79.6)], HOS-ADL [69.9 (66.9-72.9) vs 89.3 (87.3-91.3)], mHHS [60.1 (57.8-62.3) vs. 84.9 (82.5-87.2)] and HOS-Sport [41.5 (37.7-45.4) vs. 75.7 (71.7-79.7)], (p<0.001 for all). (Table 1)
- VAS pain scores were noted to significantly improve throughout the duration of the postoperative period [6.3 (5.9-6.7) to 2.2 (1.8-2.6)], (p<0.001).
- At 2-year follow-up, 81.0%, 62.0%, 58.9% of hips achieved clinically meaningful iHOT-33 thresholds for Minimally Clinically Important Difference (MCID), Patient Acceptable Symptom State (PASS) and Substantial Clinical Benefit (SCB), respectively.
- There were no incidences of infection, avascular necrosis of the femoral head, dislocation/instability, or femoral neck fracture. (Table 2)
- Two patients underwent total hip arthroplasty during their respective follow-up periods due to cartilage degeneration.

**Table 2.** Incidences of Complications Following Hip Arthroscopy via Puncture Capsulotomy

| Complications | N | |
|---|---|---|
| None | 143 | 87.7% |
| Heterotopic Ossification | 11 | 6.7% |
| Deep Venous Thrombosis | 3 | 1.8% |
| Transient Neuropraxia | 3 | 1.8% |
| Trochanteric Bursitis | 1 | 0.6% |
| Total Hip Arthroplasty | 2 | 1.2% |
| Infection | 0 | 0.0% |
| Avascular Necrosis of the Femoral Head | 0 | 0.0% |
| Dislocation/Instability | 0 | 0.0% |
| Femoral Neck Fracture | 0 | 0.0% |

## CONCLUSIONS

- The novel puncture capsulotomy approach for hip arthroscopy demonstrated significantly improved functional outcomes at a minimum of two-years follow-up.
- This improvement was seen across all prospectively collected PROMs (mHHS, HOS-ADL, HOS-Sport, and iHOT-33) and adds to the growing body of literature evaluating alternative techniques for hip arthroscopy.
- Regarding pain relief, VAS pain scores were noted to significantly improve throughout the duration of the postoperative period.
- Clinically, puncture capsulotomy illustrated favorable outcomes that exceeded MCID, PASS and SCB thresholds in a majority of patients.
- There was no incidence of hip dislocation/instability.
- Puncture capsulotomy addresses the clinical demand for an alternative arthroscopic approach that maintains capsuloligamentous integrity, provides appropriate osseous visualization and generates excellent functional outcomes.

## LIMITATIONS AND FUTURE DIRECTIONS

- There was no comparison arm and the comparative efficacy of puncture capsulotomy to other techniques was not directly assessed.
- Nevertheless, puncture capsulotomy had comparable to greater improvements in all PROM scores compared with published results of other techniques (interportal and T-capsulotomy), despite patients having greater baseline cartilage damage.
- Although this study did not report any hip dislocations, the puncture capsulotomy technique has not been biomechanically tested - thus, testing is needed to confirm its biomechanical advantage.
- As with hip arthroscopy in general and each new technique, there may be a learning curve. Puncture capsulotomy may be more challenging than other techniques, especially for addressing femoral lesions.
- Patients undergoing hip arthroscopy by the senior surgeon understood the novel technique and theoretical benefits, making them susceptible to bias.
- Long-term evaluation of outcomes is warranted to completely encompass the benefits of puncture capsulotomy.

## FUNDING SOURCE

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## KEY REFERENCES

1. Chambers CC, Monroe EJ, Flores SE, Borak KR, Zhang AL. Periportal Capsulotomy: Technique and Outcomes for a Limited Capsulotomy During Hip Arthroscopy. *Arthroscopy - Journal of Arthroscopic and Related Surgery*. 2019;35(4):1120-1127. doi:10.1016/j.arthro.2018.10.142
2. Conaway WK, Martin SD. Puncture Capsulotomy During Hip Arthroscopy for Femoroacetabular Impingement: Preserving Anatomy and Biomechanics. *Arthroscopy Techniques*. 2017;6(6):e2265-e2269. doi:10.1016/j.eats.2017.08.036
3. Domb BG, Chaharbakhshi EO, Perets I, Walsh JP, Yuen LC, Ashberg LJ. Patient-Reported Outcomes of Capsular Repair Versus Capsulotomy in Patients Undergoing Hip Arthroscopy: Minimum 5-Year Follow-updA Matched Comparison Study. *Arthroscopy: The Journal of Arthroscopic and Related Surgery*. 2018;34(3):853-863. doi:10.1016/j.arthro.2017.10.019
4. Ekhtiari S, de Sa D, Haldane CE, et al. Hip arthroscopic capsulotomy techniques and capsular management strategies: a systematic review. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2017;25(1):9-23. doi:10.1007/s00167-016-4411-8
5. Monroe EJ, Chambers CC, Zhang AL. Periportal Capsulotomy: A Technique for Limited Violation of the Hip Capsule During Arthroscopy for Femoroacetabular Impingement. *Arthroscopy Techniques*. 2019;8(2):e205-e208. doi:10.1016/j.eats.2018.10.015
6. Cvetanovich GL, Weber AE, Kuhns BD, et al. Hip Arthroscopic Surgery for Femoroacetabular Impingement With Capsular Management Factors Associated With Achieving Clinically Significant Outcomes. doi:10.1177/0363546517739824
7. Frank RM, Lee S, Bush-Joseph CA, Kelly BT, Salata MJ, Nho SJ. Improved Outcomes After Hip Arthroscopic Surgery in Patients Undergoing T-Capsulotomy With Complete Repair Versus Partial Repair for Femoroacetabular Impingement A Comparative Matched-Pair Analysis. doi:10.1177/0363546514548017
8. McGovern RP, Bucci G, Nickel BA, Ellis HB, Wells JE, Christoforetti JJ. Arthroscopic Capsular Management of the Hip: A Comparison of Indications for and Clinical Outcomes of Periportal Versus Interportal Capsulotomy. *Arthroscopy - Journal of Arthroscopic and Related Surgery*. 2021;37(1):86-94. doi:10.1016/j.arthro.2020.08.004
9. Levy DM, Kuhns BD, Frank RM, et al. High Rate of Return to Running for Athletes After Hip Arthroscopy for the Treatment of Femoroacetabular Impingement and Capsular Plication. doi:10.1177/0363546516664883
10. Parvaresh K, Rasio JP, Martin RL, et al. Achievement of Meaningful Clinical Outcomes Is Unaffected by Capsulotomy Type During Arthroscopic Treatment of Femoroacetabular Impingement Syndrome Results From the Multicenter Arthroscopic Study of the Hip (MASH) Study Group. doi:10.1177/0363546520987226