Influence of Tönnis grade on outcomes of arthroscopy for FAI in athletes: a comparative analysis

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ABSTRACT

Based on a previously reported study, it is hypothesized that Tönnis 2 changes may not be a harbinger of poor results. The purpose is to report outcomes comparing Tönnis 2 changes to those with Tönnis 0&1 changes. Previously published outcomes (modified Harris Hip Score and return to sport) among 200 consecutive athletes undergoing arthroscopic correction of femoroacetabular impingement with minimum 1-year follow-up were correlated with the Tönnis grade. Independent variables of gender and age were also evaluated. Average age was 28.6 years (range 11–60), with 148 males and 52 females. The average improvement was Tönnis 0 23.1 points (n = 37), Tönnis 1 20.6 points (n = 113) and Tönnis 2 16.4 points (n = 48). A trend (P = 0.055) towards lower scores with increasing Tönnis grade was not statistically significant. There was both statistically (P < 0.01) and clinically (> 8 patients) significant improvement across all Tönnis grades, and there was no statistically significant difference between Tönnis 0 and 1 compared with Tönnis 2 (P = 0.078). The percent that returned to sport was as follows: Tönnis 0 95%, Tönnis 1 92% and Tönnis 2 85%. A trend (P = 0.098) towards lower rates of return to sport with increasing Tönnis grade was not statistically significant, and there was no statistically significant difference between Tönnis 0 and 1 compared with Tönnis 2. Within each grade, there was no correlation with age, such that increasing age did not reflect lower scores. There was also no correlation with gender. Statistically and clinically successful outcomes can be encountered among athletes with Tönnis 2 radiographic features.

INTRODUCTION

Evidence supports that <2 mm of joint space and grade 3 Tönnis changes are indicators of poor outcomes of hip arthroscopy and represent objective contraindications to the procedure [1, 2]. Other studies have implicated Tönnis 2 changes as a similar contraindication, but none of these looked specifically at the influence of Tönnis 2 [3–7].

Domb et al. in a systematic review noted a 23% rate of conversion to arthroplasty among patients with arthritis compared with 8.3% among non-arthritic patients [8]. Subsequently, the senior author of that study reported a 40.5% conversion rate to arthroplasty among patients with grade 2 Tönnis changes compared with 10.8% rate of conversion among a matched group with Tönnis 0 or 1 changes [9].

Among athletes, several studies have commented on the negative implications of arthritis and advanced chondral damage [10–13]. However, none have looked specifically at the influence of Tönnis changes on patient-reported outcomes or return to play.

In 2011, Byrd et al. published their earliest experience in the arthroscopic management of femoroacetabular impingement (FAI), reporting on the first 100 consecutive patients with 2-year follow-up [14]. Among this group, the rate of conversion to arthroplasty was 0%. Their earliest experience in the arthroscopic management of FAI among athletes was then reported looking at the first 200 consecutive athletes with minimum 1-year follow-up [15]. Among this group, the rate of conversion to arthroplasty was 0.5%.
**MATERIALS AND METHODS**

Byrd et al. previously published their initial experience with the first 200 consecutive athletes undergoing arthroscopic correction of FAI with minimum 1-year follow-up [15]. For this current study, these previously reported outcomes were correlated using the Tönnis system originally described by Tönnis and adopted by third party insurance carriers where the grade is determined by any of the listed features (Table 1) [16–18]. The Tönnis grade was determined independently by two experienced clinicians. These were subsequently compared, and in cases where an agreement was not reached, the lower of the two grades was used so that the Tönnis grade was not being overestimated. The influence of Tönnis on patient-reported outcomes [modified Harris Hip Score (mHHS)] and return to sport was assessed. Return to sport was defined as returning at their previous level of competition. Independent variables of gender as a categorical variable and the age as both as a continuous and categorical (those above and below the median age) variable were evaluated.

An *a priori* power analysis revealed that for a group ratio of 3-to-1, a mean difference of five points and a SD of 15 within each group, we would need 285 and 95 patients in each group, respectively, in order to yield a power of 0.80.

Paired-samples *t*-tests, independent samples *t*-tests and chi-squared analyses were utilized to determine difference between groups where applicable. In addition, Spearman and Pearson correlations were used to determine the relationship between variables. Statistical analyses were performed using SPSS v23 (SPSS, Inc., Chicago, IL, USA). Significance was set at *P* < 0.05.

**RESULTS**

The average age of this previously reported cohort was 28.6 years (range 11–60 years), with 148 males and 52 females. The level of sports participation included: 97 recreational (R), 56 intercollegiate (C), 24 high school (H) and 23 professional (P) athletes. There were 37 Tönnis 0 (14 R, 15 C, 6 H and 2 P) with an average age of 29 (range 17–52 years), including 28 males and 12 females. There were 113 Tönnis 1 (62 R, 21 C, 15 H and 15 P) with an average age of 30 years (range 11–60 years), including 88 males and 24 females. There were 48 Tönnis 2 (20 R, 19 C, 6 P and 3 H) with an average age of 27 years (range 15–49 years), including 30 males and 15 females. There were only two Tönnis 3 (1 R and 1 C), including one 24-year-old male and one 42-year-old female. The Tönnis 3 data were too small for statistical analysis as there were only these two patients each with severe femoral deformities.

The average mHHS improvement for Tönnis 0 was 23.1 points [preoperative (preop) 69.0; postoperative (postop) 92.1, 95% confidence interval (CI): 16.9–29.3, *P* < 0.001, with a range of -5 to 66 points]. Tönnis 1's averaged 20.6 points (preop 73.9; postop 94.5), 95% CI: 17.9–23.4, *P* < 0.001, with a range of -11 to 60 points. Tönnis 2's averaged 16.4 points (preop 71.6; postop 88.0, 95% CI: 11.4–21.5, *P* < 0.001), with a range of -34 to 60 points. There was a trend (*r* = -0.136, *P* = 0.055) towards lower scores with increasing Tönnis grade, but this was not statistically significant. There was both statistically (*P* < 0.001) and clinically (>8 patients) significant improvement in scores across all Tönnis grades [19]. Although the amount of improvement was greater for Tönnis 0 and 1 compared with Tönnis 2, the difference was not statistically significant (21.3 versus 16.4, 95% CI: −0.54 to 10.25, *P* = 0.078).

The percent that returned to sport was as follows: Tönnis 0, 95%; Tönnis 1, 92% and Tönnis 2, 85%. Similar to outcomes scores, there was a trend (*r* = −0.119, *P* = 0.098) towards lower rates of return to sport with increasing Tönnis grade, but it was not statistically significant. Return to sport was greater for Tönnis 0 and 1 (93%) compared with Tönnis 2 (85%), although the difference was not statistically significant (*P* = 0.139).

### Table I. Tönnis classification

| Grade | Description                                      |
|-------|--------------------------------------------------|
| 0     | No signs of arthritis                            |
| 1     | Increased sclerosis, slight narrowing of the joint space, no or slight loss of head sphericity |
| 2     | Small cysts, moderate narrowing of the joint space, moderate loss of head sphericity |
| 3     | Large cysts, severe narrowing or obliteration of the joint space, severe deformity of the femoral head |

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Within each grade, there was no correlation with age, such that increasing age did not reflect lower scores. There was also no correlation with gender.

**DISCUSSION**

The six-point difference in the amount of improvement among Tönnis 0 and 1 compared with Tönnis 2 was not statistically significant, but does approach the minimal clinically important difference value of 8.3 reported by Kemp et al. for assessing improvement following hip arthroscopy [19]. Similarly in return to sport, 93% for Tönnis 0 and 1 was not statistically different than 85% for Tönnis 2; but the difference in the rate of return to sport would seem clinically relevant when discussing the prospect of surgery with athletes. The outcomes in terms of mHHS and return to sport are lower for those with Tönnis 2 changes, but nonetheless, results from surgery are generally beneficial and not contraindicated.

The previously published cohort used as the basis of this study represents the authors’ earliest experience in arthroscopic management of symptomatic FAI that had failed conservative treatment among athletes [15]. This group mostly predated current routine strategies in labral preservation. Techniques of labral restoration were in their infancy; the healing capacity of the labrum was just being defined; the rehabilitation strategies were not well developed; and the favorable nature of repair versus resection was just beginning to be reported. Thus, these results should represent somewhat of a low standard compared with current techniques. Nonetheless, collectively, a 0.5% rate of conversion to arthroplasty and 2% reoperation rate seems very acceptable.

In the original report, Tönnis grade was not recorded. Thus, the grade alone cannot be implicated as a source of selection bias. It is the perspective of these authors that Tönnis grades are a primitive indicator of the extent of pathology accompanying FAI, and within Tönnis 2 there is likely a broad spectrum of disease.

Reporting on the influence of Tönnis grade among athletes provides two different benchmarks. First is a patient-reported outcome with the mHHS, and the second is simply whether or not the athlete was able to return to his or her sport.

No other published studies have reported on the influence of Tönnis grades on outcomes among athletes, but several have commented on the role of arthritis and advanced chondral damage. Philippon et al., in a study of 45 professional athletes, found that diffuse osteoarthritis may still allow athletes to return to low impact, but not high-impact professional sports [12]. In a study by Damasena et al., of 65 elite athletes, one was found to have significant osteoarthritis at arthroscopy and decided to retire [10]. Gomberawalla et al., in a review article of the maturing athlete, noted that osteoarthritis, especially as characterized by advanced Outerbridge changes, resulted in more modest results of arthroscopy in terms of significant incidence of persistent pain and increased risk of progression to total hip arthroplasty [11]. Sansone et al. reported on 85 top-level athletes and only one exhibited a poor outcome due to severe cartilage damage [13]. However, they did note that the more symptoms athletes experienced preoperatively, the lower the probability of returning to higher level sports, and speculated that this may be due to cartilage damage or osteoarthritis.

Regarding the other independent variables that were evaluated, these authors found no more or less favorable outcomes based on gender. Similarly, it was observed that neither younger nor advancing age was an indicator of poorer outcomes. This is consistent with previously reported observations by Byrd et al. looking at 10-year follow-up of hip arthroscopy [20]. It appeared that older patients had poorer outcomes, but when those with a diagnosis of arthritis were excluded, the results of older patients were just as good as those of younger patients. Age was not an indicator of poorer outcomes, it was simply that more older patients had clinical features of arthritis, and arthritis is a harbinger of poorer results at any age. Two methodological limitations of the study include that minimum follow-up is only 1 year, and generalizations were made about all types of FAI surgery that were then subcategorized based on Tönnis grade.

The principal limitation of this study is it is based on the results of arthroscopic management of FAI with techniques that predate some of the most current methods of labral restoration and precise bony correction. Nonetheless, even with these more primitive methods, under the correct circumstances, arthroscopic surgery, even in the presence of Tönnis 2 changes, can be favorable.

Successful outcomes in the arthroscopic management of FAI are probably less dependent on the technical aspects of performing the procedure and more substantially dependent on patient selection. With regards to selection criteria, there are a few objective contraindications; most especially <2 mm of joint space and Tönnis grade 3 changes [1, 2]. However, patient selection is likely more heavily weighted towards less well-defined subjective contraindications; most importantly, patient expectations. The best operation with ideal objective indications will still fail in the presence of unreasonable expectations on the part of the patient.
CONCLUSIONS
These data support that statistically and clinically meaningful successful outcomes can be encountered even in the presence of Tönnis 2 radiographic features in terms of patient-reported outcomes (mHHS) and return to sport in athletes. These results were inferior to those with Tönnis 0 and 1 changes, although the differences are not statistically significant. Neither gender nor age is a substantially influencing variable on these outcomes.

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CONFLICT OF INTEREST STATEMENT
J. W. Thomas Byrd is a consultant for Smith & Nephew; he is a non-paid consultant and has stock in A3 Surgical. The other authors have no conflict.

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REFERENCES
1. Philippon MJ, Briggs KK, Carlisle JC, Patterson DC. Joint space predicts THA after hip arthroscopy in patients 50 years and older. *Clin Orthop Relat Res* 2013; 471: 2492–6.

2. Horisberger M, Brunner A, Herzog RF. Arthroscopic treatment of femoral acetabular impingement in patients with preoperative generalized degenerative changes. *Arthroscopy* 2010; 26: 623–9.

3. Bogunovic L, Gottlieb M, Pashos G. Why do hip arthroscopy procedures Fail? *Clin Orthop Relat Res* 2013; 471: 2523–9.

4. Gedouin JE, May O, Bonin N et al. French arthroscopy society. assessment of arthroscopic management of femoroacetabular impingement. A prospective multicenter study. *Orthop Traumatol Surg Res* 2010; 96(Suppl): S59–67.

5. Haviv B, O’Donnell J. The incidence of total hip arthroplasty after hip arthroscopy in osteoarthritic patients. *Sports Med Arthrosc Rehabil Ther Technol* 2010; 2: 18.

6. Kim K-C, Hwang D-S, Lee C-H, Kwon S-T. Influence of femoroacetabular impingement on results of hip arthroscopy in patients with early osteoarthritis. *Clin Orthop Relat Res* 2007; 456: 128–32.

7. Larson CM, Giveans MR, Taylor M. Does arthroscopic fai correction improve function with radiographic arthritis? *Clin Orthop Relat Res* 2011; 469: 1667–76.

8. Domb BG, Gui C, Lodhia P. How much arthritis is too much for hip arthroscopy: a systematic review. *Arthroscopy* 2015; 31: 520–9.

9. Chandrasekaran S, Darwish N, Gui C et al. Outcomes of hip arthroscopy in patients with Tönnis grade-2 osteoarthritis at a mean 2-year follow-up: evaluation using a matched-pair analysis with Tönnis grade-0 and grade-1 cohorts. *J Bone Joint Surg Am* 2016; 98: 973–82.

10. Damasena I, Jamieson R, Pritchard M. Hip arthroscopy has acceptable return to sport outcomes for the elite athlete. *Open J Orthop* 2012; 02: 6–12.

11. Gomberawalla MM, Kelly BT, Bedi A. Interventions for hip pain in the maturing athlete: the role of hip arthroscopy? *Sports Health* 2014; 6: 70–7.

12. Philippon M, Schenker M, Briggs K, Kuppersmith D. Femoroacetabular impingement in 45 professional athletes: associatedopathies and return to sport following arthroscopic decompression. *Knee Surg Sports Traumatol Arthroc* 2007; 15: 908–14.

13. Sansone M, Ahldén M, Jonasson P et al. Good results after hip arthroscopy for femoroacetabular impingement in top-level athletes. *Orthop J Sports Med* 2015; 3: 232596711556969.

14. Byrd JWT, Jones KS. Arthroscopic management of femoroacetabular impingement: minimum 2-year follow-up. *Arthroscopy* 2011; 27: 1379–88.

15. Byrd JWT, Jones KS. Arthroscopic management of femoroacetabular impingement in athletes. *Am J Sports Med* 2011; (39Suppl): 75–138.

16. BlueCross BlueShield of Tennessee Medical Policy Manual-Surgical Treatment of Femoroacetabular Impingement. 2016 Mar. Available at: https://www.bcbst.com/mpmanual/Surgical_Treatment_of_Femoroacetabular_Impingement.htm. Accessed: 27 March 2018.

17. Cigna Medical Coverage Policies-Musculoskeletal Hip Surgery-Arthroscopic and Open Procedures. 2016 Jan. Available at: https://www.evicore.com/CignaClinicalGuidelines/CMM-314%20Hip%20Surgery_Arthroscopic%20and%20Open.pdf. Accessed: 27 March 2018.

18. Tönnis D. Normal values of the hip joint for the evaluation of X-rays in children and adults. *Clin Orthop Relat Res* 1976; (119): 39–47.

19. Kemp JL, Collins NJ, Roos EM, Crossley KM. Psychometric properties of patient-reported outcome measures for hip arthroscopic surgery. *Am J Sports Med* 2013; 41: 2065–73.

20. Byrd JWT, Jones KS. Prospective analysis of hip arthroscopy with 10-year followup. *Clin Orthop Relat Res* 2010; 468: 741–6.