

Impact of Joint Space Narrowing on Functional Outcomes After Hip Arthroscopy

Damián Arroquy,^{1*} María Pía Silvestrini,² Sergio Ruiz,¹ Martín Rubado,¹ Martín Botta,¹ Luciano Mañero,¹ Juan Manuel Barrios²

¹Orthopedics and Traumatology Service, Clínica María Auxiliadora, Olavarría, Buenos Aires, Argentina

²School of Health Sciences, Universidad Nacional del Centro, Olavarría, Buenos Aires, Argentina.

ABSTRACT

Introduction: Femoroacetabular impingement syndrome (FAIS) can often progress to hip osteoarthritis. Although advanced osteoarthritis is a contraindication to arthroscopy, a subgroup of patients without advanced disease who have only mild joint space narrowing may be candidates for this procedure. **Objectives:** To evaluate and compare functional outcomes in patients undergoing hip arthroscopy for FAIS with joint space narrowing (Tönnis grade 1) and those with FAIS without joint space narrowing (Tönnis grade 0). **Materials and Methods:** A retrospective review included 46 hip arthroscopies performed in 44 patients. Patients were divided into two groups according to the Tönnis classification: group A (grade 0) and group B (grade 1). Functional outcomes were assessed using the modified Harris Hip Score (mHHS) and the activities of daily living (HOS-ADL) and sports-specific (HOS-SSS) subscales of the Hip Outcome Score. **Results:** Patients in group A (without joint space narrowing) had better functional outcomes, reflected in higher functional scores, than those in group B (with joint space narrowing) ($p < 0.001$). **Conclusions:** This study suggests that joint space narrowing in patients with FAIS is associated with poorer functional outcomes after hip arthroscopy. This finding may be explained by the higher prevalence of severe chondral lesions and the difficulty of labral repair in patients with joint space narrowing.

Keywords: Hip arthroscopy; Tönnis classification; functional outcomes; cam lesion.

Level of Evidence: IV

Impacto del estrechamiento articular en los resultados funcionales de la artroscopia de cadera

RESUMEN

Introducción: El síndrome de fricción femoroacetabular (SFFA), frecuentemente puede evolucionar hacia la artrosis de cadera y, si bien la artrosis avanzada contraindica la artroscopia, existe un subgrupo de pacientes que, a pesar de no tener artrosis avanzada, muestran una leve disminución del espacio articular, lo que los convierte en candidatos para este procedimiento. **Objetivos:** Evaluar y comparar los resultados funcionales de pacientes tratados con artroscopia de cadera por SFFA con estrechamiento del espacio articular (grado 1 de Tönnis) y pacientes con SFFA sin alteración (grado 0 de Tönnis). **Materiales y Métodos:** Se llevó a cabo una revisión retrospectiva de 46 artroscopias de cadera realizadas en 44 pacientes. Se los dividió en dos grupos según la clasificación de Tönnis: grupo A (grado 0) y grupo B (grado 1). Los resultados funcionales se evaluaron con el *Harris Hip Score* modificado (HHSm), el *Hip Outcome Score-Activity of Daily Living* (HOS-ADL) y su subescala, orientada al deporte (*Sport-Specific Subscale*). **Resultados:** Los pacientes del grupo A (sin estrechamiento del espacio articular) obtuvieron mejores resultados funcionales, reflejados en puntajes más altos en las escalas funcionales, comparados con los del grupo B (con estrechamiento del espacio articular) ($p < 0.001$). **Conclusiones:** El estudio sugiere que el estrechamiento del espacio articular en pacientes con SFFA se asocia con peores resultados funcionales después de la artroscopia de cadera. Esta observación podría explicarse por la mayor prevalencia de lesiones condrales severas y la dificultad para reparar el labrum en pacientes con estrechamiento del espacio articular.

Palabras clave: Artroscopia de cadera; clasificación de Tönnis; resultados funcionales; lesión tipo CAM.

Nivel de Evidencia: IV

Received on June 28th, 2026. Accepted after evaluation on August 10th, 2026 • Dr. DAMIÁN ARROQUY • damianarroquy@hotmail.com

 <https://orcid.org/0000-0003-1045-7840>

How to cite this article: Arroquy D, Silvestrini MP, Ruiz S, Rubado M, Botta M, Mañero L, et al. Impact of Joint Space Narrowing on Functional Outcomes After Hip Arthroscopy. *Rev Asoc Argent Ortop Traumatol* 2026;91(5):438-447. <https://doi.org/10.15417/issn.1852-7434.2026.91.5.2422>

INTRODUCTION

Femoroacetabular impingement syndrome (FAIS) results from abnormal contact between the acetabulum and femoral neck and can frequently cause labral or cartilage injury, leading to hip osteoarthritis. Numerous studies have shown that osteoarthritis adversely affects outcomes after hip arthroscopy. However, some patients with FAIS have mild joint space narrowing without advanced osteoarthritis and may be treated arthroscopically. A recent study with 20-year follow-up after hip arthroscopy for labral tears identified chondral damage to the femoral head and acetabulum as the most important risk factor for conversion to total hip arthroplasty (THA).¹⁻⁴

Patients with moderate or severe hip osteoarthritis, corresponding to Tönnis grades 2 and 3, have consistently had poorer outcomes after hip arthroscopy than those with no or mild osteoarthritis. Studies of patients with mild osteoarthritis (Tönnis grade 1), however, have not shown the same adverse effect on clinical outcomes as in patients with more advanced disease. In a systematic review, Domb et al. found that joint space <2 mm and Tönnis grade >1 were indicators of poor outcomes after hip arthroscopy and that THA may be justified in these patients. Based on these studies, current hip preservation practice has narrowed surgical indications to patients with good joint quality and preserved joint space, specifically joint space >2 mm and Tönnis grades 0 and 1.⁵⁻⁷

This study aimed to evaluate and compare functional outcomes after hip arthroscopy in patients with FAIS and joint space narrowing (Tönnis grade 1) and those with FAIS without joint space narrowing (Tönnis grade 0).

MATERIALS AND METHODS

Study Design, Population, and Inclusion and Exclusion Criteria

We conducted a retrospective, observational, comparative cohort study of hip arthroscopies performed in patients diagnosed with FAIS. All procedures were performed by the same surgeon.

Between January 2016 and June 2025, 55 hip arthroscopies were performed. The analysis included patients who underwent surgery for FAIS and had at least one year of follow-up. Cases with advanced joint space narrowing (Tönnis grade >1) or acetabular dysplasia were excluded. The final sample comprised 46 hip arthroscopies in 44 patients.

Indications for arthroscopic treatment were radiographic evidence of FAIS, clinical examination findings consistent with hip pain, and failure of conservative treatment. Conservative measures included relative rest, activity modification, analgesics, and muscle strengthening while avoiding deep flexion under load.

All patients underwent radiography and magnetic resonance imaging before surgery. Pincer-type deformity was defined as a center-edge angle >40°, and cam-type deformity as an alpha angle >50°. Osteoarthritis was graded according to the Tönnis classification: no joint space narrowing (grade 0) or definite narrowing (grade 1). Joint space was measured on weight-bearing anteroposterior hip radiographs using digital software (AGFA). Grade 1 was defined as narrowing <50% or residual joint space >2 mm in all regions. In total, 28 hips were classified as grade 0 and 18 as grade 1 (Figure 1).⁸⁻¹¹

Surgical Technique

All procedures were performed by the same surgeon under spinal anesthesia combined with a pericapsular block. Patients were positioned supine, with traction applied using a central post. Anterolateral and anterior portals were routinely used. An interportal capsulotomy was first performed using a banana knife. In patients with acetabular overcoverage (pincer morphology), a controlled acetabuloplasty was performed; in some cases, this was limited to creating a bleeding bone bed to promote labral repair.

Labral tears were repaired using 2.8-mm knotless PEEK anchors. Chondral lesions were graded according to the Outerbridge classification. After work in the central compartment was completed, traction was released to assess the femoral head-neck junction. In patients with cam-type deformity, osteochondroplasty was performed using a burr under fluoroscopic guidance.



Figure 1. Anteroposterior hip radiographs. **A.** Tönnis grade 0. **B.** Tönnis grade 1.

All patients were discharged on the day of surgery and instructed to maintain partial weight-bearing for three weeks. Physical therapy began in the third week, focusing first on restoring range of motion and then on muscle strengthening.

Assessment

The following variables were recorded: age, sex, deformity type, osteoarthritis grade (Tönnis), chondral lesions (Outerbridge), labral repair, and whether microfracture was performed. Functional outcomes were assessed at the final follow-up using the modified *Harris Hip Score* (mHHS), the *Hip Outcome Score–Activities of Daily Living* subscale (HOS-ADL), and its *Sport-Specific Subscale* (HOS-SSS). These instruments were administered in person, by telephone, or by email. Failure was defined as an HHS <70 or radiographic progression of osteoarthritis warranting THA. Advanced chondral lesions and the need for microfracture were also assessed as potential predictors of failure.^{1,12}

Statistical Analysis

Descriptive statistics were used to characterize the sample. Between-group comparisons of means were performed using Student's t-test or Welch's t-test, with ANOVA or the Kruskal–Wallis test used as appropriate according to whether the assumptions were met. Categorical variables were compared using the χ^2 test or Fisher's exact test, as appropriate.

To explore predictors of functional outcomes, multiple linear regression models were fitted with postoperative mHHS as the dependent variable. Covariates included age, sex, Tönnis grade, deformity type, chondral lesion grade, and HOS-ADL scores.

Kaplan–Meier curves were constructed to estimate failure-free survival, and the Tönnis groups were compared using the log-rank test. The small number of events ($n = 2$) precluded reliable estimation of a multivariable Cox regression model. A p-value <0.05 was considered statistically significant.

Analyses were performed using R version 4.5.0 (2025-04-11 ucrt; R Foundation for Statistical Computing, Vienna, Austria). The dplyr, ggplot2, and tidyr packages were used for data management and visualization; stats for comparisons of means and categorical associations; survival and survminer for survival analyses and Kaplan–Meier curves; and broom for tabular presentation of the regression models.

RESULTS

The study included 46 patients (25 men and 21 women), with a mean age of 33.9 ± 9.4 years (range 18-52) and a mean follow-up of 45.7 months (range 12-96). According to the Tönnis classification, 28 patients (60.9%) had grade 0 and 18 (39.1%) had grade 1 osteoarthritis. There were 17 cam, 20 mixed, and 9 pincer deformities. Intra-operative chondral lesions were classified as grade 0 ($n = 17$), grade 1 ($n = 1$), grade 2 ($n = 9$), grade 3 ($n = 8$), and grade 4 ($n = 11$) (Table 1).

Table 1. Baseline characteristics of the cohort by Tönnis grade.

Variable		Tönnis grade 0 (n = 28)	Tönnis grade 1 (n = 18)	p
Age (years, mean $\pm$ SD)		30.2 $\pm$ 9.7	39.6 $\pm$ 8.1	0.001
Sex (n; %)	Male	9 (32.1)	14 (77.8)	0.006
	Female	17 (60.7)	4 (22.2)	
Deformity (n; %)	Cam	8 (28.6)	9 (50.0)	0.126
	Pincer	8 (28.6)	1 (5.6)	
	Mixed	12 (42.9)	8 (44.4)	
Chondral lesion (%)	G 0-2	27 (96.4)	0 (0.0)	<0.001
	G 3-4	1 (3.6)	18 (100.0)	

Overall functional outcomes were favorable. The mean postoperative mHHS was 86.5 (median 87; range 59–91), the mean HOS-ADL was 84.9 (median 88.5), and the mean HOS-SSS was 83.9 (median 87) (Figure 2).

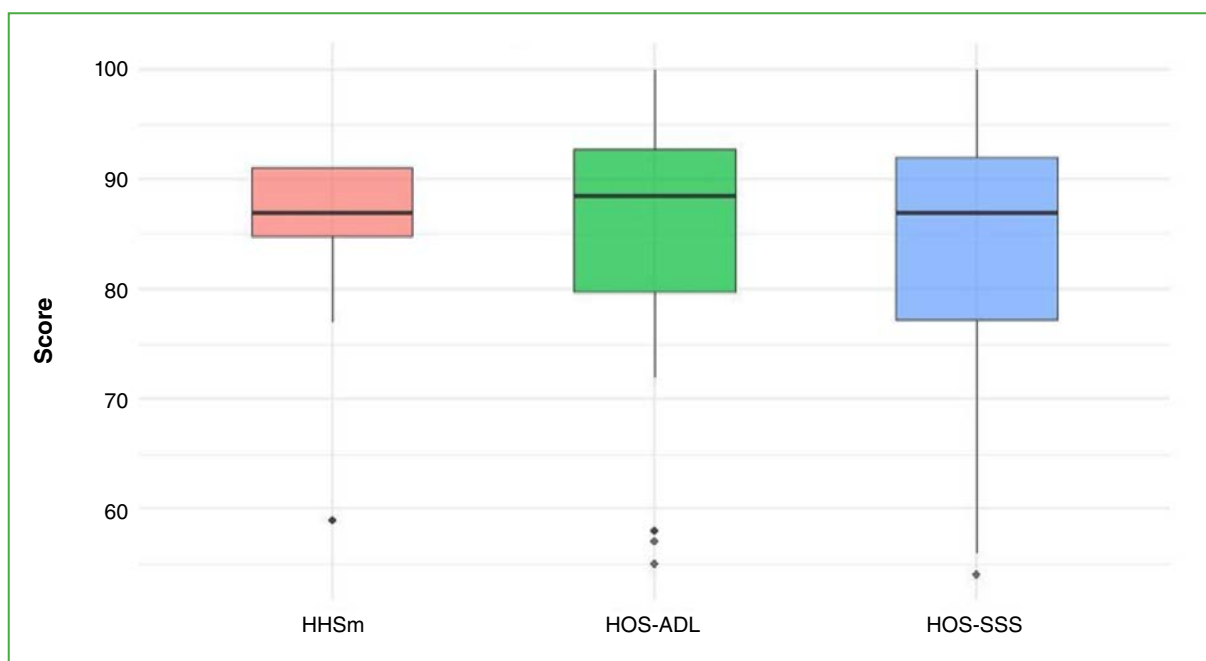


Figure 2. Distribution of postoperative HHS, HOS-ADL, and HOS-SSS scores.

HHS = Harris Hip Score; HOS-ADL = Hip Outcome Score–Activities of Daily Living; HOS-SSS = Hip Outcome Score–Sport-Specific Subscale.

When age was compared by Tönnis grade, patients with mild osteoarthritis (grade 1) were significantly older than those with grade 0 (39.6 ± 8.1 vs. 30.2 ± 9.7 years; $p = 0.001$). Patients with grade 0 also had higher functional scores: mHHS, 89.1 ± 2.5 vs. 82.3 ± 9.8 ($p = 0.010$); HOS-ADL, 91.9 ± 5.0 vs. 74.0 ± 10.5 ($p < 0.001$); and HOS-SSS, 91.2 ± 5.5 vs. 72.3 ± 10.0 ($p < 0.001$) (Table 2).

Table 2. Functional outcomes and comparisons.

Variable	Total (n = 46)	Tönnis grade 0 (n = 28)	Tönnis grade 1 (n = 18)	p
HHS (mean $\pm$ SD)	86.5 ± 7.5	89.1 ± 2.5	82.3 ± 9.8	0.01
HOS-ADL (mean $\pm$ SD)	84.9 ± 9.5	91.9 ± 5.0	74.0 ± 10.5	<0.001
HOS-SSS (mean $\pm$ SD)	83.9 ± 10.0	91.2 ± 5.5	72.3 ± 10.0	<0.001

SD = standard deviation; HHS = Harris Hip Score; HOS-ADL = Hip Outcome Score–Activities of Daily Living; HOS-SSS = Hip Outcome Score–Sport-Specific Subscale.

Confidence intervals and effect sizes confirmed the clinical relevance of these differences. The mHHS showed a large effect size (Cohen's d 1.05; 95% confidence interval [95% CI] 0.42–1.68), whereas the HOS-ADL (Cohen's d 2.34; 95% CI 1.57–3.10) and HOS-SSS (Cohen's d 2.49; 95% CI 1.69–3.27) showed very large effect sizes. These findings reinforce that patients without osteoarthritis achieve substantially greater functional benefits (Table 3).

Table 3. Effect sizes (Cohen's d) and 95% confidence intervals (95% CIs) for differences between Tönnis grades 0 and 1.

Variable	Mean difference (CI95%)	p	Effect size (Cohen's d, 95% CI)
HHS	1.8 to 11.7	0.010	1.05 (0.42–1.68)
HOS-ADL	12.4 to 23.4	<0.001	2.34 (1.57–3.10)
HOS-SSS	13.6 to 24.3	<0.001	2.49 (1.69–3.27)

HHS = Harris Hip Score; HOS-ADL = Hip Outcome Score–Activities of Daily Living; HOS-SSS = Hip Outcome Score–Sport-Specific Subscale.

In contrast, postoperative mHHS did not differ significantly among deformity types (ANOVA $p = 0.152$; Kruskal–Wallis $p = 0.114$) (Figure 3).

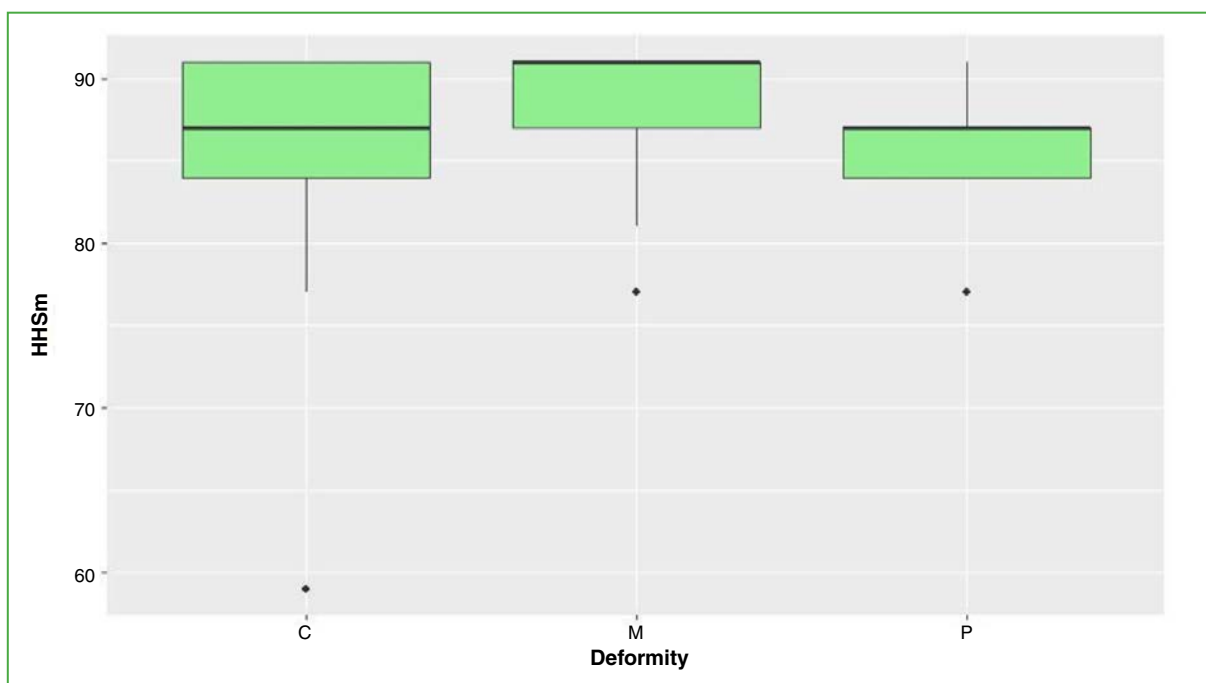


Figure 3. Postoperative Harris Hip Score by deformity type.

Chondral lesions were strongly associated with osteoarthritis grade. Advanced chondral lesions (grades 3-4) were more frequent in patients with Tönnis grade 1, and this difference was statistically significant (Fisher's exact test, $p < 0.001$) (Figure 4, Table 4). Deformity type, however, was not significantly associated with Tönnis grade (Fisher's exact test, $p = 0.126$).

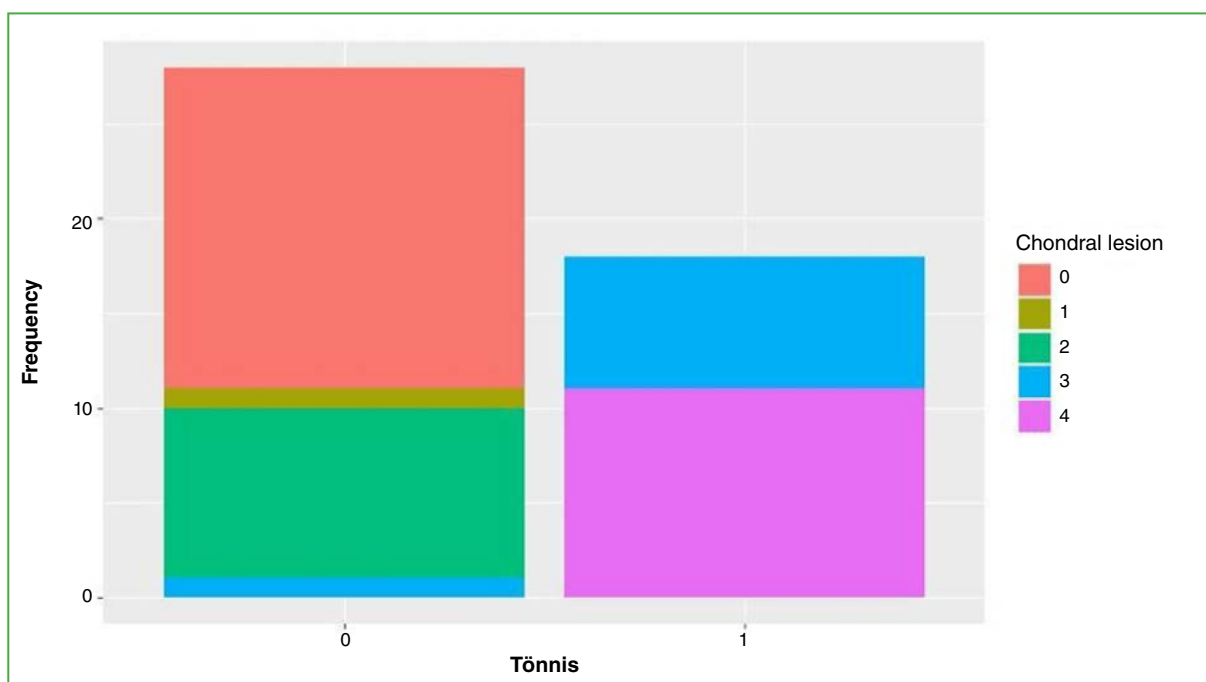


Figure 4. Distribution of chondral lesions by Tönnis grade.

Table 4. Associations between categorical variables.

Comparison	Test	p
Tönnis vs. deformity	χ^2	0.1145
Tönnis vs. chondral lesion	Fisher's	0.0001

In the multivariable linear regression analysis, no individual variable was significantly and independently associated with postoperative mHHS. The overall model explained 48% of the variability in outcomes (adjusted $R^2 = 0.48$; $p < 0.001$) (Table 5).

Table 5. Multiple linear regression model for postoperative HHS.

Variable		Beta	SE	t	p
Intercept		38.01	13.68	2.78	0.008
Tönnis grade 1		5.67	6.44	0.88	0.38
Age		0.044	0.13	0.33	0.74
Deformity	Mixed	2.57	2.21	1.16	0.25
	Pincer	1.05	3.64	0.29	0.77
Chondral lesion	1	2.63	6.77	0.39	0.70
	2	1.45	2.76	0.53	0.60
	3	-1.52	5.54	-0.27	0.78
	4	-4.72	6.35	-0.74	0.46
Sex	Male	1.49	2.50	0.59	0.55
HOS-ADL		0.46	0.37	1.25	0.22
HOS-SSS		0.05	0.39	0.13	0.89

SE = standard error; HHS = Harris Hip Score; HOS-ADL = Hip Outcome Score–Activities of Daily Living; HOS-SSS = Hip Outcome Score–Sport-Specific Subscale.

An expanded model that included sex and HOS scores slightly improved the fit, yielding an adjusted R^2 of 0.53 ($p < 0.001$). No individual covariate showed clear statistical significance. However, the interaction between Tönnis grade and HOS-ADL showed a statistical trend ($p = 0.075$), suggesting that radiographic severity may modify the effect of performance in activities of daily living on postoperative mHHS (Table 6).

Finally, survival analysis (event = mHHS < 70) showed failure-free survival of 100% in the Tönnis grade 0 group and 88.9% in the grade 1 group at 65 months of follow-up. The Kaplan-Meier curves showed a trend toward lower survival in patients with grade 1, but the log-rank test did not reach statistical significance, probably because of the small number of events ($n = 2$) (Table 7, Figure 5).

Table 6. Multiple linear regression model with a Tönnis grade × HOS-ADL interaction.

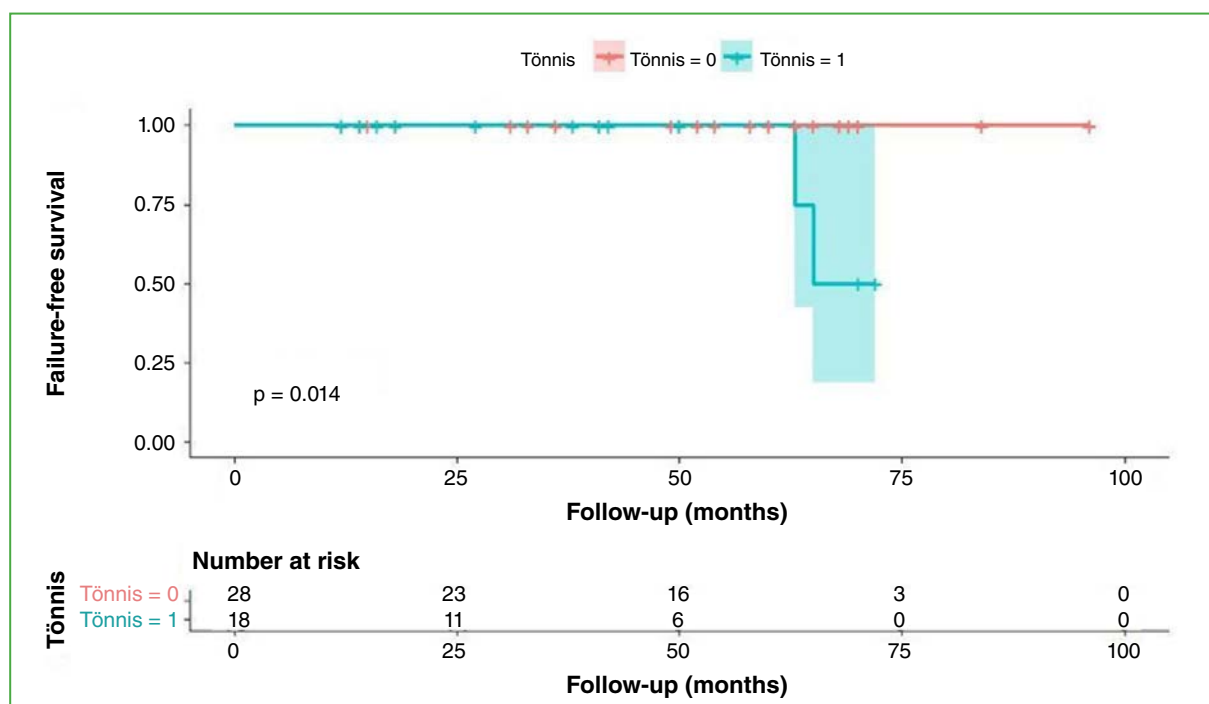
Variable		Beta	SE	t	p
Intercept		88.38	29.64	2.982	0.005
Tönnis grade 1		-53.23	32.65	-1.630	0.11
HOS-ADL		-0.00	0.30	-0.021	0.98
Age		-0.01	0.12	-0.123	0.90
Deformity	Mixed	3.02	2.11	1.428	0.16
	Pincer	-0.0	3.50	-0.027	0.97
Chondral lesion	1	-0.14	6.51	-0.021	0.98
	2	-1.44	3.06	-0.471	0.64
	3	-0.12	5.32	-0.023	0.98
	4	-2.26	6.14	-0.368	0.71
Sex	Male	2.48	2.43	1.017	0.31
Tönnis grade 1 HOS-ADL		0.62	0.34	1.838	0.07

HOS-ADL = Hip Outcome Score–Activities of Daily Living.

Table 7. Failure-free survival.

Time (months)	Tönnis grade 0 (n = 28)	Tönnis grade 1 (n = 18)	p*
65	100%	88.90%	0.1

*Log-rank test.

**Figure 5.** Survival curves for Tönnis grades 0 and 1, with the number-at-risk table.

DISCUSSION

This study compared the characteristics and functional outcomes of patients with FAIS who underwent hip arthroscopy, divided into two groups according to the degree of joint space narrowing (Tönnis classification). Patients without preoperative joint space narrowing (group A, grade 0) achieved better functional outcomes, measured using the mHHS, than those with narrowing (group B, grade 1). The predominant deformity type also differed between groups. Mixed, cam, and pincer deformities were more evenly distributed in group A, whereas cam-type deformity clearly predominated in group B.

These findings agree with the literature suggesting that osteoarthritis, even in its early stages manifested as joint space narrowing, may adversely affect outcomes after hip arthroscopy. Joint space narrowing has been associated with greater chondral damage and poorer hip function, which may explain the lower functional scores in group B. The higher prevalence of chondral lesions in this group (100% vs. 26%) further supports this observation and suggests that joint space narrowing may indicate greater intra-articular damage. Our findings are consistent with those of Domb et al. in showing that patients with Tönnis grade 1 can achieve statistically significant improvements in functional outcomes. However, the clinical relevance of these improvements remains uncertain: Nho et al. reported that patients with grade 1 osteoarthritic changes are less likely to achieve a minimally satisfactory outcome than those with grade 0.^{5,6,11,13-15}

The causal relationship between FAIS and hip osteoarthritis is well described, but whether correcting cam or pincer morphology prevents osteoarthritis progression remains debated. In a study assessing hips before and after cam resection, Van Houcke et al. found that peak contact forces were significantly elevated in patients with cam-type FAIS but returned to normal after resection. This suggests that cam resection may prevent further chondral injury. In our study, the observed difference in the distribution of bony deformities was not significantly associated with Tönnis grade. Failure-free survival at 65 months was 100% in the Tönnis grade 0 group and 88.9% in the grade 1 group. Vilaseca et al. reported a THA conversion rate of 2.43% in patients followed for more than 10 years.^{4,13,16}

Several limitations should be considered. The sample size, particularly in group B, may limit the statistical power to detect subtle differences. Longer-term follow-up would also help assess osteoarthritis progression and the need for THA. Despite these limitations, the study provides valuable information on the relationship between joint space narrowing, deformity type, and functional outcomes after hip arthroscopy.

CONCLUSIONS

These findings suggest that patients with joint space narrowing should be selected cautiously for hip arthroscopy. Although arthroscopy may relieve symptoms in some cases, patients with Tönnis grade 1 may face a higher risk of suboptimal functional outcomes and more rapid osteoarthritis progression. A thorough preoperative assessment, including careful evaluation of joint space and bony deformity, is therefore essential to counsel patients about their expectations and consider alternative treatments, such as THA, in selected cases.

Conflicts of interest: The authors declare no conflicts of interest.

M. P. Silvestrini ORCID ID: <https://orcid.org/0000-0002-7649-2318>
S. Ruiz ORCID ID: <https://orcid.org/0009-0005-1147-2200>
M. Rubado ORCID ID: <https://orcid.org/0009-0001-5729-5490>

M. Botta ORCID ID: <https://orcid.org/0000-0001-5858-4115>
L. Mañero ORCID ID: <https://orcid.org/0000-0002-2102-5798>
J. M. Barrios ORCID ID: <https://orcid.org/0000-0002-1235-9788>

REFERENCES

- 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(8):2492-6. <https://doi.org/10.1007/s11999-012-2779-4>
- Larson C, Russell Giveans M, Taylor M. Does arthroscopic FAI correction improve function with radiographic arthritis? *Clin Orthop Relat Res* 2011;469:1667-76. <https://doi.org/10.1007/s11999-010-1741-6>
- Arroquy D, Pérez Alamino L, Orlowski B, Catán A, Chahla JA, Vilaseca T. Satisfacción y retorno deportivo luego de tratamiento artroscópico del síndrome de fricción femoroacetabular. *Artroscopia (Buenos Aires)* 2021;28(2):112-7. Available at: <https://revistarelat.com/index.php/revista/article/view/117>
- Vilaseca T, Cao S. Artroscopia de cadera para síndrome de fricción femoroacetabular: Reportes funcionales a diez años. *Artroscopia (Buenos Aires)* 2024;31(3):85-90. Available at: <https://revistarelat.com/index.php/revista/article/view/348>
- Domb BG, Gui C, Lodhia P. How much arthritis is too much for hip arthroscopy: a systematic review. *Arthroscopy* 2015;31(3):520-9. <https://doi.org/10.1016/j.arthro.2014.11.008>
- Domb BG, Chaharbakhshi EO, Rybalko D, Close MR, Litrenta J, Perets. Outcomes of hiparthroscopic surgery in patients with Tönnis grade 1 osteoarthritis at a minimum 5-year follow-up: a matched-pair comparison with a Tönnis grade 0 control group. *Am J Sports Med* 2017;45(10):2294-2302. <https://doi.org/10.1177/0363546517706957>
- Oakley SP, Portek I, Szomor Z, Appleyard RC, Ghosh P, Kirkham BW, et al. Arthroscopy – a potential “gold standard” for the diagnosis of the chondropathy of early osteoarthritis. *Osteoarthritis Cartilage* 2005;13(5):368-78. <https://doi.org/10.1016/j.joca.2004.12.005>
- Duncan ST, Khazzam MS, Burnham JM, Spindler KP, Dunn WR, Wright RW. Sensitivity of standing radiographs to detect knee arthritis: a systematic review of Level I studies. *Arthroscopy* 2015;31(2):321-8. <https://doi.org/10.1016/j.arthro.2014.08.023>
- McClincy MP, Lebrun DG, Tepolt FA, Kim Y-J, Yen Y-M, Kocher MS. Clinical and radiographic predictors of acetabular cartilage lesions in adolescents undergoing hip arthroscopy. *Am J Sports Med* 2018;46(13):3082-9. <https://doi.org/10.1177/0363546518801848>
- Byrd JWT, Jones KS, Bardowski EA. Influence of Tönnis grade on outcomes of arthroscopy for FAI in athletes: a comparative analysis. *J Hip Preserv Surg* 2018;5(2):162-5. <https://doi.org/10.1093/jhps/hny01>
- Nho SJ, Beck EC, Nwachukwu BU, Cvetanovich GL, Neal WH, Harris JD, et al. Survivorship and outcome of hip arthroscopy for femoroacetabular impingement syndrome performed with modern surgical techniques. *Am J Sports Med* 2019;47(7):1662-9. <https://doi.org/10.1177/0363546519843936>
- Chandrasekaran S, Gui C, Darwish N, Lodhia P, Suarez-Ahedo C, Domb BG. Outcomes of hip arthroscopic surgery in patients with Tönnis grade 1 osteoarthritis with a minimum 2-year follow-up: evaluation using a matched-pair analysis with a control group with Tönnis grade 0. *Am J Sports Med* 2016;44(7):1781-8. <https://doi.org/10.1177/0363546516638087>
- Van Houcke J, Khanduja V, Audenaert EA. Accurate arthroscopic cam resection normalizes contact stresses in patients with femoroacetabular impingement. *Am J Sports Med* 2021;49(1):42-8. <https://doi.org/10.1177/0363546520974378>
- Fenn TW, Kaplan DJ, Brusalis CM, Chapman RS, Larson JH, Nho SJ. Functional outcome scores and conversion to total hip arthroplasty after hip arthroscopy for femoroacetabular impingement syndrome in patients with Tönnis grade 1 versus grade 0 arthritis. *Am J Sports Med* 2024;52(1):34-44. <https://doi.org/10.1177/03635465231210958>
- Lin DCM, Reichmann WM, Gossec L, Losina E, Conaghan PG, Maillefert JF. Validity and responsiveness of radiographic joint space width metric measurement in hip osteoarthritis: a systematic review. *Osteoarthritis Cartilage* 2011;19(5):543-9. <https://doi.org/10.1016/j.joca.2010.12.014>
- Kraeutler MJ, Garabekyan T, Goodrich JA, Fioravanti MJ, Chadayammuri V, Mei-Dan O. Standardizing the prearthritic hip joint space width: An analysis of 994 hips. *Arthroscopy* 2018;34(7):2114-20. <https://doi.org/10.1016/j.arthro.2018.02.036>