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Research Article

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Arthroscopic assessment of concomitant intraarticular pathologies in patients with osteonecrosis of the femoral head

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ABSTRACT

This study's purpose is to arthroscopically assess the occurrence of intraarticular pathologies in patients with osteonecrosis of the femoral head (OFNH) and to compare arthroscopic with radiologic findings. In a retrospective cohort analysis of ONFH patients undergoing combined core decompression (CD) and hip arthroscopy, concomitant intraarticular pathologies were qualitatively and quantitatively assessed by means of arthroscopy. Intraoperative findings were compared with preoperative radiodiagnostics. Descriptive statistics were performed with results displaying type, degree and prevalence of co-pathologies. Based on a cohort of 27 hips with ONFH at ARCO stages II and III, 26 (96.3%) presented with concomitant intraarticular findings. Cam-deformity ($n = 22$; 81.5%), labral defects ($n = 23$; 85.2%) and chondral defects ($n = 20$; 74.1%) were the most frequent. Four hips (14.8%) had foveal ligament anomalies. Intraoperative detection of cam-deformity positively correlated with radiologically assessed pathologic α angles ($p = 0.09$). Radiologic evaluation of the acetabular labrum distinctly differed from arthroscopic findings. Reliable statements concerning the cartilage status were not possible due to the great difference in quality of the magnetic resonance imaging (MRIs). The results of this study revealed an arthroscopically proven prevalence of co-pathologies in >95% of patients with ONFH. Cam-type deformity, labral anomalies and chondral defects were the most frequent. Comparison of arthroscopic and radiologic findings showed coherent results regarding cam-deformity but revealed distinct difficulties in the assessment of the labral and chondral status emphasizing the need for standardization of preoperative radiodiagnostics. Moreover, it still has to be evaluated whether combined CD and arthroscopy can improve on the overall outcomes achieved by performance of CD only.

INTRODUCTION

Osteonecrosis of the femoral head (ONFH) is a severe disease of the hip joint that often results in joint line collapse if it remains untreated. As it predominantly occurs in young adults aged between 30 and 50 years, early and sufficient therapy is of eminent importance to prevent premature need for total hip arthroplasty (THA) [1–4].

As regards literature on ONFH in general, little has been published on the occurrence of concomitant pathologies. This may be because the symptoms of ONFH are rather unspecific and numerous differential diagnoses of the hip might present similar clinical findings. Furthermore, radiologic diagnostics do not necessarily give an indication of accompanying pathologies. The detection of osseous pathologies by means of conventional X-ray has become well-established and magnetic resonance imaging (MRI) is unquestionably the gold standard for identifying non-osseous pathologies and ONFH [5, 6]. However, even MRI or MR-arthrography do not necessarily enable definite identification of soft tissue pathologies such as labral tears, ligament ruptures and chondral defects [7–9]

In this context, the combined use of core decompression (CD) techniques and hip arthroscopy has been reported in several studies, confirming the possibility of detecting and co-treating concomitant hip pathologies [10–13]. Just recently, Nazal *et al.* [14] also reported on potentially beneficial CD-related outcomes through the combination of both procedures. However, all publications on this specific field lack sufficient case numbers, and the prevalence of concomitant pathologies found in ONFH has still not been clarified. Only a frequent co-occurrence of ONFH and a radiologically detected pathologic head–neck junction, typical of cam-type femoroacetabular impingement (FAI), has been reported so far [15, 16].

This study's purposes are to arthroscopically assess the occurrence of intraarticular pathologies in patients with proven osteonecrosis of the femoral head (OFNH), to determine their type, degree and prevalence and to compare arthroscopic with radiologic findings. Therefore, data from an ONFH patient collective simultaneously treated by hip arthroscopy and advanced or modified advanced Core Decompression (ACD/mACD) is depicted [17–19]. It is hypothesized that intraarticular co-pathologies are regularly to be found in patients with ONFH.

MATERIALS AND METHODS

A retrospective non-randomized cohort analysis was performed with approval from the local ethics committee. The primary inclusion criteria were the simultaneous performance of core decompression (ACD or mACD) and hip arthroscopy. The original reasons for performing additional arthroscopy were the intraarticular assessment of the necrotic area and the pointer-guided two-dimensional navigation during femoral drilling.

Over a 3-year period, a total of 26 patients had received combined treatment and thereby were identified as eligible for inclusion. All participants presented with MRI-verified ONFH at ARCO stages II or III and with standard preoperative X-ray diagnostics (pelvis anteroposterior view and frog-leg lateral radiographs). Surgery was performed solely by the last author of the study. Data on prevalence and severity of arthroscopically detected intraarticular pathologies were acquired by assessing the corresponding surgical photo, video and paper documentation. As proposed by Matsuda, arthroscopic FAI surveillance was performed by dynamically assessing the anterior and lateral femoral head–neck junction without hip distraction [20]. Resulting from that and due to the lack of an established arthroscopic FAI classification system, cam-type deformity was classified as 'no' > 'slight' > 'severe'. Labral and chondral defects were classified using Beck's grading system and the International Cartilage Repair Society's classification system (ICRS) respectively [21, 22]. Findings concerning the foveal ligament were assessed as 'normal' versus 'thickening or tear'.

Evaluation of the corresponding radiologic diagnostics was performed for comparison with the arthroscopic findings. Conventional frog-leg lateral X-ray imaging was used to measure the alpha-angle (α) according to Nötzli *et al.* [23, 24] and thereby assess the presence and extent of cam-type deformity. In this context, an alpha-angle α of $\geq 60^\circ$ was defined as pathologic. Preoperative MRI diagnostics were assessed in order to detect any type of soft tissue pathology.

SPSS® Statistics (Version 21.0.0.0, IBM®) was used for statistical analyses. Descriptive data are presented as mean ($\pm$ standard deviation [SD]), percentage of the total or in total numbers. Correlation analysis was performed using *Phi* and *Cramer-V* for nominally scaled variables with the level of significance set at $P \leq 0.05$.

RESULTS

The total number of hips evaluated was 27 as one patient presented with bilateral ONFH. The mean age was 39.78 years with the gender distribution being two-thirds male and one-third female. Detailed baseline data of the study collective is provided in Table I.

Arthroscopy revealed that all but one hip (96.3%) in the study population presented with concomitant pathologies in addition to ONFH. Twenty-two hips (81.5%) presented with visible bump-formation located at the head–neck junction. Twenty-three (85.2%) had labral anomalies ranging from defect stages I–IV according to Beck *et al.* [21]. The majority presented with stage I and II defects characterized by hypertrophy, degeneration and joint-sided tears (Fig. 1). Chondral defects were found in 20 hips (74.1%), 12 of which were localized at the femoral head above the necrotic area. Here, the most frequent findings were ICRS stage I defects with the typical softening and superficial fissures in the cartilage surface. However, eight hips with proven chondral defects could not be related to ONFH and were located either at the acetabulum or the femoral head as well. In addition, four hips (14.8%) presented with anomalies of the foveal ligament which were characterized by distinct thickening or tear. Detailed tabular data of the arthroscopic findings and the performed corresponding treatment measures are provided in Table II.

The additional assessment of radiologic diagnostics was performed to allow comparison with arthroscopically detected intraarticular pathologies. As regards cam-type deformities, the mean α angle was $65.11^\circ \pm 10.50$ for the

Table I. Baseline data

Study population (hip count)	n = 27
Age (years), mean ± SD	39.78 ± 11.08
Sex (count/percentage), male/female	18/9 (66.7%/33.3%)
ONFH stage[a] (count/percentage), II/III	12/15 (44.4%/55.6%)
ONFH laterality (count/percentage), left/right	10/17 (37.0%/63.0%)
	(1 patient with bilateral occurrence)
Core decompression type (count/percentage), ACD[b]/mACD[c]	1/26 (3.7%/96.3%)
	(1 patient with bilateral mACD-treatment)

Baseline data of the patient-specific characteristics.
[a]ARCO classification system.
[b]Advanced core decompression.
[c]Modified advanced core decompression.

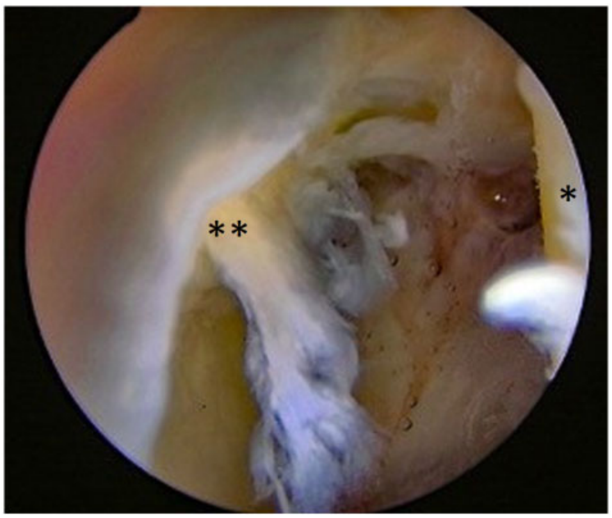

Fig. 1. Arthroscopic image from the study group showing a *part of the femoral head and a **labral full thickness tear (Grade II acc. to Beck's classification [21]).

complete study population. 19 patients (70.4%) presented with $\alpha > 60°$ indicating a pathological bump-formation (Fig. 2). Interestingly, a positive correlation of the measured α values and the arthroscopic grading was seen with the mean α rising gradually from 'no deformity' over 'slight' up to 'severe deformity' (Table III). The corresponding coefficients *Phi* and *Cramer-V* confirmed positive correlation, but both narrowly missed the level of significance with $P = 0.09$ in the assessment of pathologic versus non-pathologic results.

The MRI diagnostics acquired in multiple different outpatient locations revealed fundamental protocol differences regarding angulation, resolution, and overall quality. Despite detailed assessment by two experienced radiologists in consensus, evaluation of cartilage and foveal ligament status using the corresponding MRIs was not consistently feasible. Only evaluation on the presence of labral defects (yes/no) were sensible to perform. Here, there were distinct differences between radiologic and arthroscopic findings. On the one hand, four hips were shown to have an arthroscopically verified intact labrum, three of which had been radiologically classified as damaged. On the other hand, 5 of 23 hips with arthroscopic verification of labral defect had been radiologically assessed as normal. Detailed data and sample images are provided in Table III and Fig. 3.

DISCUSSION

Based on a collective of 27 ONFH hips, this study revealed arthroscopically proven pathologic intraarticular findings in >95% of the evaluated hips. As regards the type of concomitant pathology, cam-type deformity as well as labral and chondral defects were the most frequent. Each of these pathologies was arthroscopically verified in >70% of the study collective. Even when chondral defects that were located above the ONFH region were omitted, there were still 30% of the patients with further cartilage damage. The results of this study therefore raise the question of underlying causal connections between ONFH and intraarticular pathologies.

Assessment of cam-type deformity alone shows that its prevalence is estimated to be approximately 23% in the general population [23, 25]. Therefore, a coincidental finding of >70% in the study group appears to be rather

Table II. ONFH-accompanying pathologies

Pathology	*Count/percentage*			*Treatment (count)*		
CAM-deformity					Offset correction	
No	5	18.5%			—	
Slight	9	33.3%			7	
Severe	13	48.2%			13	
Labral status[a]				Debridement	Suture	Partial resection
Intact	4	14.8%		—	—	—
Defect I°	10	37.1%		2	—	8
Defect II°	9	33.3%		—	6	3
Defect III°	3	11.1%		1	1	—
Defect IV°	1	3.7%		—	—	—
Cartilage status[b]			Located at ONFH-zone: yes/no (count)	Debridement		ACT
Intact	7	25.9%	—	—		—
Defect I°	8	29.7%	7/1	—		—
Defect II°	7	25.9%	4/3	7		—
Defect III°	4	14.8%	1/3	—		4
Defect IV°	1	3.7%	0/1	—		1
Foveal ligament					Resection	
Intact	23	85.2%			—	
Thickening or tear	4	14.8%			4	

Count and percentage of the arthroscopically proven ONFH-accompanying hip pathologies plus corresponding treatment.
[a]Beck's classification [21].
[b]ICRS classification [22].

unlikely. Furthermore, a frequent co-occurrence with ONFH has already been reported although without proven causal relation [15, 16]. Explanatory approaches include the theory that on the one hand ONFH may be induced by impaired blood supply due to cam-deformity, and on the other that bump-formation originates from increasing structural instability due to ONFH [16]. With regard to defects at the acetabular labrum, it is known that these do not usually develop on their own but are regularly found with alterations to hip morphology [21, 26]. In this context, and in contrast to ONFH, femoroacetabular impingement has been identified as a major cause of labral anomalies [21, 27]. Therefore, the high prevalence of labral defects in the study group may be more likely due to the occurrence of cam-morphology than to ONFH itself.

As regards chondral alterations in ONFH patients, due to increasing structural instability of the subchondral bone, the overlying cartilage typically begins to soften, lift off and break up in the further course of defect emergence [2, 28]. Thus, it can be assumed that abnormal findings localized above the necrotic zone were caused by ONFH which allows an arthroscopic identification of the region of

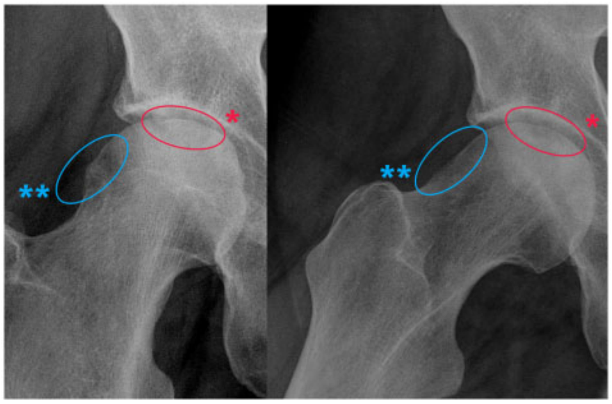

Fig. 2. Display detail of pelvis anteroposterior and frog-leg lateral X-ray of the right hip showing *ONFH ARCO III with flattening of the femoral head (red marking) and **pathological head–neck offset indicative of cam-type FAI (blue marking) – sample image from the patient collective.

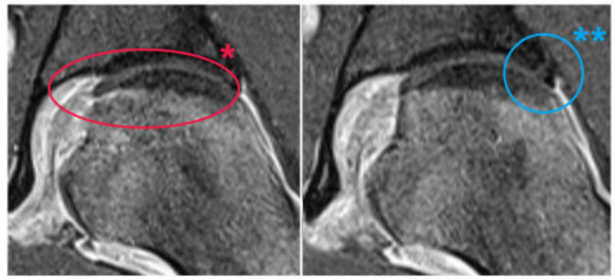

Fig. 3. MRI detail (T1 Turbo-Spin-Echo sequence) showing the left hip with *ONFH ARCO III with subchondral collapse (red marking) and **labral defect stage III acc. to Beck *et al.* with clear avulsion (blue marking).

Table III. Comparison of arthroscopic and radiologic diagnostics

Arthroscopic evaluation		*Radiologic evaluation*	
Cam-deformity		α angle (mean $\pm$SD)	
No		56.80 ± 11.12	
Slight		62.33 ± 5.48	
Severe		70.23 ± 10.71	
Labrum status[a]—count		Intact labrum—count	Labrum defect—count
Intact	4	1	3
Defect I°	10	1	9
Defect II°	9	3	6
Defect III°	3	1	2
Defect IV°	1	0	1

Comparison of arthroscopic and radiologic detection of cam-type deformity and labrum defects.
SD, standard deviation.
[a]Beck's classification [21].

structural instability or collapse. Nevertheless, as only 12 out of 27 hips of the study group presented with chondral anomalies above the necrotic zone its intraarticular identification was not always possible. Consistent with the argumentation on chondral alterations due to increasing subchondral collapse is this study's observation that the prevalence of ONFH-located chondral defects was 67% for ARCO stage III hips compared to 17% for ARCO stage II hips. It can be concluded, that the arthroscopic assessment of the necrotic area, although not always possible, strongly depends on the underlying ARCO stage.

However, since roughly 30% of the chondral anomalies were not located at the necrotic zone, ONFH may not be an adequate reason for all of these defects. A possible explanation is that these might have been caused by other intraarticular pathologies detected in the course of this study (e.g. labral defects, foveal ligament anomalies). However, they could also have been initiated by factors that this study did not assess such as trauma, previous hip diseases or simply the development of osteoarthritis.

The major finding of this study is the disproportionately frequent co-occurrence of ONFH and pathological intraarticular findings, and that this co-occurrence appears to be not the exception but the rule. Hence, in most patients, isolated core decompression does not sufficiently address the existing pathologies in the hip. However, the clinical relevance of intraarticular co-findings within the context of ONFH and their treatment by arthroscopy has not yet been clarified [10, 11–13]. Nazal *et al.* [14] presented the only publication that focuses on this particular question, vaguely indicating that the combination of CD and hip arthroscopy leads to favourable results. However, despite a mean follow-up of 7 years, as the number of evaluated hips was only $n = 11$ the results have to be considered with caution. Moreover, sufficient assessment of the effects of additional measures performed through hip arthroscopy might be difficult to realize in general. As the number of factors which may confound the outcome is huge (e.g. stage and size of ONFH, labrum and cartilage status, signs of osteoarthritis, type of CD, patient-specific factors such as ONFH risk factors etc.), distinctly greater case numbers are needed to obtain reliable results. Therefore, with this study's hip count of $n = 27$, we deliberately restricted ourselves to presenting the types of treatment applied but did not compare their outcome. Overall, valid analysis of the efficacy of arthroscopic co-treatment of intraarticular pathologies in patients with ONFH and comparison of these results with those of isolated CD will be a major task for the future.

As concerns the radiologic findings, the results were rather heterogeneous. Radiographic assessment of cam-like deformities delivered favourable results when compared to those gained via arthroscopy. The use of the α angle and its measuring on frog-leg lateral X-ray proved to be positively correlated to the arthroscopic findings allowing a preoperative assessment on a reasonable basis. Although there still is controversial discussion as to where to set a definite 'pathologic versus non-pathologic' threshold, 60° marked a reasonable limit in our analysis [29, 30].

With regard to the detection of labral defects, however, sole reliance on preoperative MRI-based findings is not advisable. The radiologic and arthroscopic findings for our study group differed considerably. Some patients with unsuspicious MRI, for example, presented with clear labral tear intraoperatively and vice versa. Furthermore, proper evaluation of cartilage and ligaments was not feasible, and this situation raised questions about the reliability of the results of MRI diagnostics. Without doubt, MRI is the gold standard for non-invasively diagnosing and staging pathologies such as ONFH, chondral defects or labral lesions. However, examination protocols may differ distinctly depending on the suspected diagnosis. As concerns this study, most of the patients presented with results from standard MRI diagnostics performed in multiple other institutions and without an appropriate tentative diagnosis being priorly made. It is likely that this at least partially explains the noticeable difference in quality on the one hand but the differences to our arthroscopic findings on the other hand, as well. When suspecting ONFH MRI protocols usually include coronal and axial proton density, axial T2 fast spin-echo as well as sagittal T1 fast spin-echo and Short Tau Inversion Recovery sequences [31]. However, due to the thin articular cartilage, the obliquely orientated joint and the highly curved articular surfaces, the proper assessment of the labrum as well as the chondral status regularly fails. In this context, large field-of-view unenhanced MRI showed to be unsuitable for detecting labral and chondral pathologies whereas unenhanced MRI with high in-plane and through-plane resolution performed at 3 Tesla may ameliorate diagnostic accuracy [8, 32]. In cases of remaining diagnostic uncertainty MR-arthrography is the suggested technique of advanced imaging to properly assess suspected labral and chondral lesions [7, 32, 33]. Therefore, it is assumable that this study's discrepancy between radiologic and arthroscopic findings might have been reduced by the use of standardized and suitable MRI protocols, combined with MR-arthrography where applicable. Nonetheless, despite these measures, a certain 'diagnostic gap' is likely to remain.

Limitations

The results obtained within the framework of this study have to be interpreted considering certain limitations. The validity of the results is restricted due to the small sample size. Similar investigations based on larger cohorts are necessary to find out whether the findings of this analysis are representative. Comparison of arthroscopic and radiologic results was impeded by large differences in the quality and standard of the MRI diagnostics. Finally, the clinical relevance of the obtained results still has to be assessed. In particular, the question as to whether arthroscopic co-treatment can have a positive impact on overall CD results has to be answered.

CONCLUSION

Based on a collective of patients with proven ONFH, the current study shows that intraarticular co-pathologies were prevalent in >95% of patients. These pathologies were revealed by hip arthroscopy performed as a supplementary procedure to CD with cam-like deformities of the head–

neck junction, labral anomalies and chondral defects being the most often detected conditions. Each of these pathologies had a prevalence of >70%. Comparison of arthroscopic and radiologic findings showed coherent results regarding the detection of cam-deformity. Radiologic identification of labral and chondral defects proved to be difficult on non-dedicated examinations, emphasizing the need for good medical history and standardized MRI protocols possibly combined with MR-arthrography. The clinical relevance of this study's findings still has to be evaluated as well as whether combined CD and arthroscopy can improve on the overall outcomes achieved by performance of CD only.

DECLARATIONS

The registration of data was approved by the local ethics committee.

ACKNOWLEDGMENTS

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available from the corresponding author upon reasonable request.

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