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Title

The association between adult hip morphology and hip osteoarthritis: a systematic review

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Publication Date

2020-04-01

DOI

10.1016/j.joca.2020.02.420

Peer reviewed

Purpose: Untreated post-traumatic scapholunate interosseus ligament (SLIL) injury may lead to the development of a specific pattern of progressive wrist osteoarthritis known as SLAC (scapholunate advanced collapse), one of the most frequent patterns of wrist osteoarthritis. The dorsal component of SLIL is known to be the strongest and main responsible for scapholunate stability, as demonstrated in previous cadaveric studies. No previous study has evaluated the distribution and severity of cartilage damage and scapholunate dissociation considering component-specific tears of the SLIL, using an imaging technique where we can directly assess both cartilage and SLIL morphology. Our aim was to evaluate the distribution and severity of cartilage damage and scapholunate dissociation assessed on multi-detector computer tomography (MDCT) arthrography in a sample of patients with SLIL injury, in regard to component-specific tears.

Methods: In this cross-sectional, retrospective study, we searched for the clinical and radiological records of patients who were referred to the radiology department to undergo MDCT arthrography of the wrist from 2012 to 2015. Patients were included if they had a history of wrist trauma associated with chronic wrist pain, with unequivocal findings of partial or complete rupture of the SLIL on MDCT arthrography. Patients were excluded if they had surgical treatment before MDCT arthrography, an associated ligament injury depicted on MDCT arthrography, any wrist fracture, chondrocalcinosis, or any congenital conditions or anatomical variations. Two musculoskeletal radiologists with 2 and 10 years of experience independently assessed the MDCT arthrography images. Morphology of SLIL dorsal and volar components was separately evaluated and graded as: normal, partial, or complete tear. Quantitative assessment of the scapholunate dissociation was performed using the coronal image at the bi-styloid plane with measurements performed using the tenth of a millimeter. Cartilage damage was assessed in 14 distinct regions of the wrist using a semiquantitative WORMS-modified scoring system (from 0 to 6), which was adapted for cartilage assessment of the wrist. For each patient, the “global” score of cartilage damage was obtained by summing all the modified WORMS scores of all regions. Additionally, we also assessed the score of cartilage damage by summing only the modified WORMS grades ≥ 3 , as these represent degenerative morphologic changes (“degenerative” score). Finally, to better represent cartilage damage specifically associated with SLAC, we considered the “radial” score as well, by summing the modified WORMS scores in regions at the radial side of the wrist. We assessed if cartilage severity was greater in patients having complete tears of the dorsal component of the SLIL compared to patients without complete tears of the same component. We did the same comparison considering involvement of the volar component of the SLIL. The same groups were compared regarding scapholunate dissociation severity. The Student's t-test and the Wilcoxon Rank-Sum test were used to compare the different groups adjusting for the presence of concomitant dorsal and volar component tears.

Results: Forty-three patients were finally included in our sample (mean age was 29.5 ± 10.6 (range 19 to 72), 65.1% (N=28) were male). On MDCT arthrography, a complete tear of the dorsal component of the SLIL was found in 20 patients (46.5%), the exact same frequency for complete tears of the volar component. Eleven patients (25.6%) had a complete tear of both dorsal and volar components of the SLIL. The intra-reader reliability for the assessment of dorsal and volar components of the SLIL was 1.0 and 0.91, respectively. The inter-reader reliability for the same features was 0.85 and 0.72, respectively. Intra-reader reliability for the modified WORMS scores varied between 0.55 (STT region) to 1.0 (several regions). For regions frequently affected by cartilage damage, inter-reader reliability for modified WORMS varied between 0.45 and 0.82. The distribution of cartilage damage and corresponding WORMS-modified scores are described in detail in Table 1. The cartilage damage scores obtained were greater in patients with complete SLIL dorsal component tears (group 2) than in other patients (group 1) (Table 2), with no significant differences in cartilage scores when considering complete SLIL volar component tears. Scapholunate dissociation was greater in patients exhibiting complete SLIL dorsal component tears (mean 5.02mm; 95%CI 4.21, 5.83) vs. patients without complete SLIL dorsal component tears (mean 2.89mm; 95%CI 2.35, 3.44), $p < 0.0001$. Scapholunate dissociation was also greater in patients with SLAC wrist ($p < 0.0001$), with a cut-off value of 3.9 mm for diagnosing SLAC (sensitivity 79.2% and specificity 94.7%).

Conclusions: In this sample of non-surgically treated patients with SLIL injury assessed on MDCT arthrography, we showed that complete tears of the dorsal component of the SLIL were independently associated with greater scapholunate dissociation and cartilage damage, suggesting in

Modified WORMS grades	Radial styloid-scaphoid	Proximal radio-scaphoid	Radio-lunate	Scaphoid-capitate	STT	Capito-lunate	Hamato-lunate
0	25 (58.1%)	28 (65.1%)	36 (83.7%)	39 (90.7%)	29 (67.4%)	34 (79.1%)	29 (67.4%)
2	1 (2.3%)	0	0	1 (2.3%)	0	4 (9.3%)	1 (2.3%)
2,5	0	2 (4.7%)	1 (2.3%)	1 (2.3%)	4 (9.3%)	0	9 (20.9%)
3	7 (16.3%)	4 (9.3%)	6 (14.0%)	2 (4.7%)	4 (9.3%)	2 (4.7%)	0
5	5 (11.6%)	4 (9.3%)	0	0	6 (14.0%)	1 (2.3%)	2 (4.7%)
6	5 (11.6%)	5 (11.6%)	0	0	0	2 (4.7%)	2 (4.7%)
Total (score > 0)	18 (41.9%)	15 (34.9%)	7 (16.3%)	4 (9.3%)	14 (32.6%)	9 (20.9%)	14 (32.6%)
Modified WORMS grades	Ulna-lunate	Scapho-lunate	Luno-triquetral	Ulna-triquetral	Hamato-triquetral	Capito-hamate	Distal radio-ulnar
0	40 (93.0%)	38 (88.4%)	43 (100%)	38 (88.4%)	42 (97.7%)	41 (95.3%)	37 (86.0%)
2	1 (2.3%)	0	0	0	0	0	0
2,5	0	1 (2.3%)	0	1 (2.3%)	1 (2.3%)	0	0
3	1 (2.3%)	2 (4.7%)	0	1 (2.3%)	0	1 (2.3%)	3 (7.0%)
5	1 (2.3%)	2 (4.7%)	0	2 (4.7%)	0	1 (2.3%)	3 (7.0%)
6	0	0	0	1 (2.3%)	0	0	0
Total (score > 0)	3 (7.0%)	5 (11.6%)	0	5 (11.6%)	1 (2.3%)	2 (4.7%)	6 (14.0%)

Cartilage Damage Scores	Dorsal Component	N	Mean (95% CI)	Student T test	Wilcoxon test
Global	Group 1	23	3.93 (1.63, 6.23)	$p = 0.0006$	$P = 0.0002$
	Group 2	20	14.97 (8.88, 21.07)		
Radial	Group 1	23	2.83 (1.25, 4.41)	$p = 0.0002$	$P < 0.0001$
	Group 2	20	12.67 (7.63, 17.72)		
Degenerative	Group 1	23	2.91 (0.97, 4.86)	$p = 0.0009$	$P = 0.0004$
	Group 2	20	12.95 (7.06, 18.83)		

vivo that the dorsal component represents the most important component of the SLIL in scapholunate (and carpal) stability, as previously demonstrated in cadaveric studies.

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THE ASSOCIATION BETWEEN ADULT HIP MORPHOLOGY AND HIP OSTEOARTHRITIS: A SYSTEMATIC REVIEW

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Purpose: Hip osteoarthritis (HOA) is a disease with increasing prevalence, but its aetiology is still not fully understood. Hip morphology has been recognised as an important risk factor. Over the last 15 years it has even been theorised that the majority of HOA cases are secondary to some sort of morphological abnormality. Morphological variants such as acetabular dysplasia and cam morphology are already known to increase the risk of HOA, while other variants might not have been identified yet. The emergence of statistical shape modelling (SSM) as a method to quantify hip shape provides new options to investigate

Methodology and characteristics of included studies.

Study	Design	N hips	Female	FU	SSM	HOA definition	Confounder adjustment	NOS
Agricola 2015	Prospective cohort / Nested case-control	1,100/114	100%	5/19	75 pts. F+P	THR	age, BMI, baseline KL	Good
Agricola 2013	Prospective cohort	1,411	79%	5	75 pts. F+P	THR / ACR	age, gender, BMI	Good
Ahedi 2017	Prospective cohort	831	51%	10	85 pts. F+A	THR	age, gender, BMI	Poor
Barr 2012	Nested case-control	102	68%	5	45 pts. F+A	THR	baseline KL, clinical, geometry	Good
Castano-Betancourt 2013	Prospective cohort	1,283	58%	6.5	67 pts. F+P	THR / KL ≥ 2	age, gender, BMI, baseline KL	Good
Faber 2017	Prospective cohort	4,100	0%	4.6	58 pts. F+A	CG ≥ 2	age, weight, height, race	Poor
Gregory 2007	Nested case-control	110	75%	6	16 pts. F	THR / KL increase ≥ 3	age, gender	Good
Lynch 2009	Nested case-control	351	100%	8.3	60 pts. F	THR / CG ≥ 2	age, height, BMD	Good
Mezhov *	Prospective cohort	799	51%	12.1	85 pts. F+A	THR	WOMAC, OARSI	Good
Nelson 2014	Nested case-control	382	61%	6	60 pts. F	KL ≥ 2	age, gender, BMI, race, baseline KL	Good
Waarsing 2011	Cross-sectional	656	82%	-	70 pts. F+P	KL ≥ 2	age, gender, BMI	Good
Waarsing 2010	Prospective cohort	≥ 409	69%	2	23 pts. F	KL ≥ 2 / JSW < 1.5 mm	-	Poor

FU = Mean follow-up in years, SSM = Of how many points does the statistical shape model consist, and what is modelled (F = Femur only, F+A = Femur and acetabular roof, F+P = Femur and hemi-pelvis), HOA = Hip osteoarthritis, NOS = Newcastle-Ottawa Scale rating (good/fair/poor, THR = Total Hip Replacement, ACR = American College of Rheumatology criteria for HOA, KL = Kellgren-Lawrence grade, CG = Croft grade, JSW = Joint Space Width, BMI = Body Mass Index, clinical = clinical factors, geometry = traditional radiographic measurements, BMD = Bone Mineral Density at the hip, WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index (pain), OARSI = OARSI grade.

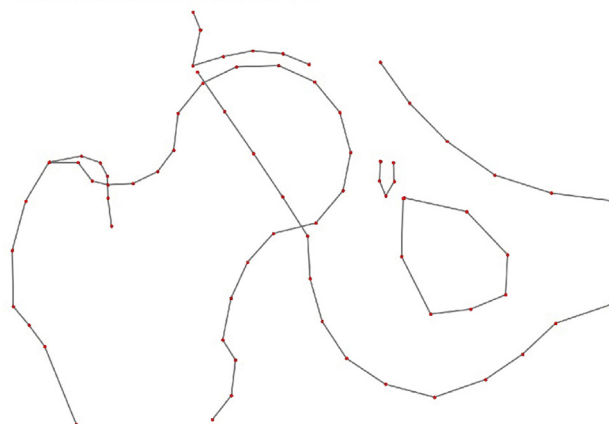
* = This study has not been published yet.

morphological risk factors beyond traditional measurements alone. The aim of this systematic review was to investigate the associations between adult hip morphology as measured by SSM and the development or progression of HOA.

Methods: Any clinical trial, cohort, case-control or cross-sectional study presenting original data was considered eligible for inclusion. HOA had to be defined as clinical, radiological or total hip replacement (THR). Studies needed to have included both participants with and without HOA, or subjects without HOA at baseline that developed incident HOA at follow-up. Morphology had to be assessed by SSM on any imaging modality. Studies were excluded if the association between morphology and HOA was not an aim of the study, or if the studied morphology was clearly related to childhood hip disease, tumours, posttraumatic or postoperative deformities. Studies that only reported 'pre-osteoarthritic changes', assessed by novel MRI techniques (dGEMRIC, T1 ρ , SHOMRI) or by hip arthroscopy, were also excluded. The literature search was carried out on July 26, 2019. We searched Embase, Ovid MEDLINE, Web of Science, Cochrane CENTRAL and Google Scholar. Two reviewers independently screened the titles and abstracts of all search results and read the full text of eligible references. Data extraction was also independently done. Between these steps a consensus meeting between the two reviewers was held to discuss any discordances. We used the Newcastle-Ottawa Scale (NOS) for risk of bias assessment, and an adaptation of the NOS for one cross-sectional study.

Results: We screened the titles and abstracts of 4,284 references, from which we selected 23 articles for full-text reading. We eventually included 12 articles for this systematic review. The included studies described a total population of 9,311 subjects, of whom 11,648 hips were analysed with SSM. The overall proportion of females was 40%. Further details of the included studies are described in Table 1. The NOS risk of bias assessment showed 9 studies with good methodological quality and 3 studies with poor quality, the latter was mainly due to poor comparability and unexplained loss to follow-up. All studies used the same method for annotation and SSM (ASM toolkit, University of Manchester, UK) on either radiographs or DXA scans. However, the number of points in the shape models varied from 16 on the femoral head and neck to 85 outlining the entire proximal femur and hemipelvis. An example of a 75-point model is shown in Figure 1. HOA was defined as THR in 8 studies, radiographic HOA (Kellgren-Lawrence or Croft grade) in 7 studies, and clinical HOA in 2 studies; some studies used multiple definitions. A multitude of shape modes significantly increased the odds for either THR or HOA when that particular shape mode deviated further from the mean shape, with adjusted odds ratios (aOR) varying from 1.21 to 5.88 per standard deviation change. Shape modes that appeared to show a similar direction of variation between studies and that resulted in significantly higher odds for THR were mostly interpreted as having less acetabular coverage or depth, a less spherical femoral head (or cam morphology) and a greater neck-shaft angle (coxa valga). Shape modes that significantly increased odds for radiographic HOA were described as a cam or pincer morphology, a longer and thinner femoral neck, a larger femoral head, larger trochanters and a smaller neck-shaft angle (coxa vara).

Figure 1
An example of a 75-point statistical shape model that includes both the proximal femur and the hemi-pelvis, as used by Agricola et al.



Conclusions: Every reviewed study found significant associations between SSM hip morphology and HOA. However, it is difficult to draw universal conclusions about which morphologies pose the highest risk, because the shape modes of the different studies cannot be compared directly with one another. Each study used a different statistical shape model, both in number and placement of the points that outline the bone. Some studies included the acetabulum or pelvis while others did not. Moreover, the anatomical variation in shape can differ between populations as well. Another limitation is the varying definitions of HOA between studies. To combat this heterogeneity of methods and therefore results, future studies should focus on using a uniform statistical shape model and definition of HOA, preferably in a large sample.

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THE IMPACT OF A SIGNIFICANT WEIGHT LOSS ON INFLAMMATION ASSESSED ON DYNAMIC CONTRAST-ENHANCED MRI AND STATISTICAL SHAPE MODELS IN KNEE OSTEOARTHRITIS: A PROSPECTIVE COHORT STUDY

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Purpose: Obesity is a worldwide health issue and one of the most important risk factors for development of osteoarthritis (OA). The