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Size and shape of the lunate surface in different types of pincer impingement: theoretical implications for surgical therapy

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SUMMARY

Objective: Acetabular rim trimming is indicated in pincer hips with an oversized lunate surface but could result in a critically decreased size of the lunate surface in pincer hips with acetabular malorientation. There is a lack of detailed three-dimensional anatomy of lunate surface in pincer hips. Therefore, we questioned how does (1) size and (2) shape of the lunate surface differ among hips with different types of pincer impingement?

Method: We retrospectively compared size and shape of the lunate surface between acetabular retroversion (48 hips), deep acetabulum (34 hips), protrusio acetabuli (seven hips), normal acetabuli (30 hips), and hip dysplasia (45 hips). Using magnetic resonance imaging (MRI) arthrography with radial slices we measured size in percentage of the femoral head coverage and shape using the outer (inner) center-edge angles and width of lunate surface.

Results: Hips with retroversion had a decreased size and deep hips had normal size of the lunate surface. Both had a normal shape of the outer acetabular rim. Protrusio hips had an increased size and a prominent outer acetabular rim. In all three types of pincer hips the acetabular fossa was increased.

Conclusion: Size and shape of the lunate surface differs substantially among different types of pincer impingement. In contrast to hips with protrusio acetabuli, retroverted and deep hips do not have an increased size of the lunate surface. Acetabular rim trimming in retroverted and deep hips should be performed with caution. Based on our results, acetabular reorientation would theoretically be the treatment of choice in retroverted hips.

Introduction

Pincer type femoroacetabular impingement (FAI) is associated with hip pain and osteoarthritis[1,2]. The underlying pathomechanism is an early abutment of a too prominent acetabular rim with the femoral neck. The common surgical treatment of pincer hips is trimming of the prominent acetabular rim. This implies the assumption that the pincer problem is caused by an oversized lunate surface – although this has never been proven so far. There is evidence in more recent literature that pincer problems can also be caused by a malorientation of the acetabulum[3,4,5] or even the entire hemipelvis[6]. For these cases, acetabular reorientation was proposed as corrective treatment[7].

Theoretically, rim trimming would only be indicated if the lunate surface is oversized. A reorientation procedure would be correct in pincer hips with acetabular malorientation. The indications for either treatment option are nowadays discussed controversially[7,8,9]. Trimming of the acetabular rim in hips with a retroverted socket could decrease the size of the lunate surface to a critical level. This increases joint contact pressure and can be the reason for early failure[10].

The size and the shape of the lunate surface have been described for normal and dysplastic hips only. Although of importance for surgical decision-making, there is no information available on the detailed anatomy of the lunate surface in hips with pincer

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impingement. Therefore, we questioned: How do (1) size and (2) shape of the lunate surface differ among hips with different types of pincer impingement compared to hips with a normal acetabulum and dysplastic hips using magnetic resonance imaging (MRI) arthrography of the hip?

Material and methods

Description of study groups

We performed a retrospective comparative study including a total of 164 selected, non-consecutive hips in 152 symptomatic patients (Table I). They were recruited from the outpatient clinic of the authors' institution. Inclusion criteria were the availability of a standardized anteroposterior pelvic radiograph[11] and a specific MRI arthrography of the hip[12]. Exclusion criteria were previous surgery, a history of pediatric hip disease, and osteoarthritis grade ≥2 according to Tönnis[13]. We compared the anatomy of the lunate surface among hips with pincer impingement ($n = 89$) to a group of hips with a normal acetabulum ($n = 30$) and hip dysplasia ($n = 45$). Pincer hips were further divided into acetabular retroversion ($n = 48$), deep acetabuli ($n = 34$), and protrusio acetabuli ($n = 7$). This resulted in a total of five study groups (Table I). The allocation to each group was based on the following criteria on conventional anteroposterior pelvic radiographs. Acetabular retroversion was defined by a simultaneous appearance of a positive crossover[14], posterior wall[14], and ischial spine sign[4] [Fig. 1]. Deep acetabulum was defined by a lateral center-edge angle exceeding 38°[15] in a mainly anteverted acetabulum. The acetabulum was defined as anteverted if no more than two of the previously defined radiographic signs for acetabular retroversion were positive [Fig. 1]. Protrusio acetabuli was present if the femoral head touches or crosses the ilioischial line [Fig. 1]. The normal acetabulum group consisted of patients with an isolated cam-type impingement and a normal appearing acetabulum [Fig. 1]. A normal acetabulum was defined if the lateral center-edge angle, acetabular index (AI), extrusion index, total femoral coverage, and anterior and posterior femoral coverage were within a previously defined normal range[16] (Table I). All patients in the normal acetabulum group underwent surgical hip dislocation with offset correction and showed no persistent impingement originating from the acetabular side (Table I). Acetabular dysplasia was defined by a lateral center-edge angle of less than 25°[17] and a minimal AI of 14°[15] [Fig. 1]. The study was approved by the local institutional review board.

Imaging technique

Anteroposterior pelvic radiographs were performed in a standardized manner[11]. The patient was placed in supine position with internally rotated legs to compensate for femoral antetorsion. The film-focus distance was 1.2 m and the central beam was directed to the midpoint between the symphysis and a line connecting the anterosuperior iliac spines[11]. One observer (TDL) assessed ten radiographic parameters (Table I) to describe the acetabular and femoral head morphology on anteroposterior pelvic radiographs using previously developed and validated software, Hip^{2}Norm (University of Bern, Switzerland[18,19]).

The MRI arthrography was obtained according to a standardized protocol described earlier[12]. In brief, the scans were performed using a Siemens Vision 1.5-T high field scanner (Erlangen, Germany) with a flexible surface coil after fluoroscopic-guided intra-articular injection of saline-diluted gadolinium-DTPA (Dotarem 1:200, Guerbert AG, Paris, France). After obtaining transversal, sagittal, and coronal proton-density-weighted and T1-weighted sequences to assess the entire joint, a radial proton-density-weighted sequence was used in which all slices were oriented orthogonal to the femoral neck and head. These slices were based on a sagittal oblique localizer, which was marked on the proton-density-weighted coronal sequence, running parallel to the sagittal oblique course of the femoral neck. The slices were defined individually for every patient resulting in 14 radial slices. Of the 14 slices every second slice was chosen, providing seven radial slices with 14 positions for measuring [Fig. 2]. Position 8 was defined as the acetabular notch and position 1 as the opposite position. Anterior was defined as position 4 and 5 for both right and left hips. The subsequent slices were acquired rotating clockwise and counterclockwise around the femoral head neck axis for right and left hips, respectively.

Table I
Demographic and radiographic data of the five study groups

Parameter	Retroversion	Deep	Protrusio	Normal acetabulum	Dysplasia	*P*-value
Patients (hips)	44 (48)	32 (34)	5 (7)	26 (30)	45 (45)	–
Age at MR acquisition (years)	25 ± 7 (17–50)	36 ± 10 (17–52)*	29 ± 11 (17–44)	29 ± 10 (18–58)	35 ± 10 (17–50)	<0.001
Gender (% male hips)	54	38	0*	57	27*	0.004
Side (% right hips)	66	41	43	67	47	0.072
Height (cm)	171 ± 11 (140–203)	173 ± 9 (155–192)	164 ± 5 (160–170)	171 ± 8 (159–185)	169 ± 9 (151 –188)	0.173
Weight (kg)	73 ± 16 (40–108)	69 ± 13 (51–105)	73 ± 18 (50–93)	73 ± 13 (45–101)	71 ± 20 (48–168)	0.837
BMI (kg/m^2)	25 ± 5 (17–40)	23 ± 4 (18–31)	27 ± 6 (20–32)	24 ± 4 (20–37)	25 ± 7 (18–65)	0.348
Surgical treatment (%)						
Surgical hip dislocation	48*	85*	86*	100	0*	<0.001
PAO	35*	0	0	0	78*	<0.001
LCE angle[32] (°)	36 ± 8 (20–48)*	43 ± 4 (39–54)*	43 ± 7 (32–52)*	27 ± 3 (23–33)	13 ± 9 (-16 – 22)*	<0.001
Acetabular index[15] (°)	1 ± 7 (−15–20)*	0 ± 4 (−7–8)*	−1 ± 3 (−6–2)*	7 ± 3 (3–13)	21 ± 6 (14–38)*	<0.001
Extrusion index[17] (%)	16 ± 6 (5–33)*	9 ± 3 (3–16)*	9 ± 6 (−1–18)*	23 ± 3 (17–27)	34 ± 7 (23–57)*	<0.001
Total femoral coverage (%)	80 ± 10 (51–95)	92 ± 6 (79–100)*	94 ± 6 (84–100)*	75 ± 5 (70–83)	62 ± 11 (32–78)*	<0.001
Anterior coverage (%)	36 ± 10 (12–59)*	33 ± 9 (16–60)*	35 ± 5 (25–41)*	20 ± 3 (15–25)	13 ± 6 (0–27)*	<0.001
Posterior coverage (%)	32 ± 8 (13–47)*	55 ± 9 (42–79)*	66 ± 5 (59–74)*	41 ± 4 (36–47)	39 ± 10 (20–60)	<0.001
Crossover sign[14] (% positive)	100*	26	0	13	42*	<0.001
Retroversion index[11] (%)†	51 ± 12 (23–74)*	19 ± 6 (10–26)	–	9 ± 5 (6–15)	20 ± 11 (7–47)	<0.001
Posterior wall sign[14] (% positive)	100*	9	0	20	67*	<0.001
Ischial spine sign[4] (% positive)	100*	24	14	23	20	<0.001
Protrusio sign (% positive)	0	0	100	0	0	<0.001

Values of continuous parameters are expressed as mean ± standard deviation with range in parenthesis.
* Significant difference compared to the normal acetabulum group.
† For hips with positive crossover sign only.