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Osteoarthritis (T Appleton, Section Editor)

The Importance of Hip Shape in Predicting Hip Osteoarthritis

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Abstract

Purpose of review This narrative review summarizes the evidence relating hip shape and risk of osteoarthritis at the hip, with a focus on the most recent body of work.
Recent findings Hip osteoarthritis (OA) is a prevalent and potentially disabling condition with few effective non-surgical treatment options. Risk factors for hip OA appear to differ somewhat from those at other sites. Variations in hip morphology, whether assessed through standard geometric measures or statistical modeling methods, seem to increase hip OA risk and may provide a novel approach to interventions to reduce or prevent OA. Such variations have also led to focused surgical interventions to "correct" abnormal shape, although comparisons with non-surgical management are lacking.
Summary There remains a lack of understanding regarding the optimal management, whether surgical, non-surgical, or a combination, for FAI syndrome. Even less is known regarding other potential morphologic variations that may contribute to OA risk. Additionally, many individuals who have shape variations that would seem to increase their risk will never develop hip OA. Questions remain regarding key risk factors for hip OA development, which individuals should be targeted for therapies, whether directed at symptoms, function, or prevention, and which therapies should be studied and offered. Trials are underway to help address some of these questions.

Introduction

Using data from the 2010–12 National Health Interview Survey, the CDC estimates that arthritis affects more than 50 million US adults (23%), with more than 20 million people reporting arthritis-attributable activity limitations [1]; this is likely to be an underestimate [2, 3] of this highly prevalent condition. Given the aging of our society

and the obesity epidemic, the burden of osteoarthritis (OA), the most common form of arthritis, will certainly continue to increase over the next 20 years [1, 4].

Hip OA (HOA) can be particularly problematic given subsequent pain and potential loss of mobility and disability. HOA accounts for the majority of total hip arthroplasty (THA) procedures which continue to increase in frequency (http://hcupnet.ahrq.gov/HCUPnet.jsp). In 2007, Kurtz et al. estimated that the demand for primary THA would grow by 174%, from 208,000 in 2005 to 572,000 in 2030, with revisions doubling by 2026 (from 41,000 in 2005 to 97,000 in 2030). [4].

Several studies have estimated the prevalence of HOA using radiographic or symptomatic criteria, or a combination. These estimates vary by population, but overall suggest a prevalence in the adult US population of around 25% for radiographic HOA, and 5–10% for symptomatic HOA [6–8]. Like other joint sites frequently affected by OA, the prevalence increases with age, but associations with other features, such as gender and BMI, are less clear, with conflicting results in the literature. In contrast to historical reports, the prevalence of HOA among African Americans was not found to be lower than that of whites in the Johnston County Osteoarthritis Project [8]. Additionally, the lifetime risk of symptomatic HOA, defined as the proportion developing symptomatic HOA by age 85 years, was estimated to be 25% using data from the Johnston County OA Project, and did not vary by age, sex, race, education level, injury, or BMI [9]. This lack of clear association with the usual OA risk factors has led investigators to consider other hip-specific risk factors for HOA, such as hip joint morphology. The following is a narrative review focused on current HOA treatment, hip shape as a risk factor for HOA, and treatment options related to hip shape variations, chosen by the author based on quality and relevance with a focus on work in the last 5 years where possible.

Treatment

In a systematic review of published osteoarthritis treatment guidelines [10] updated in 2016 [11•], we identified several therapies for OA of various sites that were recommended across multiple guidelines, and others which incurred less agreement or had less evidence, summarized below for the specific case of HOA. Of note, all available pharmacologic strategies are aimed primarily at symptomatic relief, as none have been shown to impact incidence or progression of structural change. Additionally, most treatments have been studied to a greater extent in knee OA, with results extrapolated to HOA.

Recommended non-pharmacologic treatments for HOA

- Weight loss
- Land or water-based exercise with or without physiotherapy
- Education and self-management
- Assistive devices (e.g., cane, walker)

Recommended pharmacologic treatments for HOA

- Pharmacologic treatment recommended across guidelines [10, 11•] include:

  – Acetaminophen/paracetamol (although recent work suggests minimal benefit at best)

  - NSAIDs, either selective or non-selective, with appropriate gastrointestinal and cardiovascular risk stratification (and in some cases contraindicated due to GI or CV comorbidity)
  - Tramadol
  - Opioid analgesics for refractory cases
  - Intra-articular corticosteroids
- Other considerations (with less agreement as to clinical benefit across guidelines) include:

  - Duloxetine, particularly if more centralized pain or with multiple joint sites are involved
  - Glucosamine/chondroitin
  - Other intra-articular therapies (e.g., hyaluronic acid preparations)

Surgical options for HOA

- Joint replacement surgery is a key intervention for end-stage refractory disease to improve pain and function
- Joint-preserving procedures (e.g., pelvic osteotomy, hip arthroscopy) may be considered in the absence of advanced joint damage [12]
- Hip resurfacing leaves the femoral head in place but caps it in metal, accompanied by replacement of the damaged acetabular cartilage with a metal shell and may be an option for young and active patients
- For hips with FAI syndrome but minimal to no degenerative change, additional surgical options may be considered, see below [13••, 14]

Total hip arthroplasty

Standard procedure	Removal of femoral head and acetabulum with replacement by metal, plastic, or ceramic components, with or without cement, lateral or posterior approach
Contraindications	Few absolute, although optimizing glycemic control is important due to infection risk, smoking cessation can improve wound complications, and some medications should be held, and individual risk-benefit evaluation is key [12]
Complications	In a Medicare population rates of complications in the first 90 days after primary, THA were 1% for mortality, 0.9% for pulmonary embolus, 0.2% for wound infection, 4.6% for hospital readmission, and 3.1% for hip dislocation (higher for revisions) [15]
Special points	10-year revision rates 5–20% depending on age and technique; up to 25% of patients report minimal improvement or dissatisfaction with outcomes [12]
Cost/cost-effectiveness	THA is thought to be cost-effective, although no recent data are available [16]

Femoroacetabular impingement surgery

Standard procedure	Open or arthroscopic with labral preservation
Contraindications	Poorer outcomes have been reported in the presence of advanced degenerative changes

Complications	Arthroscopic repair: In > 1600 hips, the overall complication rate was 8%, higher in females and with traction time longer than 60 min; major complications in 1% [17] Open repair: In over 300 hips, the overall complication rate was 9%; none resulted in long-term morbidity other than one case of partially resolved sciatic neurapraxia [18]
Special points	No controlled studies comparing surgical to non-surgical management, or showing a long-term reduction in OA incidence or progression following such procedures
Cost/cost-effectiveness	Unknown, one study from 2012 suggested arthroscopic repair in those without arthritis was cost effective [19]; another suggested reduced resource use with arthroscopic versus open approaches [20]

Recent findings: hip shape as a risk factor for hip OA

Morphology at the hip has been more extensively studied than at other joints affected by OA, likely due to recognized conditions such as congenital dysplasia and femoroacetabular impingement (FAI) that have been tied to development of HOA in particular. FAI has become a hot topic in the orthopedic and rheumatologic literature, particularly in the last decade [21, 22, 23••]. FAI can manifest as cam morphology (abnormalities of the femoral head/neck), pincer morphology (generally acetabular overcoverage) or a combination of these shape variations, leading to dynamic impingement and symptoms, with the latter termed FAI syndrome per the Warwick agreement [24••]. These morphologic changes are best assessed using cross-sectional imaging techniques, although they can also be determined using conventional radiography, which is particularly useful when determining prevalence in large epidemiologic cohorts and for screening in a clinical setting. Using data from the population-based Johnston County OA Project, we have recently reported that one in four men and one in ten women have radiographic evidence of cam morphology (based on an AP alpha angle of 60° or more), while up to 10% of the cohort had evidence of pincer morphology, or acetabular overcoverage [25•]. These estimates were similar to those from a population-based study in Norway, where 35% of men and 10% of women had evidence of cam morphology [26].

Several epidemiologic studies have also identified associations between HOA outcomes and morphologic features. In a nested case (baseline Kellgren Lawrence grade [KLG] < 3, follow-up KLG 3 or more) control (KLG < 3 at baseline and follow-up) study using Johnston County OA Project data, we found that case hips had a higher frequency of cam morphology (greater AP alpha angles and higher frequency of triangular index sign) in both men and women, while protrusio acetabuli (overcoverage/pincer morphology) was more likely in case hips only in women [27]. In the Chingford cohort, which includes about 1000 white women in the UK [28], women who underwent THA after 19-year follow-up were found to have more cam morphology features (higher AP alpha angles and triangular index height), as well as a higher frequency of acetabular dysplasia, versus those who did not undergo THA. Using data from CHECK, a prospective cohort study in the Netherlands, Agricola et al., found that cam morphology was associated with higher odds of severe rHOA or THA [29], while pincer morphology was not [30].

Statistical shape modeling (SSM) is an analytic tool that can identify global variations in hip joint shape that may contribute to OA risk, in contrast to the predefined geometric measures considered above. Gregory et al. published the first work on SSM in radiographic HOA [31]. We and others have identified associations between specific variations in hip shape and prevalent and incident radiographic and symptomatic HOA and THA [32–34]. Using the same SSM in two distinct cohorts (Chingford and CHECK), only one mode of variation was consistent in both [35]. SSM using dual-energy X-ray absorptiometry (DXA) hip scans has also demonstrated associations between hip morphologic changes and radiographic HOA and hip pain [36]. An Australian cohort of individuals with DXA, X-ray, and MRI data showed that SSM-based modes of variation were associated with radiographic HOA, hip cartilage volume, and muscle strength as well as with the development of hip pain and 10-year risk of THA [37]. Another study found that hip geometry by SSM and predefined geometric parameters was associated with radiographic HOA at 6.5 years, independent of other clinical features [38]. Variations in hip shape by SSM are also associated with OA at the knee, likely due to alterations in kinetic chain biomechanics [39, 40]. Novel methodology for analysis of these complex datasets [41] and more automated tools for shape assessment [42] may improve our understanding of these associations and inform potential interventions.

Other studies have further explored risk factors for pain and HOA progression related to hip morphology. In a British birth cohort, BMI and gains in BMI seemed to affect frequency of hip morphologic change [43]. In a population sample from Canada where about half of individuals had radiographic evidence of cam or pincer morphology, higher physical activity was associated with hip pain overall, with a stronger effect in those with these morphologies [44]. Several studies have identified associations between genetic markers of HOA risk and hip shape [45–47]. There are clear gender differences in hip shape, and we and others have identified racial/ethnic variation in overall HOA prevalence [8] as well as in relation to hip morphologies that will likely be relevant to future management strategies [25•, 27, 48, 49].

Current and future options for management of HOA due to morphologic changes

There has been substantial interest in the orthopedic community around potential surgical interventions for some morphologic features, particularly cam morphology. This has been detailed elsewhere by orthopedists who perform these procedures, and according to a publication from the ANCHOR group, improvements in hip arthroscopy techniques and equipment have made it (rather than the traditional open approach) the primary surgical technique for most cases of FAI [13••]. However, it is important to note that there are still no published randomized controlled trials comparing non-surgical management to any surgical procedure. Those studies that are available are generally small, have short follow-up, high risk of bias, and often are single-surgeon cohorts, limiting generalizability. In fact, in a recent systematic review, Fairley et al. note these limitations and review the evidence from 18 studies. When comparing surgical approaches, symptomatic outcomes appeared somewhat better for arthroscopic compared to open approaches. Evidence of long-term outcomes was lacking, as only two of these studies had more than 3 years of follow-up, which is a major limitation in a condition like HOA that takes years to develop.

However, some available data suggests increased OA progression following FAI surgery. The authors of the review also note that "conservative measures may avert surgery in 39–89% of people with FAI over 12-28 months" [23••]. According to clinicaltrials.gov, as of December 20, 2017, there are 25 active clinical trials of FAI treatment; three of these compare surgery to physiotherapy, while one compares arthroscopic surgery to sham surgery. Others are considering intra-articular injections, nerve blocks, different forms of physiotherapy and exercise, and other modalities as possible interventions. Hopefully these and other future studies will help to clarify the risk and benefit of surgery and those who may benefit from alternate interventions. As we have learned from studies in knee OA, well-designed randomized trials are essential to evaluate the efficacy of surgical interventions, even when these procedures are being performed routinely [50–52].

Despite the lack of direct comparison trials, there is growing interest in the possibility of non-surgical interventions for FAI syndrome that might reduce symptoms, increase function, and potentially reduce or prevent the development of HOA over time. Wall et al. performed a systematic review of non-operative treatment for FAI in 2013, noting in the introduction that "FAI surgery has evolved…at a pace far quicker than our understanding about the natural history and epidemiologic characteristics of the condition [53••]." This review assessed 53 articles, only 5 of which included primary evidence (but no randomized trials), with the others representing reviews and discussion pieces. Among the 5 articles with primary evidence, there was substantial heterogeneity regarding population, FAI assessment, and treatment regimen, all had low to very low quality of evidence, and none defined a primary outcome measure. However, there was a suggestion of benefit in symptoms and function from non-operative therapies and activity modification in the 2 highest quality studies. The authors of the review also provide a summary of the other 48 review or discussion articles, of which about half promoted physical therapy for FAI despite the lack of evidence.

There is also interest in possible prevention strategies focused on HOA secondary to morphologic variation. Several studies have identified an increased prevalence of cam morphology among athletes and young adults; in these individuals, the presence or development of cam morphology is associated with higher frequency of radiographic HOA [54, 55]. Finite element analyses have shown that loading patterns during skeletal maturation could contribute to the development of cam morphology [56]. The fact that skeletally immature individuals, particularly those involved in sport, may be at higher risk of developing cam morphology suggests that altering loading during this crucial time frame could be a possible preventative strategy to reduce future HOA risk.

Summary

There is a growing literature regarding the frequency of morphologic variations at the hip, and increasing evidence that these morphologies are associated with important outcomes like incident radiographic and symptomatic HOA and THA. However, many questions remain, including why a large number of individuals with these morphologies are completely asymptomatic and do not develop HOA. What are the key risk factors? Which individuals should be targeted for therapies? Additionally, even in

FAI syndrome, while the frequency of surgical intervention continues to increase, the risk to benefit ratio of these procedures is unclear, particularly in the absence of large randomized controlled trials including sham surgery and/or physiotherapy approaches. Hopefully, current and future studies will help to clarify some of these key issues.

Compliance with Ethical Standards

Conflict of Interest

Amanda E. Nelson reports grants from NIAMS K23AR061406 and the CDC, during the conduct of the study, and personal fees from GSK and from Health Press Ltd., outside the submitted work.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

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