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Incidence of Heterotopic Ossification in Anterior Based Muscle Sparing Total Hip Arthroplasty: A Retrospective Radiographic Review

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Abstract: Heterotopic ossification (HO) is a known complication following total hip arthroplasty (THA). The anterior based muscle sparing (ABMS) approach is a variation of a direct anterior approach through the Watson–Jones interval. To date, few studies have evaluated HO formation following this surgery. We examine the incidence of HO in a consecutive series of THAs using this approach by three different surgeons at a single center. Standard preoperative radiographs were examined to determine the type of degenerative arthritis, and follow-up radiographs a minimum of 9 months after surgery were evaluated for the presence and classification of HO. The overall incidence of HO after ABMS THA in this study was 86/233, or 36.9%, which is comparable to recent studies of direct anterior and traditional approaches. Class III and IV HO is uncommon in ABMS surgery (3.9% and 1.3%, respectively) and appears to decrease with increased surgical experience with this technique.

Keywords: primary; total hip arthroplasty (THA); heterotopic ossification (HO); Brooker classification; minimally invasive surgery (MIS); anterior based muscle sparing (ABMS)

1. Introduction

The anterior based muscle sparing (ABMS) (modified Watson–Jones) approach to total hip replacement is a minimally invasive intermuscular approach without muscle transection which was reported initially by Bertin and Rottinger [1], and has been recently shown to have comparable outcomes to the direct anterior (Heuter) approach (DAA) [2]. It is sometimes referred to as the anterolateral minimally invasive (ALMI) approach [1]. Potential advantages include decreased soft tissue trauma [1] overall and early recovery of hip function and gait mechanics [2], as well as lower dislocation rates compared with the posterior approach [3] and a lower infection rate when compared to a direct lateral Hardinge–Bauer approach [3]. Midterm registry implant survival is comparable to other contemporary approaches [3].

Heterotopic ossification (HO) is a frequent radiographic finding following total hip arthroplasty (THA) using traditional approaches, with an incidence of as high as 61% overall and 8.2% high grade [4]. This finding is thought to be the result of osteoinductive growth factors released with the trauma of injury or surgery [5,6] and, although the degree of HO formation is multifactorial, soft tissue trauma during surgery may be an important causative factor. HO is usually evident by 6 weeks after THA, matures during the first 6 months, and does not develop further thereafter [7,8]. Only a small percentage of patients with the most extensive HO report clinical effects such as significant pain, stiffness, and dysfunction [9].

We hypothesized that HO would be decreased after the ABMS THA compared with traditional approaches since less invasive approaches are reported to cause less soft tissue trauma. Because this

contemporary technique is said to be associated with a learning curve, we further hypothesized that HO formation correlates with less surgical experience. The purpose of our study, therefore, was to determine the incidence of HO in THA patients who have undergone ABMS surgery at one institution, by three surgeons of various experiences.

2. Materials and Methods

This study was approved by our institutional review board (#4494X), and was exempt from obtaining informed consent, as this was a retrospective review with de-identified patients. Our goal was to study 3 sets of 100 consecutive ALMI THA patients (a cohort of convenience), from 3 different surgeons with radiographic follow-up of at least 9 months after their primary surgery. Because the third surgeon (surgeon C) was early in his career, he had fewer patients with appropriate follow-up, so we continued recruitment in his practice until he had similar numbers to the other two surgeons. Surgeries were performed between December 2012 and August of 2014, and the dates varied slightly between surgeons. Two-hundred thirty-three hips were identified; 88 additional hips in the consecutive series were excluded because they did not have adequate radiographic follow-up, and 1 hip was excluded because the patient had simultaneous bilateral THAs (Table 1). No other hips were excluded.

Table 1. Surgeon experience and patients included.

Surgeon	Prior ABMS THA	Dates of THA	Included	Excluded
A	1740	12/12–6/13	74	26
B	321	12/12–6/13	82	18
C	10	4/13–8/14	77	45
Total			233	89

ABMS = anterior based muscle sparing; THA = total hip arthroplasty.

Two of the three surgeons (surgeons B and C) were fellowship-trained adult reconstructive surgeons, and the most experienced surgeon with this technique (surgeon A) was fellowship trained in trauma surgery. At the time of the surgery, surgeon A had performed 1740 ABMS hips, surgeon B, 321 hips, and surgeon C, 10 hips. The technique of ABMS THA is described in detail elsewhere [2,10]. All implants in this cohort were non-cemented. Patients were full weight-bearing and received Aspirin 325 mg by mouth twice a day for 6 weeks for deep vein thrombosis (DVT) prophylaxis. A suction drain was used for 24 hours in all patients. No patient received radiation or indomethacin prophylaxis to prevent HO formation.

Demographic data from the chart review were obtained, which included patient sex and age at surgery. Preoperative anteroposterior (AP) and lateral digital radiographs were reviewed for each patient, and the type of arthritis was classified as either hypertrophic, atrophic, or normotrophic based on the Bombelli classification [11]. AP and lateral digital radiographs at a minimum of 9 months post-operatively were graded for HO using the Brooker classification, the most widely accepted method (Table 2) [7]. This classification provides a fair intraobserver reliability ($K = 0.74$) [12,13]. Pre- and post-operative radiographs were graded by the same experienced investigator (ACM), to reduce inter-observer error.

Table 2. Brooker classification of heterotopic ossification [8].

Class	Description
1	Islands of bone within the soft tissues of the hip
2	Bone spurs from the pelvis or proximal end of the femur, leaving at least 1cm between opposing bone surfaces
3	Bone spurs from the pelvis or proximal end of the femur, reducing the space between opposing bone surfaces to less than 1 cm
4	Apparent bone ankylosis of the hip

Logistic regression was used to determine the relative risk of HO associated with gender. The Fisher's exact test was used to determine the relationship between patient age (65 years and less/>65 years) and HO status (yes/no) and also high-grade HO (3 and 4) (yes/no) versus surgeon (most experience / lesser experience). A Kruskal–Wallis one-way analysis of variance test was performed to compare the Brooker scores between surgeons.

3. Results

The initial study population included 322 hips, while the final study population included 233 hips. Eight-eight hips were excluded for lack of appropriate follow-up radiographs, and 1 because the patient had simultaneous bilateral THA. A total of 112 (48.1%) hips were implanted in men, and 121 (51.9%) were implanted in women. The average age at surgery of the patients in the study was 64.3 years (range, 29–91). Of note, there were no surgeries related to HO in the patients enrolled in this study.

The overall incidence of HO after ABMS THA in this study was 86/233, or 36.9%. This was 28/74 (37.8%) for the most experienced surgeon with this technique, 58/159 (36.5%) for the intermediate and least experience surgeons combined. Of note, the combination of Class III and IV HO was 12/233 (5.2%) for the whole cohort: 0/74 (0%) for the most experienced surgeon with this technique and 12/159 (7.5%) most for intermediate and least experienced surgeons combined (Table 3) ($p = 0.0044$). This trend was noted even though surgeon A had more male patients, and male patients were more likely to form HO (Table 4) ($p = 0.0001$).

Table 3. Incidence and Brooker [8] category of heterotopic ossification by surgeon.

Surgeon	Class 0	Class 1	Class 2	Class 3	Class 4
A	46/74 (62.2%)	13/74 (17.6%)	15/74 (20.3%)	0/74	0/74
B	49/82 (59.8%)	19/82 (23.2%)	8/82 (9.6%)	5/82 (6.1%)	1/82 (1.2%)
C	52/77 (67.5%)	13/77 (16.9%)	6/77 (7.8%)	4/77 (5.2%)	2/77 (2.6%)
Total/233	147 (63.1%)	45 (19.3%)	29 (12.4%)	9 (3.9%)	3 (1.3%)

Table 4. Age and sex category by surgeon.

Surgeon	N	Older than 65 Years:65 Years and Younger	Male:Female
A	74	38:36	38:36 (52% male)
B	82	34:48	37:45 (46% male)
C	77	28:49	29:48 (38% male)

The crude incidence rate of HO and relative risks for different contributing factors revealed that there were significantly more male patients who developed HO (55/112, 49.1%) than females (31/121, 25.6%) ($p = 0.0001$). We found no tendency for increased HO formation in patients older than age 65 (40/100, 40%) compared with patients 65 years and younger (46/87, 52.7%) ($p = 0.40$). There was no statistical difference in the formation of HO between different types of arthritis, according to the Bombelli classification ($p = 0.53$).

4. Discussion

Patients, surgeons, and health systems value efficient hip replacement surgery with accelerated recovery, low complications, and excellent outcomes. There is growing evidence that an anatomic dissection and approach, with a minimum of soft tissue trauma and muscle retraction, may contribute to the achievement of such a result [1,14,15]. These are also factors that contribute to HO, so HO formation may act as a surrogate for diminished soft tissue trauma.

HO development following ABMS THA surgery was 86/233, or 36.9%, which is comparable to studies of direct anterior [16] and posterior THA [17], and lower than the prevalence with a direct

lateral approach with (Liverpool) [18] and without (Hardinge–Bauer) [19] bone attachment. Our results demonstrate higher rates of HO compared with two other reports of the ABMS technique [20,21], and we are unsure of the reason for these differences. It is fair to say, however, that there is significant variation in the reported incidence of HO in the literature; and this is likely related to small study sizes, variations in the methodology of measurement, differing implant geometries, and confounding patient risk factors, to name some examples.

In this study, we found that Brooker III and IV HO are rare with the ABMS approach (5.3%) and were, in fact, not found in patients operated on by the surgeon with the most experience in this technique. The overall degree of HO for the entire cohort is consistent with other studies of contemporary THA techniques [16], but this is a new finding vis-a-vis surgical experience. Our observation needs to be corroborated with larger, multicenter studies to understand more specifically what degree of surgical experience is associated with a measurable decrease in high-grade HO, and if this finding is approach specific.

We acknowledge several weaknesses of this study. Small sample size may make correlations and statistical relationships too weak for appropriate power, leading to the possibility of Type II statistical errors. This small cohort size is a weakness that could be addressed by larger studies that evaluate multiple surgeons and institutions. Next, the proportion of men included for each surgeon was different, and this factor alone is a risk factor for HO. Because the proportion of men was highest for the most experienced surgeon, and lowest for the least experienced surgeon, the differences that we found may have an even higher magnitude (we do think that they are directionally correct). Lastly, because we use aspirin routinely for DVT prophylaxis, our HO rates may be lower than for those that use a different prophylaxis regimen [22]. Despite these shortcomings, we do document the incidence of HO, and for the first time, relate significant HO to surgical experience, for a new hip surgical approach.

In conclusion, HO formation following ABMS THA surgery was 86/233, or 36.9%, which is comparable to recent studies of direct anterior and posterior THA, and lower than the direct lateral approach. Class 3 and 4 HO are uncommon (3.9% and 1.3%, respectively), and the incidence of class 3 and 4 HO is least for the surgeon with the most experience with this technique. The lower incidence of HO may be a surrogate for diminished soft tissue trauma.

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