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Early Failures in Total Hip Arthroplasty — A Changing Paradigm

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ABSTRACT

Between 2001 and 2011, 1168 revision hip arthroplasties were reviewed for "early" failures within 5 years of the primary total hip arthroplasty (THA). 24.1% underwent revision within 5 years of index THA. Aseptic loosening, infection, instability, metallosis, and fracture were common modes of failure. In our previous report from 1986 to 2000, 33% were "early" revisions, with instability and aseptic loosening accounting for over 70% of these early failures. While the proportion of "early" revisions decreased 9% from our previous report, this rate remains alarming. The emergence of metallosis and aseptic loosening of monoblock metal on metal shells as leading causes of early failures is concerning. This report suggests caution in the early adoption of new innovations before evidence based medicine is available to justify the risk of their use.

Total hip arthroplasty (THA) has proven to be a reliable procedure in alleviating pain and improving function for those patients with severely symptomatic end-stage hip disease. As life expectancy continues to increase and as hip arthroplasty is extended to a younger, more active cohort, greater demands have been placed on the durability of hip arthroplasty. Fortunately survivorship of conventional metal-on-plastic designs has, for the most part, met these demands with survivorships ranging from 85% to 94% at up to 20 years [1–7]. Since patients have come to expect such results, any outcome short of this is met with significant patient and surgeon dissatisfaction.

In a previous report evaluating 745 hip revisions performed from 1986 to 2000, 33% involved revising a THA within five years of index arthroplasty [8]. With hemiarthroplasty failures excluded, instability (39%) and aseptic loosening (36%) accounted for over 70% of these early failures. Subsequent to this report, strategies to mitigate such early failures entered the marketplace such as large femoral heads to improve stability, porous metals to enhance fixation and alternative bearings to improve wear [9–11]. These innovations were heralded as significant advances in the area of hip arthroplasty. Unfortunately despite the innovations of the last decade, we continue to see early failures in our tertiary referral revision practice. In the last ten years we have noticed a change in both the proportion of our revisions occurring within 5 years of index surgery as well as the reason for these early failures in THA. The purpose of this report is to reanalyze the proportion of our revision practice that required revision surgery within five years of index arthroplasty as well as to investigate the cause of these early failures.

Materials and Methods

After IRB approval, we retrospectively reviewed the records of 1272 revision hip arthroplasties at our tertiary referral center performed by eight surgeons from 2001 to 2011. We documented index arthroplasty date, revision date and failure mechanism. One thousand one hundred and six-eight patients had complete medical records while one-hundred and four patients were excluded due to inadequate medical records. Early hemiarthroplasty failures were also excluded from the analysis. Patients were included in the early failure data set if they had revision of a primary THA from 2001 to 2011 for a failure within 5 years of the primary arthroplasty. The final early failure dataset included 282 patients.

The overall percentage of early failures (within 5 years after index THA) was calculated as a percentage of the overall number of revisions with complete records performed from 2001 to 2011. The percentages of each failure mechanism were calculated as a percentage of the overall number of early revision THAs within 5 years of the index THA. These percentages were compared to our previously published early revision THA data from 1986 to 2001 calculated in a similar fashion with hemiarthroplasty failures removed. Time to failure was calculated in years from the time of index surgery to the time of revision surgery.

Failure mechanisms included aseptic loosening, instability, infection, polywear/osteolysis, periprosthetic fracture, and metal-metal related failure. All other failure mechanisms were included as miscellaneous, which included heterotopic ossification, iliopsoas impingement, leg length discrepancy, failed resurfacing, extruded

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Table 1
2001–2011 Early Revision Diagnosis.

Revision Diagnosis	Percentage
Aseptic loosening	82 (29.0%)
Aseptic loosening femur	49 (17.3%)
Aseptic loosening acetabulum	33 (11.7%)
Infection	55 (19.5%)
Instability	54 (19.1%)
Metallosis	39 (13.8%)
Fracture	26 (9.2%)
Fracture femur	19 (6.7%)
Fracture acetabulum	6 (2.1%)
Fracture trochanter	1 (0.3%)
Miscellaneous	26 (9.2%)
Psoas irritation	7 (2.4%)
Heterotopic ossification	5 (1.7%)
Pain	3 (1.0%
Squeaking	3 (1.0%)
Failed resurfacing	3 (1.0%
Leg Length Discrepancy	2 (0.7%)
Trochanter nonunion	1 (0.3%)
Loose poly	1 (0.3%)
Snapping hip	1 (0.3%)

polyethylene liner, pain, snapping hip, squeaking, and trochanteric nonunion. Metallosis related failure was defined as well fixed metal–metal components revised due to elevated metal ion levels, pain, adverse local tissue reactions noted on MRI or ultrasound, or gross metallosis noted at the time of revision. Metal–metal components revised for other reasons were classified under the appropriate mechanism of failure.

Results

Two Hundred eighty-two of the 1168 hip revisions (24.1%) were within five years of index THA. In order of prevalence, 82 (29.0%) were revised for aseptic loosening (33 (11.7%) acetabular failures and 49 (17.3%) femoral failures), 55 (19.5%) for infection, 54 (19.1%) for instability, 39 (13.8%) for metallosis, 27 (9.5%) for miscellaneous diagnosis and 26 (9.2%), for peri-prosthetic fracture (Table 1). Miscellaneous revisions (26 (9.2%)) included: iliopsoas impingement 7 (2.4%), heterotopic ossification 5 (1.7%), pain 3 (1.0%), failed resurfacing 3 (1.0%) squeaking hip 3 (1.0%), leg length discrepancy 2 (0.7%), trochanter nonunion 1 (0.3), snapping hip 1 (0.3%), and loose poly 1 (0.3%).

The mean time to early revision was 1.81 years. The mean time to early revision was 2.89 years for metallosis, 2.10 years for aseptic loosening, 1.86 years for miscellaneous problems, 1.59 years for instability, 1.48 years for infection, and 0.85 year for periprosthetic fracture.

Metal on metal bearings were involved in 42.9% of our early revisions. The percentages of cup types, stem designs and bearing surfaces for the early revisions performed from 2001 to 2012 are detailed in Tables 2–4. Regarding aseptic acetabular loosening, 22 (66.6%) of the failed cups were monoblock metal on metal cups, 10 (30.3%) were modular metal on polyethylene cups, and 1 (3.0%) was a modular cup with ceramic liner (Table 5). Aseptic femoral loosening was noted in 17 (34.6%) taper wedge designs, 8 (16.3%) modular designs, 7 (14.2%) cemented stems, 5 (10.2%) metaphyseal engaging stems, 5 (10.2%) unknown designs, 4 (8.1%) diaphyseal engaging stems, 2 (4.1%) taper round designs, and 1 (2.0%) metaphyseal engaging modular neck designs (Table 6).

Table 2
2001–2011 Early Revision Cup Types.

Cups	
Modular polyethylene	120 (42.5%)
Monoblock metal	80 (28.3%)
Modular metal	40 (14.1%)
Unknown	21 (7.4%)
Modular ceramic	16 (5.6%)
Cemented	2 (0.6%
Implex ceramic	2 (0.6%)
Metal polyethylene sandwich	1 (0.3%)

Table 3
2001–2011 Early Revision Stem Types.

Stems	
Metaphyseal	84 (29.7%)
Tapered wedge	56 (19.8%)
Modular	43 (15.2%)
Unknown	33 (11.7%)
Diaphyseal	25 (8.8%)
Cemented	21 (7.4%)
Metaphyseal modular neck	7 (2.4%)
Resurfacing	5 (1.7%)
Tapered wedge modular neck	4 (1.4%)
Tapered round	2 (0.6%)
Taper rectangular	1 (0.3%)
Modular diaphyseal	1 (0.3%)

Compared to data from 1986 to 2001, metallosis emerged as a new failure category accounting for 13.8% of the early failures. Monoblock metal cups were the most common design in revision for metallosis (Table 7–8). Failures due to instability improved from 38.9% to 19.1%. Early revision for infection increased from 16.6% to 19.5%. Early revision for aseptic loosening decreased from 35.7% to 29.0%. No early revisions occurred for polyethylene wear-related failures in the recent series compared to 5.6% of early revisions due to wear-related failures in the previous report (Fig. 1).

Discussion

Primary total hip arthroplasty is a reliable and successful procedure for relieving pain and dysfunction in patients with hip arthritis [1–7]. With this success, patients have come to expect functional survivorship of their implant in excess of 15–20 years. As we have come to better understand the failure mechanisms of total hip arthroplasty, numerous modifications, such as large femoral heads to improve stability, porous metals to enhance fixation and alternative bearings to improve wear, have been introduced over the last decade in hopes of decreasing the rate of early as well as late failures [9–11]. Since our previous report, we have noticed a shift in the rate and cause for early revision of primary total hip arthroplasty and sought to investigate these changes.

Our previous report, reviewing 745 total hip revision procedures from 1986 to 2001, found that 33% of these revisions involved THA within 5 years of the index arthroplasty [8]. In our current report, the prevalence of early failure has decreased 9%. Unfortunately, early failures still account for 24.1% of our revisions. While this modest decrease may be due to improved techniques and materials, increases in patient life expectancy as well as an increasing willingness to revise older patients may have increased the denominator of this calculation [12]. This increase in the denominator alone may have contributed to the decreasing percentage of early revisions in the current study.

Table 4
2001–2011 Early Revision Bearing Surfaces.

Bearing surface	
Metal polythylene	122 (43.2%)
Metal metal	121 (42.9%
Unknown	18 (6.3%)
Ceramic ceramic	16 (5.6%)
Ceramic polyethylene	4 (1.4%)
Ceramic metal	1 (0.3%)

Table 5
Acetabular Component Aseptic Loosening: Cup Type.

Acetabular Aseptic Loosening: Cups	
Monoblock metal	22 (66.6%)
Modular polyethylene	9 (27.2%)
Metal ceramic	1 (3.0%)
Modular metal	1 (3.0%)

Early revision procedures performed for typically late failure mechanisms such as aseptic loosening and osteolysis seem to be decreasing due to improved materials. Fevang et al, in a review of the Norwegian Arthroplasty Register from 1987 to 2007, reported an overall decrease in the rate of revisions, but found a shift towards a higher percentage of revisions being performed early, mainly due to dislocation and infection [13]. A recent review of the Medicare database by Katz et al, showed the highest rate of failure occurred in the first 18 months following primary surgery [14]. Our data support this observation. The percentage of early revision due to aseptic loosening decreased from 35.7% to 29.0%. There were no early revisions due to osteolysis in our recent cohort compared to 5.6% in our previous series. Improvements in polyethylene technology in the last decade, most notably the absence of polyethylene sterilized by gamma radiation in air, likely led to this change. However, of the aseptic acetabular loosenings, 66% were seen in monoblock metal cups. This cup design contributed to 26% of all aseptic loosening cases. Moreover, monoblock metal cups only made up 28.3% of the cups in our cohort, but were involved in 66% of the aseptic acetabular loosening cases. Thus, the reduction in overall aseptic loosening would be magnified if monoblock metal cups had not been utilized during this period.

In our initial report, 33% of revisions occurred early, with instability (39%) being the most common cause of failure, followed by aseptic loosening (35.7%), infection (16.6%), wear-related failure (5.6%) and fracture (3%) [8]. Ulrich et al also found high rates of early failures reporting that 50% of their 237 revisions performed over a 10 year period occurred within 5 years of the index arthroplasty [15]. The prevalence of failure mechanisms in their series was similar to our initial report with instability (30.5%) being the most common cause for early revision followed by aseptic loosening (27.1%) and infection (19.6%).

In comparison to our previous report, numerous shifts in the failure modes and rates were noted. Most notably, instability, as a reason for revision, greatly decreased from 39% to 19.1%. The use of large diameter heads, the recognition of the importance of soft tissue repair, and possibly the emergence of alternative approaches may have led to this change. This is supported by our subgroup analysis that demonstrated that large head metal on metal designs were only involved in 9.2% of our revisions for instability despite making up 28.3% of the cups in our overall cohort of revisions. This is contrasted by the modular metal cups being involved in 12.9% of our instability revisions despite only making up 14.1% of the cups in our overall cohort of revisions.

Table 6
Femoral Aseptic Loosening: Stem Type.

Aseptic Femoral Loosening: Stems	
Tapered Wedge	17 (34.6%)
Modular	8 (16.3%)
Cemented	7 (14.2%)
Unknown	5 (10.2%)
Metaphyseal	5 (10.2%)
Diaphyseal	4 (8.1%)
Tapered Round	2 (4.1%)
Metaphyseal Modular neck	1 (2.0%)

Table 7
Metallosis: Cup Type.

Metallosis: Cups	
Monoblock metal	33 (84.6%)
Modular Metal	5 (12.8%)
Metal Poly Sandwich	1 (2.5%)

Not all of the shifts in revision diagnosis are encouraging. Aseptic loosening still accounted for 29.0% of our early revisions with only a slight improvement from the 35.7% prevalence reported previously. While a portion of these failures can be attributed to monoblock metal cup designs, this remains somewhat surprising, especially on the femoral side. Taper wedge designs made up a disproportionate number of the aseptic femoral loosenings (34.6%) despite only being employed in 19.8% of the cases in the overall cohort. A mitigating factor may have been the concomitant introduction of minimally invasive surgery during this time period, limiting visualization during implant insertion.

Infection continues to be of concern and constituted a slightly larger percentage of our early revisions in the last decade at 19.5%, up from 16.6%. This increase may be a reflection of our tertiary referral status or the trend of offering arthroplasty to hosts with significant comorbid conditions which can predispose them to periprosthetic infection [16].

Periprosthetic fracture also increased from 3.2% to 9.2% of our revisions. With the aging population, this failure mechanism will likely continue to increase [17]. However, eighteen of the 25 fractures (72%) in our series occurred in the first 3 months after surgery suggesting that many of these may have been unrecognized calcar fractures. No obvious trends between stem design and femur fractures were noted. Surgeons should obtain adequate visualization of the calcar and inspect for nondisplaced fractures to avoid this preventable complication.

The most alarming finding in this review was the emergence of "metallosis" as a significant early failure mechanism accounting for 13.8% of our early failures over the last decade. Large diameter monoblock metal on metal articulations enjoyed great popularity during the last decade due to the theoretical benefit of improved wear and increased range of motion [9]. Our high percentage of early metal on metal failures is in keeping with the recent trend in reports of high early failure rates of large diameter metal on metal articulations [18–22]. "Metallosis" in the current report included only failures related to the metal on metal articulation (pain, elevated ion levels, adverse local tissue reactions, and gross metallosis at revision). This is especially concerning since "metallosis" from the bearing surface as a sole failure mechanism represented a significant proportion of our early revisions (13.8%) and may be a harbinger of failure for this bearing couple in the future. Moreover, MOM components revised for aseptic loosening alone were categorized as such and, unfortunately, these monoblock metal on metal cup designs led to the majority (66%) of our early acetabular aseptic loosenings. Metal on metal designs, whether failing from the articulation or the cup design, constituted a significant proportion of our early revisions (21.0%). With failures

Table 8
Metallosis: Stem Type.

Metallosis: Stems	
Metaphyseal	15 (38.4%)
Modular	9 (23.0%)
Tapered Wedge	7 (17.9%)
Diaphyseal	3 (7.6%)
Resurfacing	2 (5.1%)
Cemented	1 (2.5%)
Metaphyseal modular neck	1 (2.5%)
Tapered Wedge modular neck	1 (2.5%)

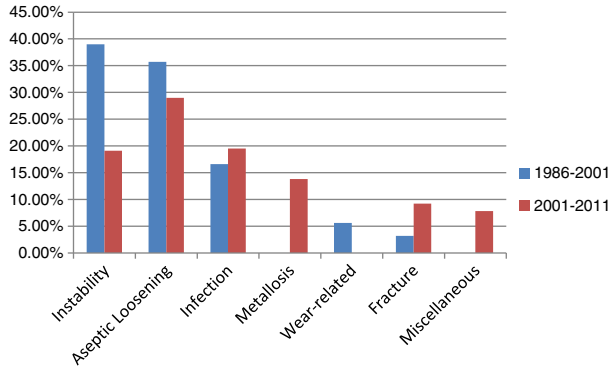

Fig. 1. Early failure diagnosis comparison.

directly attributable to metal on metal articulations and monoblock cup designs excluded, the overall percentage of revisions occurring within 5 years of the index procedure would have declined from 33% in our previous report to 19.9%.

This study has several limitations. First, the major weakness stems from our unknown referral pool. Thus, it is impossible to accurately define the number of primary hip arthroplasties from which the revisions resulted. Additionally, these failures reflect the techniques and bearing surfaces utilized for primary total hip arthroplasty in our catchment area. Thus, these results may reflect failure rates specific only to our region of the country. Additionally, as more fellowship trained adult reconstruction surgeons emerge, it is likely that an increasing number of revisions are being performed at community hospitals. Thus, being a tertiary referral center, there may be selection bias from the community towards referral of the perceived more difficult revisions (i.e. infection and metallosis) rather than the perceived less difficult revision (i.e. aseptic loosening, instability). However, despite these limitations, the fact that our referral catchment area has remained the same over the last 25 years, without an additional tertiary referral center in the region, strengthens these results.

Conclusion

Early failure of a total hip arthroplasty is disturbing to patients and surgeons alike. Despite recognition of common early failure mechanisms in a previous report, only a modest decrease in such early failures was noted in the last decade. These can partially be attributed to improved diagnostic acumen to detect unusual failure mechanisms as well as the evolution of new failure mechanisms — metallosis and aseptic failure of monoblock metal on metal acetabular cups. The emergence of these metal on metal related failures as a significant percentage of the early failures in our area is alarming and highlights the importance in remaining vigilant when evaluating these patients.

Early failures are most often attributed to either technical errors or early acceptance of surgical techniques or innovations. Before evidence based data are available to justify the risk of their use, care must be taken to make sure that early adoption of such innovations in either technique or implant design does not result in an increased risk of early failure. Our report strongly supports this notion, as the exclusion of metal on metal designs would have resulted in a significant decrease in the proportion of our revision practice occurring within 5 years of the index arthroplasty.

This report depicts the fluidity of early failure rates and mechanisms and demonstrates that continual review is warranted to recognize the changing failure mechanisms in total hip arthroplasty.

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