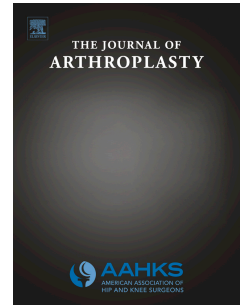


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Modifiable risk factors are common in early revision hip and knee replacement

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1 **Abstract**

2 **Introduction**

3 Obesity, smoking, uncontrolled diabetes, and poor dental health are modifiable risk
4 factors for revision total joint arthroplasty. In an effort to protect patients from the
5 devastating complication of revision surgery while also reducing cost, joint
6 replacement practices have developed a hard stop for patients with these conditions
7 so that they can be improved prior to surgery. However, adherence to this practice
8 is variable among joint replacement surgeons. We hypothesize that a relatively high
9 rate of revision arthroplasty patients had modifiable risk factors at the time of
10 primary surgery.

11 **Methods**

12 A retrospective review of all revision total hip and knee arthroplasties performed at
13 an academic, tertiary referral center within 2 years of primary surgery was
14 conducted. The presence of BMI >40, A1c >8, poor dentition, and smoking status
15 were obtained from the electronic medical record. Risk factors were described and
16 compared between infected revisions and non-infected revisions.

17 **Results**

18 128 revision arthroplasties were performed at our institution from July 2015 to July
19 2016. 23/57 (40.4%) of total hip revision and 31/71 (43.7%) of total knee revision
20 patients had at least one modifiable risk factor. Infected hip revision patients were
21 more likely to have increased BMI compared to non-infected patients. Infected knee
22 revision patients were more likely to smoke, have poor dentition, and have >1
23 contraindication compared to non-infected patients.

24 **Conclusions**

25 A high percentage of patients undergoing early revision arthroplasty had at least
26 one modifiable risk factor for a primary joint replacement. Joint replacement

27 surgeons may help reduce revision surgery through counselling and appropriate

28 referral for modification of risk factors.

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30 Introduction

31 With the advent of bundled care payment models, more attention is paid to
32 maximizing patients with modifiable health conditions that put them at risk for
33 failure of their joint arthroplasty (1). Modifiable risk factors include obesity (BMI >
34 40), smoking, diabetes (Hgb A1c>8), dental decay, and chronic opioid use.
35 Improvement of these conditions is potentially under the control of the patient.
36 Each of these conditions lead to poorer results including higher infection, loosening,
37 and dislocation rates. (2-8) Surgeons, hospitals, and insurance companies are
38 adopting the policy of only offering joint replacement if these conditions are
39 modified prior to surgery in an effort to reduce readmissions, complications, and
40 revision surgeries. (9-12).

41 Little work has been done to determine how modifiable risks factors may impact
42 rates of early revision surgery. We hypothesize that many patients undergoing
43 early revision surgery had modifiable risk factors at the time of the index joint
44 replacement. The goal of our study is to review a series of revision hip and knee
45 replacement surgeries performed within 2 years of the index arthroplasty to
46 determine how many patients had modifiable risk factors.

47

48 **Materials and Methods**

49 After approval from our Institutional Review Board, a retrospective chart
50 review was undertaken for all revision total joint arthroplasty (TJA) procedures
51 performed at our institution from July 1st, 2015 to July 1st, 2016. Current Procedural
52 Terminology codes (CPT) codes for revision and resection hip and knee procedures
53 (CPT codes: 27090, 27091, 27125, 27130, 27132, 27134, 27136, 27137, 27138,
54 27438, 27446, 27447, 27486, 27487, 27488) were used to gather patient medical
55 record numbers. 614 revision surgeries were performed by the 3 surgeons over the
56 study period. Patients were excluded from the study if the primary arthroplasty was
57 greater than 2 years before revision surgery. 486 patients had primary surgery
58 greater than 2 years before the revision surgery, leaving a study group of 128
59 revision surgical patients.

60 The primary outcome of this study is the incidence of modifiable risk factors
61 in patients undergoing revision arthroplasty within 2 years of the primary surgery.
62 Differences in risk factor incidence for prosthetic joint infection revision compared
63 to aseptic revision are secondary outcomes of the study. From the medical record,
64 we recorded each patient's BMI at the time of revision surgery and smoking history,
65 history of any dental problems, comorbidities, and ASA score at the initial encounter
66 with our institution. In patients with a history of diabetes mellitus, a hemoglobin
67 A1c level was also obtained before revision surgery. The indication for revision was
68 also recorded. The number of patients with modifiable risk factors for primary TJA
69 in our practice was calculated. These contraindications included BMI greater than or
70 equal to 40, current smoking status, poor dentition, and hemoglobin A1c greater
71 than or equal to 8 in patients with DM.

72 Additionally, risk factors were compared between revision cases indicated by
73 infection and cases with another indication. Pearson's chi-square tests were used to
74 compare the prevalence of each risk factor between both infected and non-infected
75 revisions. Simple Interactive Statistical Analysis (SISA) web-based software was
76 used for statistical calculations

77 (www.quantitativeskills.com/sisa/statistics/towby2.htm). Statistical significance
78 was set at $p \leq 0.05$.

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79 **Results**

80 During the study period, 57 total hip arthroplasties (THA) and 71 total knee
81 arthroplasties (TKA) were resected or revised at our institution within 2 years of
82 the index surgery. Revision total hip and hip arthroplasty patients were similar in
83 age, ASA score, Charlson Comorbidity Index, BMI, and (in patients with diagnosis of
84 DM) Hgb A1c (Table 1). Tables 2 and 3 demonstrate the indications for, respectively,
85 hip or knee revision and the associated risk factors for each type of revision.

86 The incidence of at least one modifiable risk factor in early revision
87 arthroplasty were 23/57 (40.4%) in revision THA patients and , 31/71 (43.7%) in
88 revision TKA. Table 4 demonstrates the number of hip and knee patients with none,
89 one, two, or three risk factors present. 12/71 (16.9%) TKA patients and 10/57
90 (17.5%) THA patients had two or three risk factors. No patient had all 4 risk factors.

91 Results for PJI and aseptic revision comparisons for both hip and knee
92 surgeries are in Table 5. In summary, hips revised for infection were more likely to
93 have high BMI as a contraindication compared to hips revised for another reason.
94 There was no difference in dental status, smoking status, Hgb A1c, or the presence
95 of >1 contraindication between infected hips and hips revised for another reason.

96 Knees revised for infection were more likely to have smoking or dental status
97 as a contraindication compared to knees revised for another reason. There was no
98 difference in BMI or A1c between infected knees and knees revised for another
99 reason. Infected knees were more likely to have >1 contraindications.

100 Discussion

101 This study found that over 40% of patients undergoing revision surgery
102 within 2 years of their primary procedure had at least one modifiable risk factor and
103 over 16% had more than one risk factor. This study also found an association
104 between BMI and THA infections compared to other revision indications and an
105 association between smoking and poor dentition with infected TKA. Potentially,
106 addressing these factors prior to index surgery may have helped in preventing early
107 revision surgery.

108 Modifiable risk factors such as obesity, smoking, and glycemic control are
109 associated with other adverse outcomes besides revision, including unplanned
110 readmission and discharge to other healthcare settings (13-15). The cumulative
111 effect on revision surgery or other adverse outcomes from these risk factors is not
112 well understood. However, one study has attempted to provide assessment tool for
113 cumulative risks of readmission after arthroplasty (9).

114 Surgeons, other healthcare professionals, and patients are able to modify risk
115 factors. Defroda et al. produced a pilot study on the modification of risk factors,
116 including obesity, smoking, and poor glucose control. They found that 19/29
117 (66.5%) patients counselled to modify risk factors followed up with their index
118 surgeon. Eight of these 19 patients met criteria in 3-6 months of initial counsel. In
119 that small study, dental clearance was obtained in all patients with poor dentition,
120 but only ½ patients with poorly controlled Hgb A1c had obtained adequate glycemic
121 control in the 3-6 months, which is not surprising using Hgb A1c. However, only
122 4/11 patients quit smoking and only 1/6 patients obtained a BMI of under 40. (10).
123 These results demonstrate that these risk factors can truly be modified, but that
124 time is also needed for weight loss and glycemic control.

125 Our study is consistent with other studies implicating both smoking and
126 obesity have as risk factors for multiple indications for revision arthroplasty,
127 including infection and aseptic loosening (16-20). Our study cannot determine
128 causality between the risk factors and the need for revision. There may also be cases

129 in which risk factors cannot be modified. Potential options for weigh loss include,
130 diet exercise and lifestyle modification as well as bariatric surgery. Concerning
131 obesity, one study found that 26% of overweight and obese patients were able to
132 achieve and maintain a 10% weight loss (21). PCP-centered weight loss programs
133 are effective. However, programs emphasizing calorie management and close
134 patient contact with a dietician may be more effective (22). More radical weight loss
135 strategies, like bariatric surgery, are controversial (23). Bariatric surgery may also
136 paradoxically increase complications after joint replacement surgery despite weight
137 loss (24). Despite optimal treatment some patients may never lose enough weight to
138 reduce their BMI to below 40. In these cases, a decision must be made as to whether
139 the risk factor is modifiable or not. If not the best option may be to proceed with
140 surgery, understanding that risk of complications or revision is higher.

141 Outpatient smoking cessation programs are also effective (25). Simple
142 explanation of the risks of smoking by their surgeon are helpful. One study found
143 that 13 of 30 smokers quit “cold-turkey” after surgeon’s counsel before arthroplasty
144 with 8 more patients quitting with the aid of outpatient programs or nicotine
145 replacement therapy (26).

146 Several practices have reported using a hemoglobin A1c of 8% as a cutoff for
147 surgery (27, 28). While diet modification and weight loss, especially low-
148 carbohydrate diets, can help lower Hgb A1c (29), appropriate medical management
149 of diabetes mellitus is also needed (30). However, perioperative control of glucose
150 levels is also important. Sliding scale insulin provides this control, but a permissive
151 sliding scale should be used with the aim of glucose at 140-180 mg/dL to allow for
152 stress hyperglycemia after surgery (31).

153 Due to the retrospective nature of the study, we cannot prove causality. We
154 do not know that if these factors were modified prior to primary surgery that
155 revision surgery would not have been needed. However, it is reasonable to assume
156 improving the modifiable risk factors in the 40% of patients having a modifiable
157 factor, may reduce revision rates. Also, we do not have data from the primary

158 surgery, which was most often performed at another institution. It is possible that
159 risk factors may have been modified prior to surgery and then changed afterwards.
160 Also, the referral patterns for our region and practice may be unrepresentative of
161 other regions and institutions. As a tertiary referral center, we may see a higher
162 ratio of complicated revision cases, as simpler revisions may be provided by the
163 primary surgeon. In addition, other risk factors may be modifiable that we could not
164 evaluate in our study. Current opioid use is a modifiable risk factor for revision TJA
165 (32). However, at the initial encounter nearly all patients had painful implants and
166 were already on opioid medications. We could not reliably ascertain opioid use at
167 the time of primary surgery from the electronic medical record.

168 In conclusion, over 40% of revision TJA patients revised at a tertiary referral
169 center and specialized joint replacement practice within 2 years of the primary
170 surgery had modifiable risk factors for revision surgery. Stricter use of a “hard stop”
171 for surgery and optimization of modifiable risk factors may improve the patient
172 morbidity and healthcare costs of revision surgery.

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297

Table 1 Patient demographics

Mean (SD)	Hip Revision	Knee Revision
Age	60.4 (14.0)	61.1 (11.8)
ASA	2.5 (0.54)	2.5 (0.53)
CCI	2.9 (1.8)	2.8 (1.8)
BMI	32.8 (7.8)	32.9 (6.1)

Table 2-Modifiable factors as related to diagnosis for revision total hip replacement

Diagnosis for revision	Number of patients	Modifiable Risk Factors				
		BMI	Smoking	Hgb A1c	Dentition	More than 1 risk factor
Infection	23 (40.4%)	7 (30.4%)	4 (17.4%)	0	5 (21.7%)	4 (17.4%)
Loosening	15 (26.3%)	0	5 (33.3%)	0	3 (20.0%)	3 (20.0%)
Instability	10 (17.5%)	0	3 (30.0%)	1 (10%)	2 (20.0%)	1 (10.0%)
Fracture	8 (14.0%)	2 (25.0%)	1 (12.5%)	1 (12.5%)	1 (12.5%)	2 (25.0%)
Tendonitis	1 (1.8%)	0	0	0	0	0
Total	57	9 (15.8%)	13 (22.8%)	8 (14.0%)	11 (19.3%)	10 (17.5%)

Table 3- Modifiable factors as related to diagnosis for revision total knee replacement

Diagnosis for revision	Number of patients	Modifiable Risk Factors				
		BMI	Smoking	Hgb A1c	Dentition	More than 1 risk factor
Infection	30 (42.3%)	4 (13.3%)	13 (43.3%)	3 (10.0%)	10 (33.3%)	10 (33.3%)
Laxity	14 (19.7%)	1 (7.1%)	2 (14.3%)	1 (7.1%)	2 (14.3%)	1 (7.1%)
Arthrofibrosis	11 (15.5%)	1 (9.1%)	0	1 (9.1%)	0	1 (9.1%)
Extensor Disruption	7 (9.9%)	1 (14.3%)	1 (14.3%)	0	0	0
Loosening	5 (7.0%)	1 (20.0%)	1 (20.0%)	1 (20.0%)	0	0
Malalignment	3 (4.2%)	0	1 (33.3%)	0	0	0
Pain and Snapping	1 (1.4%)	0	0	0	0	0
Total	71	8 (11.8%)	18 (25.4%)	6 (8.5%)	12 (16.9%)	12 (16.9%)

Table 4 Number of patients with potential modifiable risk factors

	0	1	2	3	Any risk factors
Hips	34 (60%)	13 (23%)	8 (14%)	2 (3%)	23 (40 %)
Knees	40 (56 %)	19 (27 %)	11 (15 %)	1 (1 %)	31 (44 %)
Total	74 (58 %)	32 (25 %)	19 (15 %)	3 (2 %)	54 (42 %)

Table 5. Modifiable risk factors in infected revision arthroplasty

		Infection	Not Infection	OR	CI	P value
BMI						
	Hip	7/23 (30.4%)	2/34 (5.9%)	7.0	1.30-37.64	0.023
	Knee	4/30 (9.8%)	4/41 (13.3%)	3.0	0.51-17.59	0.2
Smoking						
	Hip	4/23 (26.5%)	9/34 (22.8%)	0.58	0.16-2.19	0.43
	Knee	13/30 (43.3%)	5/41 (12.2%)	5.5	1.69-17.95	0.005
A1c						
	Hip	0/23	2/34 (5.9%)	0.28	0.013-6.03	0.82
	Knee	3/30 (10.0%)	3/41 (7.3%)	1.41	0.26-7.51	0.4
Dentition						
	Hip	5/23 (21.7%)	6/34 (17.6%)	1.3	0.34-4.88	0.38
	Knee	10/30 (33.3%)	2/41 (4.9%)	9.75	1.95-48.8	0.006
>1 risk factor						
	Hip	4/23 (17.4%)	6/34 (15.0%)	1.19	0.30-4.76	0.80
	Knee	10/30 (33.3%)	2/41 (4.9%)	9.75	1.95-48.8	0.006