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Prior High Tibial Osteotomy Does Not Affect the Survival of Total Knee Arthroplasties
Results From the Danish Knee Arthroplasty Registry

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Prior high tibial osteotomy does not affect the survival of total
knee arthroplasties

– Results from the Danish Knee Arthroplasty Registry

Keywords: Total Knee Arthroplasty, Survival, High Tibial Osteotomy, Revision, Osteoarthritis

21 Abstract

22 **Background:** High tibial osteotomy (HTO) is a joint preserving treatment of unicompartmental
23 osteoarthritis in the knee. In cases with insufficient or deteriorating clinical results patients may
24 undergo a total knee arthroplasty (TKA). The influence of prior HTO on TKA survival is debated.

25 **Methods:** We conducted a population-based registry study comparing 1,044 primary TKA in
26 patients with prior HTO to 63,763 de novo TKA inserted from 1997 to 2015. Implant survival was
27 estimated by Kaplan Meier analysis with revision of any kind as endpoint. Patient- and surgery
28 characteristics, including choice of implant design, were compared and their influence on TKA
29 survival was estimated by Cox regression. Finally, indications of revision were compared between
30 the groups.

31 **Results:** TKA following HTO had an inferior survival with a 10-year estimated survival of 91%
32 compared to 94% for de novo TKA, corresponding to a crude hazard ratio (HR) of 1.73 ($p < 0.001$).
33 However, after adjustment for differences in sex and age this risk diminished (HR=1.19, $p = 0.09$).
34 The choice of implant constraint was similar between the groups and in both groups posterior
35 stabilized TKA (PS-TKA) was associated with inferior survival with an adjusted hazard ratio of
36 1.46 ($p = 0.03$) in post-HTO TKA when compared to cruciate retaining TKA.

37 **Conclusion:** TKA following HTO had a crude inferior survival when compared to TKA without
38 prior surgery of any kind. The inferior survival was explainable by patient characteristics, defined
39 by male sex and lower age, rather than the prior HTO. However, when the prior HTO resulted in the
40 use of PS-TKA the survival decreased.

41 Introduction

42 45% of the people in the western world are estimated to develop symptomatic primary knee
43 osteoarthritis (OA) during their lifetime [1] making OA a major cause of disability [2].
44 Unicompartmental OA can be treated with high tibial osteotomy (HTO) [3] in order to postpone or
45 maybe avoid subsequent arthroplasty surgery [4]. HTO is most commonly conducted either as medial
46 open wedge or lateral closed wedge procedure to treat medial OA. Of these, closed wedge is the
47 classical procedure while open wedge has become more common in the recent years [5]. The clinical
48 results from HTO might deteriorate over time and 33% are later treated with a total knee arthroplasty
49 (TKA) [4]. These conversion TKA are complicated by scar tissue, altered knee mechanics and
50 retained surgical hardware [6–8]. It may therefore be hypothesized that prior HTO leads to an inferior
51 survival of conversion TKA and that the altered knee mechanics might result in the need of more
52 constrained implants. There is a current dispute about the impact of previous HTO on the survival of
53 subsequent TKA as well as the optimal choice of constraint [9–14], and recent epidemiological
54 studies from Nordic knee arthroplasty registries report conflicting survival estimates [15–17].
55 Therefore, the purpose of this study was to analyze the survival of TKA inserted in knees previously
56 treated with HTO based on data from the Danish Knee Arthroplasty Registry (DKR).

57 Methods

58 *Study population*

59 The study was based on registrations from the Danish Knee Arthroplasty Registry (DKR) which has
60 been collecting data prospectively on knee arthroplasties performed in Denmark (population of 5.7
61 mill.) since the registry was initiated the 1st of January 1997. Recently, the DKR was reported suitable
62 for epidemiological studies [18] and the registry completeness has increased from 88% in 2010 to
63 99% in 2015 [19]. The DKR records patient characteristics such as age, gender, weight, previous knee
64 surgeries, as well as details about the surgeries including procedure time and perioperative
65 complications (fractures, rupture of the patella ligament etc), and details regarding components,
66 including level of constraint and supplementation defined as stem, augments or cones. Comorbidity
67 is recorded using the Charnley classification which has been associated with the outcome of
68 arthroplasties [20], and is sorted in class A (patients with unilateral arthritis), B1 (patients with
69 bilateral arthritis), B2 (patients with opposite knee treated with arthroplasty) and C (patients with
70 other conditions limiting their active daily living). In addition, the DKR is linked with the Danish
71 Civil Registration System which has been collecting information on Danish citizens since its origin
72 in 1968 and, among other data points, contains vital status [21].

73 The DKR defines revision as exchange, addition or removal of any component in an existing
74 arthroplasty. Indications for revision are classified as aseptic loosening, pain, instability, infection,
75 polyethylene failure, secondary insertion of patella component, progression of arthritis and others
76 (including periprosthetic fractures, soft tissue injury and stiffness) and have the possibility of
77 reporting multiple indications for a single revision. We created a clinical hierarchy to rank the
78 indications for revision (Table 1) and thereby only considered the most important indication for each
79 revision. TKAs were grouped according to level of constraint in cruciate retaining (CR), posterior

80 stabilized (PS), constrained condylar (CCK), hinged (Hinged), and undefined when the components
81 were unknown.

82 From the DKR, we retrieved data on all TKAs inserted due to primary OA from 1st of January 1997
83 till 31st of December 2015 in knees previously treated solely with high tibial osteotomy (HTO).
84 Registrations in the DKR do not allow for distinction between closed or open wedge HTO thus both
85 procedures were included in this group. The validity of the reported HTO was reviewed by auditing
86 patient records of a sample of all HTOs converted to TKA, performed at our local hospital (n=134).
87 Of these 128 (96%) were confirmed with prior HTO, in 3 (2%) cases we were unable to retrieve the
88 patient record but confirmed the diagnosis by crosschecking in the Danish National Patient Registry
89 [22] and in 3 (2%) cases we could not confirm the HTO. As controls, we retrieved all de novo TKA
90 from the same period, inserted due to primary OA in patients without registered prior knee surgery
91 of any kind. We considered each knee as an individual observation thus patients treated bilaterally
92 with TKA, within the study period, contributed with two individual observations. Recent studies have
93 addressed the potential problems with bilateral observations and reported these as negligible in large
94 epidemiological arthroplasty studies concerning revisions [23,24].

95

96 *Statistics*

97 Kaplan Meier analysis was used to estimate survival and these estimations were compared by Log
98 Rank test. We considered revision of any kind as endpoint and censored unrevised patients by the
99 first coming event of death, emigration or end of study by the 31st of December 2015. Cox regression
100 was used to compare the risk of revision between the groups with de novo TKA as reference and with
101 successive adjustment for patient characteristics that both differed statistically and were of clinical
102 interest. The assumption of proportional hazards was tested by Schönfeld residual test [25] and was
103 not violated for the chosen co-variates ($p > 0.1$, for all comparisons) except age. In long term

104 arthroplasties studies, as this, the hazard related to age varies over time thus violating the assumption
105 of proportional hazards ($p < 0.001$ in this study). Therefore, we chose to include age as a time-varying
106 co-variate in the cox regression analysis. Furthermore, death could arguably be a collateral risk in
107 long term arthroplasties studies due to the long follow up in an elderly population [26]. Therefore,
108 we additionally analyzed the hazard ratio by competing risk regression based on Fine-Gray's
109 proportional sub hazards model with death as a competing risk [27]. We found a slightly increased
110 crude hazard ratio when calculated by competing risk regression (1.85 vs. 1.73) with a similar level
111 of significance ($p < 0.001$ for both analyses). The difference is explainable by a higher age in the de
112 novo group with increased risk of experiencing the competing event. In this paper, we present the
113 more widely used Cox regression as the difference was small and the results from Cox regression is
114 more usable for orthopaedic surgeons informing patients [28]. Categorical variables were compared
115 by chi square test if $n \geq 5$ and by Fischer's exact test if $n < 5$, and Wilcoxon Rank sum test was used to
116 compared cumulative variables. A 95% confidence interval (CI) was chosen and $p < 0.05$ was
117 considered as significant. Standard deviations (SD) were clustered at a hospital-level to shield against
118 inter-hospital variations such as traditions in decision making. All analyses were conducted in
119 STATA 15.

120

121 Ethics and funding:

122 The study was approved by the Danish Data Protection Agency (entry no. 2008-58-0028) and the
123 authors did not receive any specific grant from funding agencies in the public, commercial, or not-
124 for-profit sectors.

125 Results:

126 *Study Population*

127 In total 65,127 TKA were retrieved from the DKR. We excluded incorrect registrations (HTO: n=5,
128 de novo: n=315) and estimated missing values in weight, duration of index surgery and Charnley
129 class by multiple imputation. An overview of excluded and missing values is presented in table 2 (see
130 appendix). 64,807 TKA were included in the final analyses and of these 1,044 were TKA following
131 HTO and 63,763 were de novo TKA. In total 12,130 patients contributed with bilateral TKA and of
132 these 72 had bilateral post-HTO TKA, 232 had post-HTO TKA in one knee and de novo TKA in the
133 other, and 11,826 had bilateral de novo TKA.

134

135 *Patient and surgery characteristics*

136 Patient and surgery characteristics differed on key variables between TKA following HTO and de
137 novo TKA (table 3). The proportion of males was significantly higher in the HTO group (57% vs
138 35%, $p<0.001$), the average age was 8 years lower in patients with previous HTO (62 years vs 70
139 years, $p<0.001$) and there was a longer follow up in this group (8.55 years vs 6.58 years, $p<0.001$).
140 On average, the surgical procedure was 17 minutes longer in patients with previous HTO (88 minutes
141 vs 71 minutes, $p<0.001$), and both perioperative complications (2% vs 0.5%, $p<0.001$) and
142 component supplementation (3% vs 1%, $p<0.001$) were more pronounced in this group. Statistically,
143 the distribution in Charnley class and the preoperative weight differed significantly but these
144 differences were small and not of clinical interest.

145

146 *Survival*

147 To evaluate potential improvement in the survival of TKAs during the last decades we compared the
148 survival of TKA from 3 different time periods (1997-2003, 2004-2009, 2010-2015). No significate

149 difference when tested by log rank test ($p=0.14$) or Cox regression ($p>0.27$, for all comparisons) thus
150 adjustment for time periods as confounding variable was omitted.

151 TKA following HTO had an inferior estimated survival as depicted in figure 1 ($p<0.001$) with an
152 estimated 1- and 10-year survival of 0.97 (CI: 0.96-0.98) and 0.91 (CI: 0.89-0.93) compared to 0.98
153 (CI: 0.98-0.99) and 0.94 (CI: 0.94-0.95) in de novo TKA. The difference corresponded to a significant
154 crude hazard ratio (HR) for revision of 1.73 (CI: 1.40-2.15, $p<0.001$) in TKA following HTO.
155 However, the significant hazard ratio decreased after adjustment for the difference in sex (HR=1.69,
156 CI: 1.36-2.09, $p<0.001$) and the significance vanished after adjustment for age as a time varying co-
157 variate (HR=1.19, CI: 0.97-1.45, $p=0.09$). Older age (per year) had a baseline inferior risk of revision
158 (HR= 0.97, CI: 0.97-0.98, $p<0.001$) and for each year the patient got older, the baseline risk decreased
159 additionally with 0.01 (CI: 0-0.01, $p<0.001$).

160 161 *Revisions*

162
163 The distribution of revision indications did not differ significantly between the groups ($p=0.59$) as
164 shown in table 4. However, instability and wear occurred more frequent (22.5% vs 17% and 7.25%
165 vs 4%, respectively) in our group of patients with previous HTO. Aseptic loosening was the most
166 frequent indication in both groups but occurred more frequent patients with de novo TKA (27% vs
167 22.5%) whereas infection was more evenly distributed between the groups (24% in de novo TKA and
168 22% in TKA following HTO).

169 170 *Type of implant*

171 In the HTO group, cruciate retaining TKA (CR-TKA) were used in 80% ($n=829$) and posterior
172 stabilized TKA (PS-TKA) in 15% ($n=150$). The remaining 5% ($n=65$) were mainly undefined. A
173 similar distribution was present for de novo TKA with 81% ($n=51,866$) CR-TKA, 14% ($n=8,657$)
174 PS-TKA and 5% ($n=3,240$) mainly undefined. Although the difference between groups was statically

175 significant ($p < 0.001$), we consider it without clinical relevance. Since PS-TKA and CR-TKA
176 dominated both groups, we compared the survival of PS-TKA to CR-TKA.

177 Overall, the survival of both PS-TKA and CR-TKA was unchanged ($p > 0.17$) during the three time
178 periods (1997-2003, 2004-2009, 2010-2015) thus adjustment for time periods was omitted. The mean
179 follow up were clinically comparable between the two types of implants (PS-TKA: 6.66 years vs CR-
180 TKA: 6.50 years, $p < 0.001$).

181 In post-HTO TKA, there was no difference in age (PS-TKA: 63 vs CR-TKA: 62, $p = 0.68$) or duration
182 of index surgery (PS-TKA: 91 minutes vs CR-TKA: 87 minutes, $p = 0.11$). However, other
183 characteristics differed both statistically and clinically between the two implants. In PS-TKA, females
184 were more frequent (60% vs 40%, $p < 0.001$), the average weight was slightly lower (83 kg vs 85 kg,
185 $p = 0.03$) and the distribution in Charnley class differed slightly ($p = 0.04$) with a higher proportion of
186 patients in class C in PS-TKA (8% vs 3%). Altogether, 12% ($n = 18$) of the PS-TKA were revised
187 compared to 9% ($n = 75$) of the CR-TKA thus PS-TKA was associated with an increased crude hazard
188 ratio for revision of 1.45 (CI: 1.05-2.01, $p = 0.02$). The increased hazard was unaffected by successive
189 adjustment for the differences in sex, weight and Charnley class with a final adjusted hazard ratio of
190 1.46 (CI: 1.05-2.03, $p = 0.03$). Noteworthy, the need for additional components (11% vs 1%, $p < 0.001$)
191 and perioperative complications (4% vs 1%, $p = 0.01$) were more pronounced in PS-TKA indicating a
192 more complicated procedure. Instability was the leading cause of revision in PS-TKA (28%)
193 compared to infection in CR-TKA (24%). However, the overall distribution of indications did not
194 differ between the two implants ($p = 0.63$).

195 In de novo TKA, age, sex, weight, Charnley class and procedure time did not differ clinically
196 between PS-TKA and CR-TKA. Revision occurred more frequent in PS-TKA (7%, $n = 586$) when
197 compared to CR-TKA (4%, $n = 2,155$) corresponding to a crude hazard ratio of 1.60 (CI: 1.24-2.07,
198 $p < 0.001$). The need for component supplementation was slightly more pronounced in PS-TKA (2%

199 vs 0.5%, $p<0.001$) whereas the frequency of perioperative complications was similar (1% vs 0.5%,
200 $p=0.08$). Indications for revisions differed significantly in de novo TKA ($p<0.001$) even though
201 aseptic loosening (PS-TKA: 29% vs CR-TKA: 26%) and infection (PS-TKA: 24% vs CR-TKA: 25%)
202 were the most frequent indication of revision in both group. Instability occurred more frequent in CR-
203 TKA (19%) than in PS-TKA (11%) as opposed to the tendency in post-HTO TKA.

204 Discussion

205

206 The data from the DKR revealed an inferior crude survival of TKA inserted after HTO. Preoperative
207 characteristics differed between the groups with an increased proportion of men (57% vs 35%) and
208 lower age (62 years vs 70 years) in post-HTO TKA. These factors have previously been shown to
209 increase the risk of revision [29–31] and, in this study, the increased hazard ratio for revision
210 disappeared after adjustment for sex and age with age being the determining factor. In addition,
211 differences in perioperative characteristics indicated a more complicated index surgery when TKA
212 followed HTO with an increased procedure time (88 minutes vs 71 minutes), need for component
213 supplementation (3% vs 1%) and perioperative complications (2% vs 0.5%). As these characteristics
214 were determined by the knee condition following HTO and presumably led to increased operative
215 complexity, we did not adjust for these in our Cox regression. The Cox regression suggests that age
216 and sex carried the risk of revision, and not the prior HTO. However, from the data, it is not possible
217 to determine if age and sex carried the risk of revision alone or they were characterizing a group of
218 patients sharing other risks such as high physical activity and/or expectations which might lead to an
219 undesired result from both the HTO and the TKA [32].

220 This study complements recent studies with opposing results from the other Nordic arthroplasty
221 registries [15–17]. The results oppose studies from Sweden and Finland which have reported an
222 inferior survival of TKA following HTO with an adjusted hazard ratio ranging from 1.4-1.7 [15,16],
223 but are in concordance with results from the Norwegian registry reporting a similar survival for both
224 groups with an insignificant adjusted HR of 0.97 [17].

225 Post-HTO TKA were revised more frequent than de novo TKA (9.5% vs 4.5%) but overall there was
226 no significant difference in the distribution of indications for revision in this study. However, an
227 interesting tendency was present as both revisions due to instability (22.5% vs 17%) and wear (7.25%
228 vs 4%) occurred more often in TKA following HTO. The tendency of increased implant wear might

229 be related to the increased follow up or associated with potential undefined characteristics, such as
230 increased physical activity, in patients treated with TKA following HTO. The higher frequency of
231 instability could be related to the complexity of the index surgery depicted in the prolonged duration
232 of index surgery, threefold increase in component supplementation and fourfold increase in
233 perioperative complications. Both the increased incidence of instability and the increased complexity
234 of index surgery could be explained by the altered knee anatomy after HTO-surgery described
235 elsewhere [33,34]. A similar complexity and increased proportion of instability have been described
236 for TKA inserted in knees with previous fractures [35] thus implying meticulously balancing of the
237 knee and choice implants as key components of post-HTO knee arthroplasty surgery as well [32].
238 The current study also investigated the survival among different implants inserted in knees with
239 previous HTO. We found that posterior stabilized TKA (PS-TKA) had approximately 1.5 times
240 increased risk of revision when compared to cruciate retaining TKA (CR-TKA). This risk sustained
241 after adjustment for pre-operative difference between the groups. PS-TKA might be chosen in
242 challenging cases which is supported by the increase in component supplementation (11% vs 1%),
243 perioperative complications (4% vs 1%) and the trend towards increased revisions due to instability
244 (28% vs 24%). In de novo TKA, PS-implants had a similar increased risk of revision (HR of 1.64)
245 when compared to CR-TKA. The need for additional components was slightly increased in PS-TKA
246 (2% vs 0.5%) however not as pronounced as in post-HTO TKA. In addition, perioperative
247 complications did not differ between the implants in de novo TKA and revision due to instability was
248 not more pronounced in de novo PS-TKA. Thus, even though PS-TKA was associated with inferior
249 survival in both groups, PS-TKA following HTO seemed to be a more complicated procedure than
250 de novo PS-TKA. However, it is not possible to conclude if the increased risk of revision was a result
251 of the implant itself or confounded by the surgical conditions and/or surgeon preference. These results
252 challenge former studies conducted on smaller cohorts which concluded a similar outcome [13,14]

253 for PS-TKA when compared to CR-TKA in post-HTO TKA but supports a recent study from the
254 Australian Knee Arthroplasty Registry reporting an increased HR for revision of PS-TKA compared
255 to CR-TKA[36]. The increased risk of revision observed with PS-TKA combined with the higher
256 incidence of revision due to instability might encourage surgeons to consider the need for a more
257 constrained solution when planning primary TKA in challenging post-HTO knees. However, more
258 studies are needed to elucidate this relationship.

259

260 The study has some limitations to address. Firstly, information and selection bias might be present in
261 registry studies and, currently, the number of misclassifications is unknown in the DKR. However,
262 our validation study supports the reliability of the DKR concerning HTO. Secondly, the pooling of
263 open and closed wedge osteotomies might disguise individual challenges such as patella baja
264 following closed wedge osteotomy [8]. However, a recent study found no difference in the outcome
265 of TKA following lateral closed wedge or medial open wedge osteotomy [37]. Thirdly, the time from
266 HTO to TKA was not retrievable and might be a confounding variable as patients with early HTO failure
267 might be a younger subgroup with a complex HTO thus affecting the TKA survival. Fourthly, even
268 though Charnley class is associated with the outcome of arthroplasties [20] it does not provide
269 information about medical comorbidities, such as diabetes, affecting implant survival [38,39] and the
270 age difference in this study might have resulted in an uneven distribution of medical comorbidities.
271 Fifthly, almost one third of the patients contributed with bilateral observation in this study. This is a
272 higher proportion than previously reported not to bias the result of epidemiological studies [23]. To
273 evaluate the influence of including bilateral observation we repeated analyses including only the first
274 TKA in each patient and found similar results (data not shown) supporting that ignoring bilateral
275 observation did not bias this study. Finally, this study solely analyzed differences in survival leaving
276 differences in the clinical outcome between TKA following HTO and de novo TKA unknown.

277 In summary, this national registry-based long-term study shows a crude inferior survival of TKA in
278 knees with prior high tibial osteotomy when compared to de novo TKA. However, after adjustment
279 for male sex and younger age post-HTO TKA had similar survival as de novo TKA. In addition, we
280 found that posterior stabilized TKA was associated with inferior survival in post-HTO TKA when
281 compared to cruciate retaining TKA. We conclude that HTO alone does not alter the survival of a
282 subsequent TKA and surgeons should not desist HTO due to concerns for increased risk of later TKA-
283 revisions. However, post-HTO TKA is more complicated and if posterior stabilized TKA is needed
284 the risk of revision seems to increase.

285 Table 1

	Indication	Definition
1.	Infection	Confirmed or suspected infection
2.	Aseptic loosening	Aseptic implant loosening
3.	Wear	Polyethylene failure
4.	Instability	Surgeon or patient reported instability
5.	Secondary Patella	Secondary insertion of patella component
6.	Pain	Patient reported pain
7.	Others	Periprosthetic fractures, soft tissue injury, stiffness, etc.
8.	Undefined	Revisions without registered indications

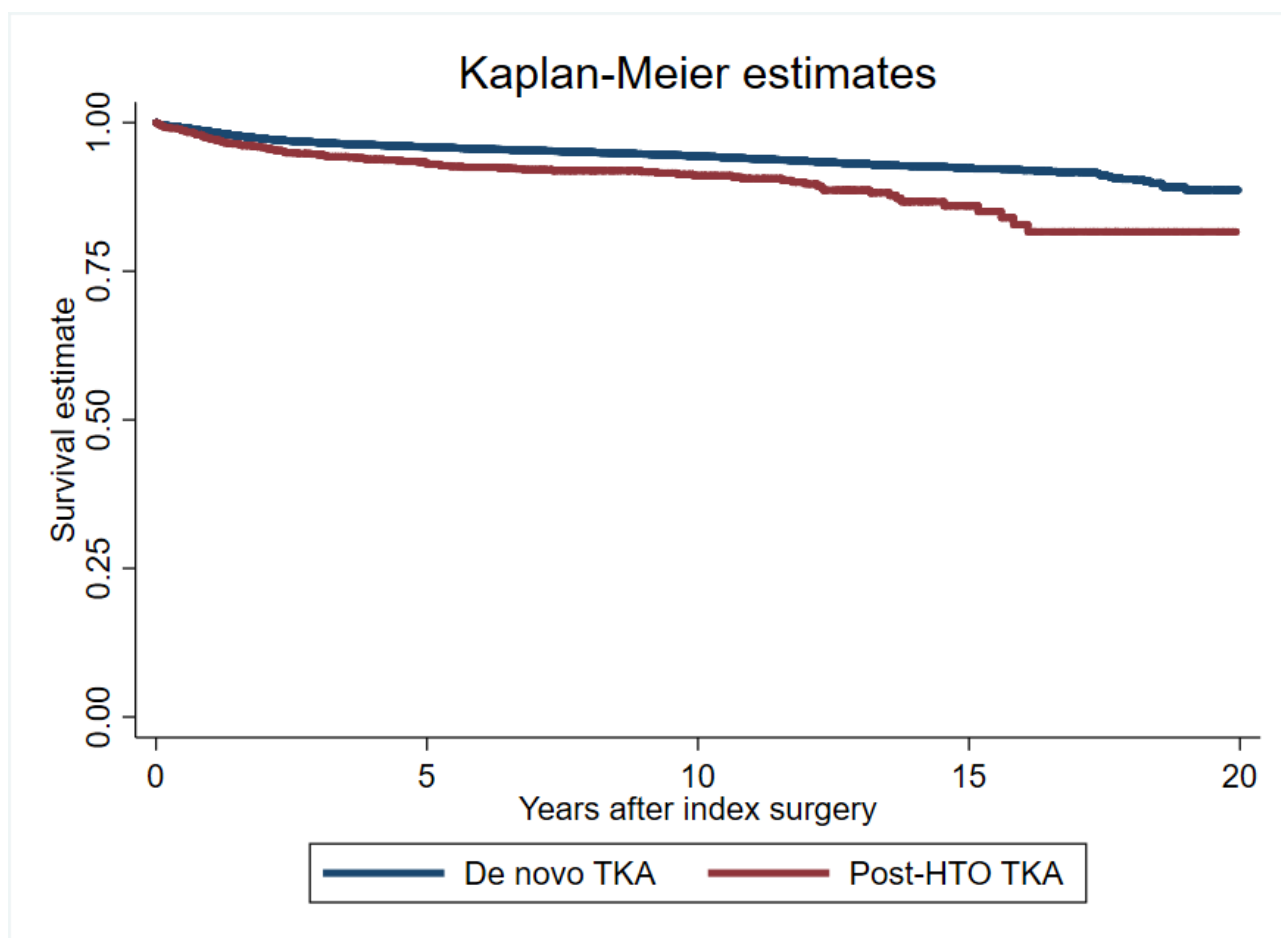
286 Table 1: Hierarchy of indications for revision. Clinically most important from top to bottom.
287
288289 Table 3:
290

	Post-HTO TKA	De novo TKA
Observations	1,044	63,763
Revisions	98 (9.5 %)***	2,933 (4.5 %)***
Mean Follow up (years)	8.55***	6.58***
Patient characteristics:		
Sex		
Male	596 (57%)***	22.621 (35%)***
Female	448 (43%)***	41.142 (65%)***
Mean age (years)	62 (SD:9.5)***	70 (SD: 9)***
Mean weight (Kg)	85 (SD: 20)**	84 (SD: 19)**
Charnley Class		
A	399 (38%)**	22.474 (35%)**
B1	386 (37%)**	22.356 (35%)**
B2	215 (21%)**	15.360 (24%)**
C	44 (4%)**	3.573 (6%)**
Surgery characteristics:		
TKA		
Cruciate retaining	829 (80%)***	51,866 (81%)***
Posterior stabilized	150 (15%)***	8,657 (14%)***
Hinged constrained	5 (0%)***	41 (0%)***
Non-hinged constrained	4 (0%)***	215 (0%)***
Undefined	56 (5%)***	2,984 (5%)***
Mean procedure time (minutes)	88 (SD: 28)***	71 (SD: 22)***
Perioperative complications	18 (2%)***	403 (0.5%)***
Component supplementation	32 (3%)***	646 (1%)***

291 Table 3: Patients and surgery characteristics sorted in TKA following high tibial osteotomy (HTO) and de novo TKA.
292 Asterisks indicates level of significance (*≤0.05, **<0.01, ***<0.001). SD: standard derivations.
293

294 Figure 1

295



296

297 **Figure 1:** Kaplan-Meier survival estimate for post-HTO TKA when compared to de novo TKA ($p < 0.001$). In patients
298 with TKA following HTO the estimated 1-, 5- and 10-year survivals were 0.97 with a 95% confidence interval (CI) of
299 0.96-0.98, 0.93 (CI: 0.91-0.94) and 0.91 (CI: 0.89-0.93), respectively. Accordingly, the estimated 1-, 5- and 10-year
300 survivals were 0.98 (CI: 0.98-0.99), 0.96 (CI: 0.96-0.96) and 0.94 (CI: 0.94-0.95) for de novo TKA.
301

302 *Table 4*
 303

Indications	Post-HTO TKA	De novo TKA
Aseptic loosening	22 (22.5%)	796 (27.0%)
Infection	21 (22.0%)	707 (24.0%)
Instability	22 (22.5%)	498 (17.0%)
Pain	7 (7.25%)	221 (7.5%)
Secondary insertion of patella component	7 (7.25%)	250 (8.5%)
Wear	7 (7.25%)	117 (4.0%)
Unknown	4 (4.0%)	98 (3.5%)
Others	8(8.25%)	246 (8.5%)
<i>Total</i>	<i>98 (100%)</i>	<i>2,933 (100%)</i>

304 **Table 4:** Indications of revision sorted in post-HTO TKA and de novo TKAs. P=0.59 tested by Fishers Exact test

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- 306
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419 Appendix

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421 *Table 2:*

422

	TKA following HTO	de novo TKA	Total
TKA before exclusion	1,049	64,078	65,127
Excluded:			
Revision before index surgery	0	74	74
Missing side	0	14	14
Unicompartment Arthroplasty	5	193	198
Second stage of two staged revision	0	34	34
Included TKA	1,044	63,763	64,807

Missing Weight	35	1,876	1,911
Missing duration of index surgery	0	141	141
Missing Charnley class	7	158	165
Imputed variables	42	2,175	2,217

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Table 2: Observations with missing or imputed values. Patients with revision before index surgery, unicompartment arthroplasties, missing side or second stage of two stage-revision were excluded. Missing observations in weight, duration of index surgery and Charnley class were estimated by multiple imputation by either predictive mean matching or ordered logistic regression.