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Description: Table_3_Leisure-time physical activity reported by patients with a history of sports-related injuries or other injuries at follow-up among patients with total knee arthroplasty.

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5): Figures 1

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Description: Figure 1 TKA had been done between years 2000-2013 to 60 years or younger.

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1 Knee arthroplasty until age 60 – role of sports and other injuries

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16 Short title: Knee arthroplasty until age 60

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27 ABSTRACT

28 **BACKGROUND:** The primary aim of the study was to investigate how total knee arthroplasty
29 (TKA) patients with underlying injuries differ in injury type and physical activity after the
30 arthroplasty.

31 **METHODS:** A questionnaire was sent to TKA patients, ≤ 60 years at surgery, and knee
32 injury as the cause of knee OA. The final study group consisted of 70 patients.

33 **RESULTS:** Average age of patients at TKA was 51.8 years (Standard Deviation [SD] 5.2),
34 and at follow-up 57.6 years (SD 6.5). Of the injuries, 26% were sports-related, 29% had
35 occurred at work, 23% in traffic accidents, and 13% during leisure-time (no sports-related).
36 Sports-related injuries had occurred at younger ages than others had (mean 23.4 vs. 35.2
37 years, $p=0.001$). Time from injury to arthroplasty was longer in patients with sports-related
38 injuries compared to others (mean 26.6 vs. 17.4 years, $p=0.003$). At follow-up age-adjusted
39 mean amount of weekly physical activity measured as leisure-time metabolic equivalent
40 (MET) index (MET-hours/week) was higher in patients with sports-related injuries than in
41 patients with other injuries (42.1 vs. 18.5, $p=0.001$).

42 **CONCLUSIONS:** Previous knee injury was the cause of severe knee osteoarthritis and TKA
43 in 20% of the patients 60 years or younger. The time from injury to arthroplasty was longer
44 among patients with sports-related than among those with others. Patients with previous
45 sports-related knee injury were more physically active after arthroplasty than patients with
46 others.

47
48 **Key words:** Knee Osteoarthritis - Total Knee Arthroplasty - Knee Injury - Physical Activity

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52 Introduction

53 Recent meta-analyses and prospective studies have reported that subjects with previous knee
54 injury are at an almost three-fold risk for knee osteoarthritis (OA) compared to those without
55 such injuries.¹⁻³ In the early stage of the disease, conservative treatment is usually
56 recommended, and operative treatment has traditionally been preferred for older patients with
57 severe OA. In the 1980's the incidence of total knee arthroplasty (TKA) among Finns in
58 Finland aged 30 to 59 was 0.5 operations per 100,000 inhabitants, but at the end of the
59 follow-up period in 2006 the incidence had risen to 65 operations per 100,000 inhabitants.⁴

60
61 Despite the fact that physical activity has many health benefits, some sports-related injuries
62 may cause problems later in life. The type of knee injury has an impact on the risk of OA. A
63 ligament or tendon injury, meniscal injury or meniscal resection and fracture of a lower limb
64 carried a nearly six-fold risk of OA.² Among athletes, knee injury is often followed by OA
65 and is the most common reason for permanent disability.⁵ The increase in total knee
66 replacements among younger patients may be a result of a growing number of knee injuries
67 and expanding indications for the procedure.⁶ The role of knee injury, and especially the type
68 of injury, as a risk factor for severe knee OA leading to TKA among people in their working
69 age should be studied in more detail.

70
71 The aim of this study was to investigate the role of acute injuries (sports vs. others) in the
72 aetiology of knee OA leading to TKA in patients aged 60 or younger. The secondary aim was
73 to study whether previous sports injury correlated with higher level of physical activity after
74 arthroplasty.

75

76

Materials and Methods

Between the years 2000 and 2013 total knee replacements were performed on 652 patients aged 60 years or younger in Orton Orthopaedic Hospital, Finland. We excluded nine patients not speaking Finnish or Swedish. The operating orthopaedic surgeons recorded his/her opinion on the cause of the knee OA in light of the patient history. Based on this opinion, 350 patients with primary OA as the cause of OA were excluded. Of the remaining patients, 127 (20%) had previous knee injury as the cause of knee OA, and they were included in our study. Ninety-six percent (122/127) of them could be reached (Fig. 1).

A postal questionnaire was sent in 2014 to the patients with previous injury as the cause of OA (n=122, 69 male). Besides detailed questions on previous knee injuries the questionnaire included questions on anthropometrics, work history, chronic diseases other than OA, symptoms, recent physical activity and also questions on possible OA among relatives. Body mass index (BMI) was calculated based on patients' self-reported height and weight at follow-up. We calculated a leisure time activity metabolic equivalent (MET) index (cumulative leisure MET hours/week) by assigning a multiple of resting metabolic rate to activity, and by calculating the product of intensity x frequency x times of activity.^{7,8}

Eighty-five patients (70%) responded to our questionnaire and 73 (60%) of these agreed to participate; 12 patients declined to complete the questionnaire. After checking patients' records three participants were excluded because of diagnoses other than OA (one patient with recurring dislocation of the patella, one with juvenile idiopathic arthritis and one with spastic diplegia). Thus, the final study group consisted of 70 patients, 36 females and 34 males. Patients' characteristics are shown in Table I.

102 *Ethical aspects*

103 The ethics committee of the Universities of Applied Sciences in Helsinki Area approved the
104 study protocol (16.10.2013), and permission to use the patient registration was granted by the
105 National Institute for Health and Welfare (Dnro THL/1648/5.05.00/2013).

107 *Statistical analysis*

108 Statistical analyses were performed with SPSS (version 22.0; SPSS Inc., Chicago, Illinois,
109 USA). Comparisons between the groups were performed with T-test. When comparing BMI
110 and MET index between patients with sports-related injuries and other injuries, analysis of
111 covariance (ANCOVA) were performed with using age at follow-up as a covariate. Results
112 are given in proportions or in mean differences and their 95 % Confidence Intervals (CI). $p <$
113 0.05 (two-tailed) was accepted as a statistically significant threshold.

115 **Results**

116 The average age of the patients at the time of the TKA was 51.8 years (SD 5.4, range 38.0-
117 60.0), mean age at the time of the follow-up questionnaire was 57.6 years (SD 6.4, range
118 44.0-70.0), and mean follow-up time between the TKA and questionnaire was 6.2 years (SD
119 3.6, range 0.5–13.0) (Table I). Ten of the patients were over 65 years at the time of follow-
120 up, and were retired. Fifty-eight patients younger than 65 years reported their employment
121 status and 53% of them were working full-time or part-time. Twenty-six of the patients
122 younger than 65 years were retired. Only two patients with earlier sports injury (2/18)
123 reported not working either full-time or part-time work while, as in the group with other
124 injuries, 67% (30/45) reported being retired. When responding to follow-up questionnaire
125 patients with sports-related knee injuries were on average younger than patients with other

126 injuries (54 years vs. 58 years, mean difference -4.3 years, 95 % CI -7.7 - -0.9, p=0.014)
127 (Table I).

128

129 *Previous knee injury*

130 Twenty-six percent (18/70) of the knee injuries had occurred in sports and 29% (20/70) of the
131 knee injuries had occurred at work. All except one of the patients (17/18) with sports-related
132 injuries reported the sports in which the injury had occurred. Half of the injuries had occurred
133 in team sports (n=9), such as soccer, basketball, ice hockey or Finnish baseball. Sports-
134 related knee injuries had also occurred in badminton, downhill and cross-country skiing.
135 Traffic accidents were the cause for the injury in 23 (16/70) percent of the patients, and 13%
136 (9/70) of the patients reported that the injury had occurred in leisure time, such as falling at
137 home or when hunting or disembarking from a boat. Seven of the patients did not provide
138 exact details of the injury situation. There was no gender difference in the type of injury
139 (p=0.369). Fifty-three percent (35/66) of the patients with knee injuries leading to TKA
140 reported more than one injury in the lower limb.

141

142 One-third (33%, 16/48) of all patients with previous knee injuries reported that they had
143 suffered a combined knee ligament and meniscal injury. These types of injuries were more
144 common in sports than elsewhere (57% vs. 24%, p=0.025). Only five patients had had
145 isolated anterior cruciate ligament (ACL) injury and one of the fourteen lower-limb bone
146 fractures was sports-related (7% vs. 38%, p=0.031). Slightly fewer isolated meniscal injuries
147 had occurred in sports than elsewhere (7% vs. 27%, p=0.134).

148

149 Sports-related injuries had occurred at younger ages than other injuries (mean age 23.4 vs.
150 35.2 years, mean difference -11.8 years, 95% CI -18.6 - -5.0, p=0.001), and the time from

151 injury to arthroplasty was longer in patients with sports-related injuries than with others
152 (mean 26.6 vs. 17.4 years, mean difference 9.2 years, 95% CI 3.4 – 15.0, $p=0.003$). In
153 seventeen patients, the arthroplasty was performed less than ten years after the knee injury,
154 and in only one of these was the injury sports-related.

155

156 Almost every patient (97%, 57/59) reported having had knee surgery, such as meniscal
157 resection or ACL and medial collateral ligament (MCL) repair surgery before TKA. Some of
158 the patients had had several arthroscopies before TKA, no differences between sports-related
159 and others injury were seen.

160

161 At the follow-up there was a trend for patients with sports-related injuries to report less knee
162 pain and fewer symptoms than patients with other injuries ($p=0.055$) (Table II). Otherwise,
163 no difference was seen in pain and symptoms between sports-related injuries and other
164 injuries regarding other anatomic locations.

165

166 *Physical activity*

167 Most of the patients (82%) reported having received sufficient exercise instructions after
168 TKA, but 11% would have wanted to have more instructions - all of them were patients
169 suffering work or traffic-related accidents.

170

171 Most of the patients (80%, 48/60) had exercised regularly during their lifetimes at least two
172 times per week. All patients ($n=18$) with a sports-related injury and 71% ($n=30$) of other
173 patients had exercised regularly before TKA ($p=0.011$) (Table III). At follow-up 78% (47/60)
174 of the patients exercised regularly; 89% (16/18) of patients with sports-related injuries and
175 74% (31/42) of other patients ($p=0.194$). Sixteen patients had been physically inactive

176 (exercised less than two times/week) before TKA, and seven of them were still inactive at
177 follow-up, all patients with other injuries. Twenty-one patients had bilateral TKA, and eight
178 of them were patients with sports-related injuries. Despite bilateral knee endoprosthesis these
179 patients were as physically active as the others (age-adjusted mean MET index 30.6 vs. 23.0,
180 mean difference -7.6 MET index, 95% CI -21.8 – 6.6, $p=0.290$).

181
182 Preoperatively (11) 17.6% of the patients reported that they could walk only 200 meters or
183 less before TKA. Nine of those eleven patients responded to the specific question on physical
184 activity at follow-up, and all of them reportedly exercised regularly. One of the patients
185 reportedly exercised less than 15 minutes per time, and the others walked or jogged from 15
186 minutes to over 2 hours.

187
188 Average exercise intensity corresponded to the intensity of walking among 68% of the cases
189 (43/63), but 14% of the patients reported engaging in higher-intensity physical activity, such
190 as jogging. Half of the patients exercised at least one hour at a time, and over half of them did
191 exercise 11 times or more during a month. At follow-up the patients with sports-related
192 injuries reportedly exercised at higher intensity ($p=0.002$), and engaged more often in leisure
193 time physical activity at an intensity at least equivalent to jogging ($p=0.001$) compared to
194 patients with other types of injury. No gender differences were found in exercise type,
195 intensity, duration or frequency. Overall, the post-TKA volume of leisure-time physical
196 activity was higher among patients with sports-related injuries than the others (age-adjusted
197 mean MET index: 42.1 vs. 18.5, mean difference 25.0 MET index, 95% CI 10.5 – 39.6,
198 $p=0.001$).

199

200 In physically inactive patients BMI was slightly higher than in physically active patients
201 (age-adjusted mean 32.2 vs 29.1, mean difference 3.1 kg/m², 95% CI -0.6 – 6.3, p=0.054).
202 Recent physical activity among the patients is shown in more detail in Table III. Among the
203 sub-group of patients who reported to have some repetitive long-lasting pain at the follow-up,
204 patients with sports-related injuries had a higher age-adjusted MET index than did other
205 patients. The difference in the MET index was 42.3 vs. 18.6 in patients knee pain (mean
206 difference 25.4, 95% CI 8.8 – 41.9, p=0.004). Among patients reporting back pain the
207 corresponding MET index difference was 29.3; 95% CI 10.0 – 48.6, p=0.004 (means 41.8 vs.
208 14.4), and in patients with shoulder pain 24.4, 95% CI -0.6 – 49.5, p=0.055 (means 45.2 vs.
209 21.6).

211 Discussion

212 Previous knee injury increases the risk of knee osteoarthritis even at a young age. Our
213 primary aim was to investigate the role of acute injuries in the aetiology of knee OA leading
214 to TKA until age 60. In the estimation of the orthopaedic surgeons, 18.7% of the 652 patients
215 treated with TKA in our clinic at the age of 60 years or younger, the cause of knee OA was
216 previous knee injury. Twenty-six percent of them had injured their knees in sports, and the
217 rest of the injuries had occurred mainly in traffic accidents or at work. Patients with sports-
218 related injuries had their TKA nearly 30 years after the injury had occurred, but in the
219 patients with other injuries the mean time to TKA was ten years shorter.

220
221 Lohmander et al.⁹ in their review reported that 10-20 years after sports-related knee injury
222 (ACL injury or meniscal tear) half of the patients had radiological signs of OA of the knee
223 and pain with functional impairment. Only one patient with a previous sports-related knee
224 injury in our study had TKA less than ten years after the injury. Patients with sports-related

225 injuries were on average 12 years younger at the time of the injury than patients sustaining
226 other injuries. In high-energy accidents the most common injuries were bone fractures and
227 combinations of various knee ligament and meniscal tears. ACL and other ligament injuries
228 besides the meniscal tears were especially common among sports-related injuries.

229

230 Many factors contribute to the development of early OA after ACL injury, such as trauma to
231 the articular cartilage, age at the time of injury, changes in gait, multiple injuries and knee
232 joint instability.¹⁰⁻¹² Kettunen et al.¹³ concluded that participating in sports involves a risk of
233 knee injuries and this may lead to disability later in life. Tveit et al.¹⁴ also reported that
234 previous knee injury is associated with knee OA in former impact athletes, but not in non-
235 impact athletes. According to the review by Øiestad et al.¹⁵ patients with isolated ACL
236 injuries had lower prevalence of knee OA than with knee ligament injury combined with
237 meniscal tears. Claes et al.¹⁶ in their meta-analysis found that the prevalence of radiographic
238 knee OA after ligament ACL reconstruction was lower than had been thought. When
239 meniscal resection was associated with reconstruction it increased the risk for developing
240 OA. Nearly the entire study group reported having undergone some kind of knee surgery
241 before TKA such as arthroscopy, meniscal resection and ACL or other knee ligament
242 reconstruction. However, the question whether ACL reconstruction leads to early OA is still
243 under debate.¹⁷

244

245 Seventy-six percent of the patients had exercised regularly earlier in their lifetimes. After
246 TKA, 78% of all patients reported they had continued their exercise habits. Patients with
247 sports-related injuries were more active than other patients before TKA, but after TKA the
248 difference between the groups disappeared. Likewise in Chang et al.¹⁸ study, low-impact
249 sports, such as walking, cycling and swimming were common in our patients. In Waldstein

250 and co-authors review¹⁹ low-impact activities increased and high-impact activities decreased
251 after unicompartmental knee arthroplasty. On average our patients with sports-related injuries
252 continued to engage in physical activity at higher levels of intensity than other patients. This
253 was also seen in the amount of physical activity. Patients with sports-related injuries had
254 higher weekly MET index values than the others. It has been concluded that sports activities
255 are not dependent only on TKA itself, but also on the motivation of the patient.²⁰ This may
256 also be the reason for cause of our patients with sports-related injuries; they had been
257 exercising regularly before TKA and were willing to continue physical activities after TKA at
258 the same level of intensity as before TKA. However, Chang et al.¹⁸ refuted the hypothesis
259 that patients participate more actively in physical activities after TKA than they did before
260 surgery. After all the recent review¹⁹ showed that patients, who participated regularly in
261 sports before knee arthrosis, sports participation decreased slightly after unicompartmental
262 knee arthroplasty. Also Arnold et al.²¹ found in their systematic review postoperative physical
263 activity levels in TKA patients were lower than activity levels in their healthy controls.
264 However, our patients had TKA in younger age and this may partly explain that patients with
265 sports-related injury had higher MET index values than patients with other injuries.

266

267 We compared pain and symptoms to MET index values and when patients reported pain and
268 symptoms in the knee, patients with sports-related injuries had significantly higher MET
269 indices than others. Paxton et al.²² concluded that patients reported being more physically
270 active after TKA than before TKA. However, in their report accelerometry-based outcomes
271 showed that physical activity was lower or at the same level as before surgery. We did not
272 have either pre-injury, preoperative or post-operative accelerometer recordings. Although
273 TKA improves functional performance and reduces pain associated with knee osteoarthritis,
274 little is known about the influence of TKA on overall physical activity levels.²² Overall,

275 musculoskeletal symptoms were common in our patients. However, despite self-reported pain
276 in the knee, spine and shoulder, patients with sports-related injuries reported significantly
277 more physical activity than patients with other previous injuries. However, patients with
278 knee injuries sustained at work or in traffic also had more concomitant injuries at different
279 locations in the body. This may explain their slower recovery and return to physical activity.
280 Our material was taken from the knee arthroplasty register of one orthopaedic hospital during
281 the period 2000-2013. Seventy patients responded to our questionnaire, and the final number
282 of patients with sports-related injuries was low, which limits the conclusions that can be
283 drawn from the results. Furthermore, we used a retrospective study design with self-reported
284 questionnaire. The injuries had occurred long ago, thereby increasing the risk of memory
285 recall bias. However, we were able to check the patients' medical records, which
286 considerably improved the reliability of the results of this study.

288 **Conclusions**

289 Previous knee injury was the cause of severe knee osteoarthritis in one-fifth of the young
290 TKA patients, and one-fourth of the injuries were sports-related. Patients with sports-related
291 injuries engaged in more higher-intensity physical activity after arthroplasty than did the
292 other patients.

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299

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303

304 **Conflicts of interest**

305 The authors have none to declare.

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TITLES OF TABLES

- Table I.** - Characteristics of patients undergoing with total knee arthroplasty
- Table II.** - Self-reported prolonged pain and/or recurrent symptoms in different joints among patients with total knee arthroplasty
- Table III.** - Leisure-time physical activity reported by patients with a history of sports-related injuries or other injuries at follow-up among patients with total knee arthroplasty

TITLE OF FIGURE

- Figure 1** - TKA had been done between years 2000-2013 to 60 years or younger

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Table I. - Characteristics of patients undergoing with total knee arthroplasty.

	All	Group with previous sports- related injuries	Group with previous other injuries	Mean difference	95% CI ^b	p - value ^c
	n=70 mean±SD ^d	n=18 ^a mean±SD ^d	n=45 ^a mean±SD ^d			
Gender, male (n (%))	34 (49)	7 (39)	25 (56)			0.645
At the time of surgery						
Age (yrs)	51.8±5.2	50.0±5.3	52.2±5.3	2.2	5.1 - 0.8	0.219
BMI ^e (kg/m ²)	29.0±5.0	27.8±4.1	28.7±4.8	0.9	3.5 - 1.6	0.155
At the time of follow-up						
Age (yrs)	57.6±6.5	54.1±5.9	58.4±6.2	4.3	7.7 - 0.9	0.064
Time from surgery to follow-up (yrs)	6.2±3.7	4.5±3.0	6.6±3.7	2.2	4.1 - 0.2	0.075
BMI ^e (kg/m ²)	29.9±5.3	28.6±4.3	29.9±5.5	1.2	4.2 - 1.7	0.645

^aThe study group consisted of 70 patients, 63 of them reported where their injury occurred

^b 95% Confidence Interval, 95% CI

^c p - values for statistical difference between groups with previous sports injuries and previous other injuries

^dSD=Standard deviation

^eBMI=Body mass index

Table II. - *Self-reported prolonged pain and/or recurrent symptoms in different joints among patients with total knee arthroplasty.*

Region	Pain and symptoms			p-value*
	All	Group with previous sports-related injuries	Group with previous other injuries	
	n (%)	n (%)	n (%)	
Hip	24 (48)	8 (47)	16 (49)	0.924
Knee	50 (88)	18 (16)	32 (82)	0.055
Ankle	18 (34)	5 (28)	13 (37)	0.495
Shoulder	26 (47)	9 (50)	17 (46)	0.778
Hand	14 (27)	5 (28)	9 (27)	0.919
Back	31 (54)	8 (44)	23 (59)	0.306
Other pain, no arthrosis pain	21 (36)	7 (41)	14 (33)	0.569

*p-values for statistical difference between the group with previous sports-related injuries and group with previous other injuries

Table III. - *Leisure-time physical activity reported by patients with a history of sports-related injuries or other injuries at follow-up among patients with total knee arthroplasty.*

	Group with previous sports-related injuries	Group with previous other injuries	<i>p</i> -value ^a
	n=18 n (%)	n=42 n (%)	
Exercise at least 2 times /week	18 (100)	30 (71)	0.011
Present exercise (yes)	16 (89)	31 (74)	0.194
Average exercise intensity corresponds			0.002 ^b
to walking	10 (56)	29 (71)	
alternative walking and jogging	1 (6)	10 (24)	
jogging	7 (39)	2 (5)	
Average exercise duration per session			0.544 ^b
less than 15 minutes	2 (11)	5 (12)	
15 minutes and less than 30 minutes	0 (0)	6 (14)	
30 minutes and less than 1 hour	6 (33)	10 (24)	
1 hours and less than 2 hours	9 (50)	19 (45)	
over 2 hours	1 (6)	2 (5)	
Monthly exercise frequency			0.202 ^b
5 times or less	1 (6)	12 (29)	
6 to 10 times	4 (22)	7 (17)	
11 to 19 times	5 (28)	12 (29)	
20 times or more	8 (44)	11 (26)	
MET index (MET-hour/week) ^c [age-adjusted mean]	42.3	18.5	0.001

^a*p*-values for statistical difference between the group with previous sports-related injuries and the group with previous other injuries

^b*p*-values for differences over categories.

^cIndex used in the calculation of MET hour/week based on intensity * duration * frequency

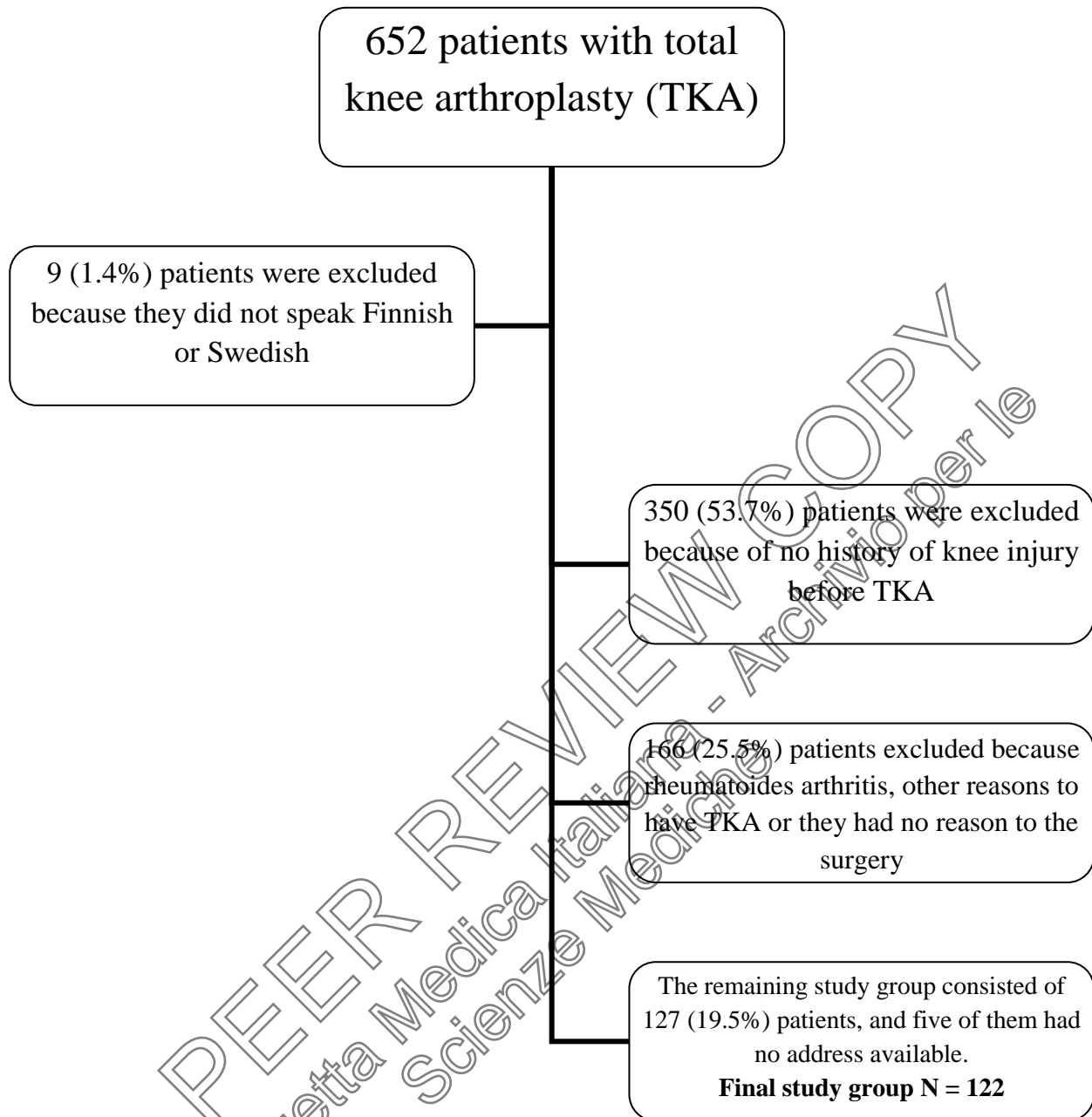


Fig. 1. TKA had been done between years 2000-2013 to 60 years or younger.