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A Nationwide Register-based Study

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Manuscript

Arthrodesis of the knee after failed knee arthroplasty

A nationwide register-based study

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Abstract

Background: Arthrodesis is considered a salvage procedure for failed knee arthroplasty. Data on the use of this procedure is limited. The purpose of the present study was to identify the incidence, causes, surgical techniques and outcomes of arthrodesis after failed knee arthroplasty in a nationwide population.

Methods: Data were extracted from the Danish Civil Registration System, the Danish National Patient Register and the Danish Knee Arthroplasty Register. Using individual data linkage, a total of 92,785 primary knee arthroplasties performed in Denmark from 1997 to 2013 were identified. Of these, 165 were followed by arthrodesis. Hospital records of all identified cases were reviewed. A competing risk model was used to estimate the cumulative incidence of arthrodesis in the study period. Differences in cumulative incidences were compared with Gray's test.

Results: **A total of 164 arthrodeses were performed for causes related to failed knee arthroplasty.** The 15-year cumulative incidence of arthrodesis was 0.26% (95% CI, 0.21-0.31%). A significant decrease in the 5-year cumulative incidence from 0.32% for procedures performed from 1997 to 2002 to 0.09% for procedures performed from 2008 to 2013 was observed ($p<0.0001$). The most common causes of arthrodesis were periprosthetic infection **in 152 patients** (93%), extensor mechanism disruption **in 46 patients** (28%), soft tissue deficiency **in 25 patients** (15%) and severe bone loss **in 11 patients** (7%) In 79 patients (48%), there were two or more indications for arthrodesis. Solid fusion was achieved in 65% of the patients. Fusion was significantly improved with intramedullary nail fixation compared to external fixation ($p=0.01$). A total of 34 patients (21%) were treated with repeat arthrodesis, and 23 patients (14%) eventually required above-knee amputation.

Conclusions: The cumulative incidence of arthrodesis within 15 years after primary knee arthroplasty was 0.26%. The results showed a significant decrease in the 5-year cumulative incidence during the study period, suggesting an overall improvement in prevention of this adverse outcome of knee arthroplasty.

Level of evidence: Prognostic Level III, retrospective cohort study.

Introduction

Knee arthroplasty is a common surgical procedure performed more than 8,000 times a year in Denmark (1). **The corresponding number in the United States (US) is 600,000 (2). Although most procedures are successful, complications still occur.** Serious complications of knee arthroplasty may eventually lead to knee arthrodesis. The reported incidence of arthrodesis following failed knee arthroplasty varies from 0.21% to 1.11% (3-5). **Usually the patient has undergone several attempts to preserve the knee, including revision arthroplasty, before arthrodesis is considered (6;7).** However, in patients with an unreconstructable knee, arthrodesis remains an important salvage procedure, not least in order to avoid above-knee amputation. **The primary indication for arthrodesis is infection (8).** Other indications include severe bone loss, soft tissue defects and extensor mechanism deficiency (9-12).

Previous literature on arthrodesis for failed knee arthroplasty has been based on single-center studies or case series with a limited number of patients. **We believe this data are not necessarily representative and further data is needed to better understand the circumstances leading to arthrodesis.** We therefore conducted a nationwide study with the purpose of identifying the incidence, causes, surgical techniques and outcomes of arthrodesis following failure of knee arthroplasty.

Materials and Methods

Data sources

This retrospective study was based on nationwide data from the following Danish registers:

The Danish Civil Registration System (CRS)

The CRS was established in 1968. It contains information on all persons residing in Denmark. Each person is registered with a unique identification (ID) number, which allows for individual data linkage across national health registers. It also enables individual searches of hospital records. The CRS continuously receives information on status including emigration, disappearance and death, allowing for practically complete follow-up (13).

The Danish National Patient Register (DNPR)

The DNPR was established in 1977. It contains information on all persons in contact with the Danish healthcare system including public and private hospitals. Data on surgical procedures are registered with a code according to the Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures, which was introduced January 1, 1996 (14). Registration to the DNPR is compulsory. The registration completeness of surgical procedures is approximately 90% and even higher for orthopedic procedures (15;16).

The Danish Knee Arthroplasty Register (DKR)

The DKR has collected information on all primary and secondary knee replacement procedures performed in both public and private hospitals in Denmark since January 1, 1997. Registration to the DKR has been compulsory since June 1, 2006. **The completeness of registration in the DKR is assessed using the DNPR as a reference.** During the entire period, the completeness for primary procedures has been above 90% (17).

Data collection

Identification of primary knee arthroplasties

The study population included all primary knee arthroplasty procedures performed during a 17-year period from January 1, 1997 to October 15, 2013. **As described,**

neither the DNPR nor the DKR are fully complete. Therefore, the study was based on searches in both registers, considering the possibility that a procedure was registered in one but not the other register.

The DNPR was searched for all surgical procedure codes relating to primary knee arthroplasty (KNGB0-99), as defined in table 1. Data included information on date and hospital of the surgical procedure. A total of 89,545 procedures were identified. Similarly, the DKR was searched for data on all primary knee arthroplasty procedures. A total of 85,312 procedures were identified. **Data on emigration, disappearance and death were extracted from the CRS.** The datasets were merged by identification (ID) number, resulting in a total population of 93,260 primary knee arthroplasties. It was methodologically decided that an ID number could only appear two times in the dataset, that is. one primary procedure on left and right knee respectively. Any additional procedure was considered a misclassification of a secondary procedure. Consequently, 346 procedures were excluded from the merged dataset. Another 129 procedures were excluded due to a missing or invalid status in the CRS. The final study population consisted of 92,785 primary knee arthroplasties (table 2).

Identification of knee arthrodeses

The DNPR was searched for all surgical procedure codes relating to knee arthrodesis (KNGG-39-99) (table 1) including information on date and hospital of the surgical procedure. A total of 415 procedures were identified. These were linked to the merged dataset by ID number, thereby identifying 195 patients who were registered with both a primary knee arthroplasty and an arthrodesis. **Hospital records were obtained from the national patient administration system or from hospital archives and reviewed.** Fifteen patients were excluded because the arthrodesis was incorrectly registered. Eleven patients were excluded because the arthrodesis was performed in an extremity,

in which the knee arthroplasty was inserted before 1997. Four records were missing or incomplete. The remaining 165 patients were included in the study (table 2).

Information on hospitalization for primary knee arthroplasty, any subsequent knee surgery and arthrodesis was collected from the records.

Statistical analysis

Statistical analyses were conducted using SAS version 9.3 for Windows. As a measure of the frequency of arthrodesis, we used the cumulative incidence, that is, the probability of an event occurring within a given period of time. The cumulative incidence of arthrodesis was estimated using a competing risk model implemented in a SAS macro (18), in which death was defined as a competing risk for arthrodesis. Emigration or disappearance during the study period caused censoring. Censoring also occurred if none of the above mentioned events were met at the end of the study period. Differences in cumulative incidences were compared with Gray's test (19). Categorical data were analyzed with Pearson's chi square test. P-values of less than 0.05 were considered statistically significant.

Study approval

Before initiating the study, approval was obtained from the Danish Data Protection Agency (reg. no. 2007-58-0015) and the Danish National Board of Health (reg. no. 3-3012-398/1). The study did not require informed consent from the patients.

Source of funding

The study received external funding from Hans and Nora Buchard's Fund, a private non-profit foundation. The funding did not play a role in the conduct of the study.

Results

A total of 92,785 primary knee arthroplasties performed in Denmark from 1997 to 2013 were identified. Of these, 165 arthroplasties were followed by arthrodesis (0.18%). One arthrodesis was performed due to bone metastases from colon cancer. The remaining 164 arthrodeses were performed for causes related to failure of the knee arthroplasty. These patients, 86 males and 78 females, represented the study population.

Cumulative incidences

The cumulated incidence of arthrodesis within 15 years after primary knee arthroplasty was 0.26 percent (95% CI, 0.21-0.31%). The observations were divided into three consecutive time periods from 1997 to 2002, 2003 to 2007 and 2008 to 2013, depending on when the primary knee arthroplasty was performed (figure 1). **As a result, the observation time in the three periods ranged from approximately five to fifteen years (figure 1).** Regardless of time period, the risk of arthrodesis was highest within the first five years after primary knee arthroplasty. Comparing the 5-year cumulative incidence, a decrease from 0.32% in the first period (upper curve) to 0.09% in the third period (lower curve) was observed. Likewise, a decrease in the 10-year cumulative incidence from 0.37% in the first period (upper curve) to 0.23% in the second period (middle curve) was observed. The observed differences in cumulative incidences were statistically significant (Gray's test, $p<0.001$).

In addition, the observations were divided on a regional level depending on which hospital had performed the primary procedure. Administrative regions of Denmark included the Capital Region, Region Zealand, South Region, Central Region and North Region. The incidence of arthrodesis differed significantly across the regions (Gray's test, $p=0.001$). The two regions with the lowest and highest cumulative incidences are illustrated in figure 2.

Primary knee arthroplasty

Patient characteristics at the time of primary knee arthroplasty are reflected in table 3. The mean age of the patients was 66.5 years (range, 22 to 92). The most common underlying diagnoses were osteoarthritis (66%) and posttraumatic arthritis (13%), defined by sequelae of fracture of the patella, femoral or tibial condyles. A total knee arthroplasty (TKA) was used as primary implant in 149 patients (91%). Nine patients (5%) were treated with a unicompartmental arthroplasty, four of which were later exchanged to TKA. Forty-eight patients (29%) were healthy (that is, no significant comorbidity) at the time of primary knee arthroplasty, whereas 105 patients (64%) had comorbid medical conditions (range, 0 to 4), most commonly hypertension (26%), heart diseases (16%) and neurologic diseases (15%). There were 35 smokers (21%) and 13 alcohol abusers (8%). Another thirteen patients (8%) were on immune-suppressive treatment such as glucocorticoids and methotrexate.

Subsequent knee surgery

A total of 153 patients (93%) underwent subsequent surgery on the affected knee prior to arthrodesis. Eleven patients (7%) were treated initially with arthrodesis following primary knee arthroplasty. **The mean number of surgical procedures was 2.4 (range 0-9), including soft tissue surgery in 108 patients (66%) and revision arthroplasty in 118 patients (72%) prior to arthrodesis.** Complications associated with failure of the primary knee arthroplasty included infection in 107 patients (65%), mechanical problems in 15 patients (9%), wound healing problems in 12 patients (7%), extensor mechanism disruption in 9 patients (5%), soft tissue deficiency in 8 patients (5%), aseptic loosening in 6 patients (4%), pain in 6 patients (4%), stiffness in 5 patients (3%) and periprosthetic fracture in 3 patients (2%).

Knee arthrodesis

The main indication for arthrodesis was periprosthetic infection, which was present in 152 knees (152 patients) (93%). **Microorganisms isolated pre- or intraoperatively in infected knees are shown in table 4.** The predominant microorganism was staphylococcus. Fourteen infections (9%) were polymicrobial, usually a combination of gram-positive cocci and gram-negative rods. Other indications for arthrodesis included extensor mechanism disruption in 46 patients (28%), soft tissue deficiency in 25 patients (15%), severe bone loss in 11 patients (7%), intractable pain in 9 patients (5%), stiffness in 6 patients (4%), periprosthetic fracture in 4 patients (2%) and chronic knee dislocation in one patient (0.6%). In 79 patients (48%), there were two or more indications for arthrodesis.

The surgical techniques of arthrodesis included external fixation in 120 patients (73%) and internal fixation in 39 patients (24%), of which 32 patients were managed with intramedullary nailing and 7 patients with compression plating. One arthrodesis was achieved using K-wires. Another was achieved uninstrumented. In three cases, the surgical technique was unknown. Arthrodesis was performed as a 2-stage procedure in 89 patients (54%) with removal of the prosthesis and insertion of a spacer followed by a period of antibiotic treatment and then arthrodesis. In 71 patients (43%), a 1-stage procedure was performed. Information on stage was missing in four cases.

Mean follow-up time after arthrodesis was 1.6 years (95% CI, 1.3-1.9). Five patients died of medical complications within few months after arthrodesis. A solid fusion was achieved in 106 patients (65%), including **fusion in 27 of 32 patients** (84%) **with** intramedullary nail fixation and **73 of 120 patients** (61%) **with** external fixation The difference in fusion rates between the two types of fixations was statistically significant (p=0.01). Of 7 plate fixations, only 3 fused (43%). Fusion rates for 1-stage and 2-stage procedures were compared, but there was no significant difference (p=0.22). An

increasing number of previous revision arthroplasties was associated with a lower rate of overall fusion (p=0.02). In 113 of 152 patients (74%), infection was successfully eradicated**, including 22 of 33 patients (67%) with internal fixation and 88 of 114 patients (77%) with external fixation (p=0.22).** There was no difference in success rates between 1-stage and 2-stage procedures (p=0.08).

A total of 34 patients (21%) were treated with repeat arthrodesis due to failure of first attempt at fusion, of which only nineteen achieved successful fusion. Twenty-three patients (14%) eventually required above-knee amputation. Of these, eight had a history of failed repeat fusion. Causes of amputation included uncontrollable infection, non-fusion and soft tissue compromise.

Discussion

In this nationwide study, we identified 164 arthrodeses performed as a result of failed knee arthroplasty in the period 1997-2013. The 15-year cumulative incidence of arthrodesis was 0.26% compared to an overall crude incidence of 0.18% (164 of 92,785 arthroplasties). These results confirm previously reported incidences ranging from 0.21% to 1.11% (3-5). During the study period, the 5-year cumulative incidence of arthrodesis decreased from 0.32% to 0.09%, which is lower than previously reported. This finding may indicate that treatments with knee arthroplasties have generally improved in the last decades. **However, it may also indicate that there are now better surgical techniques to treat severe complications of knee arthroplasty.**

The main cause of arthrodesis was periprosthetic infection, which is consistent with previous literature (8). Microorganisms in infected knees were largely staphylococcus species, corresponding to other recent studies (9;12;20). Other important causes of arthrodesis, also previously reported, were extensor mechanism

disruption, soft tissue deficiency and severe bone loss (7;10-12). It is important to consider new treatment options for these complications. For instance, skin grafts, muscle flaps and extensor mechanism allograft in reconstruction of extensive soft tissue deficiencies (21;22). In addition, severe bone defects are now managed with modular or customized revision prostheses or even tumor prostheses (23).

Although our results showed an overall decrease in the cumulative incidence of arthrodesis, we observed large regional differences in the incidence. This is probably explained by different approaches among surgeons in terms of treatment indications for arthrodesis. In other words, some surgeons may turn to more traditional methods for treating severe complications of knee arthroplasty, such as amputation, whereas others rely on repeat revisions or more experimental methods as mentioned above.

In the present study, the preferred surgical techniques of arthrodesis were external fixation (**120 of 164 patients**, 73%) and intramedullary nail fixation **(32 of 164 patients, 20%** The overall fusion rate of arthrodesis was 65% **(106 of 164 patients)**. A previous large study found a similar fusion rate of 66% (4). More recent studies have reported higher rates between 75% and 85% (7;10;24). Infection was successfully eradicated in **113 of 152 patients (74%)** with infected knee prostheses. This is also comparable to other studies where the success rate varies between 67% and 80% (10;25).

The surgical techniques of arthrodesis were evaluated retrospectively. Comparing the results of various fixation techniques would ideally require a randomized controlled trial. Despite this limitation, we made several observations because of the large number of patients included in the study. First, we found that fusion was significantly improved with intramedullary nail fixation (**27 of 32 patients,** 84%) compared with external fixation (**73 of 120 patients,** 61%). These findings are supported by several other

authors (24;26-28). Next, we found a greater overall fusion rate with a decreased number of previous revision arthroplasties, which is most likely explained by better preserved bone stock. Other authors have made same observations (24;29). Finally, we observed that the success rate of eradicating infection was higher with external fixation (**88 of 114 patients,** 77%) than with internal fixation (**22 of 33 patients,** 67%). Although this was not significant, other studies have reported similar results (6;24).

The main purpose of the DKR is to provide information on the epidemiology and quality of treatments with knee arthroplasty. **For this reason, the DKR receives reports of all revision procedures performed in Denmark**. Any revision procedure, in which the knee prosthesis is removed to perform an arthrodesis, should also be reported to the DKR. However, the register has only received reports of 74 arthrodeses in the period 1997-2013, which is less than half the number of arthrodeses identified in the DNPR within the same period of the present study (n=164) (1), suggesting that orthopedic surgeons do not systematically report this procedure to the DKR. **Moreover, registers may underestimate the number of arthrodeses performed for failed knee arthroplasty**. **We believe this finding is partly explained by a lack of knowledge about the reporting requirement, in part by organizational structures in orthopedic departments, where arthrodeses are sometimes performed by other surgeons than those who perform the arthroplasty procedures.**

This is the largest study we are aware of on arthrodesis for failed knee arthroplasty. The study included 92,785 primary knee arthroplasties identified in nationwide registers, thereby minimizing selection bias. Registration of surgical procedures in the DNPR has been validated on several occasions showing high completeness above 90% (15;16). Likewise, the completeness for primary knee arthroplasty procedures in the DKR has been shown to be high (17). In the present study, registration of arthrodeses in the

DNPR was validated by review of hospital records. Fifteen of 195 arthrodeses (8%) were incorrectly registered. If a similar number of arthrodeses were never reported to the DNPR, we would still have identified more than 90% of all arthrodeses performed in the study period. Thus, the risk of underestimating the incidence was low. **In the process of validation, four patients were excluded from the study due to missing or incomplete records.** However, information on these patients would not have affected the incidence significantly.

A competing risk model was used to estimate the cumulative incidence. In contrast to other traditional approaches such as the Kaplan-Meier method, this model takes into account the competing risk of death (30). In this study, a considerable proportion of the population died during the study period. Using a competing risk model rather than the Kaplan-Meier method, in which death is censored, the bias of overestimating the incidence was eliminated. **Overall, it is reasonable to assume that our data are representative.**

In conclusion, the cumulative incidence of arthrodesis within 15 years after failed knee arthroplasty was 0.26% in a nationwide population of 92,785 primary knee arthroplasties performed from 1997 to 2013. In the last part of the study period, the 5-year cumulative incidence was reduced to 0.09%, which is lower than previously reported. **This finding suggests that orthopedic surgeons have already made great progress in treatment of complications associated with knee arthrodesis such as extensor mechanism disruption, soft tissue deficiency and severe bone loss.**

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Figure Legends

Figure 1. Competing risk analysis illustrating differences in cumulative incidences of arthrodesis over the 17-year study period

Figure 2. Competing risk analysis illustrating differences in cumulative incidences of arthrodesis across the Danish regions

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Fig. 1
Flowchart illustrating selection of the study population identified in the DNPR and the DKR.
Fig. 2
Competing risk analysis illustrating differences in cumulative incidence of arthrodesis over the nearly 17-year study period.
Fig. 3
Competing risk analysis illustrating differences in cumulative incidence of arthrodesis across the Danish regions. The regions with the lowest and the highest cumulative incidence are shown.

TABLE I The NOMESCO Surgical Procedure Codes Used for Identification of the Study Population

Procedure Code	Description of Surgical Procedure
KNGB0	Primary partial prosthetic replacement of knee joint not using cement
KNGB1	Primary partial prosthetic replacement of knee joint using cement
KNGB20	Primary total prosthetic replacement of knee joint not using cement
KNGB30	Primary total prosthetic replacement of knee joint using hybrid technique
KNGB40	Primary total prosthetic replacement of knee joint using cement
KNGB59	Primary total prosthetic interposition arthroplasty of knee joint
KNGB99	Other primary prosthetic replacement of knee joint
KNGG39	Fusion of the knee joint without fixation
KNGG49	Fusion of the knee joint with internal fixation
KNGG59	Fusion of the knee joint with external fixation
KNGG99	Other excision, reconstruction, or fusion of knee joint

TABLE II Patient Characteristics at the Time of Primary Knee Arthroplasty

Category	No.
Underlying diagnosis	
Osteoarthritis	109
Posttraumatic arthritis	22
Rheumatoid arthritis	9
Traumatic fracture	2
Sequelae of septic arthritis	2
Sequelae of chronic osteomyelitis	1
Sequelae of hemophilic arthropathy	1
Underlying diagnosis unknown	18
Type of implant	
Total knee arthroplasty	149
Unicompartmental knee arthroplasty	7
Patellofemoral arthroplasty	2
Rotating-hinge implant	2
Resection implant	2
Implant unknown	2
Medical condition	
Healthy	48
Hypertension	43
Heart disease	27
Neurologic disease	24
Endocrine disease	21
Rheumatic disease	17
Lung disease	16
Peripheral vascular disease	8
Osteoporosis	7
Kidney disease	5
Liver disease	2
Malignant disease	1
Medical condition unknown	11

TABLE III Isolated Microorganisms in Infected Knees

	No.
Gram-positive cocci	
Staphylococcus aureus	36
Staphylococcus epidermidis	36
Hemolytic streptococci	14
Enterococcus faecalis	10
Unspecified staphylococci	9
Unspecified gram-positive cocci	3
Unspecified enterococci	2
Streptococcus pneumonia	2
Non-hemolytic streptococci	1
Peptostreptococcus	1
Gram-positive rods	
Corynebacterium	4
Propionibacterium	1
Gram-negative rods	
Escherichia coli	7
Proteus	3
Pseudomonas	1
Klebsiella	1
Pasteurella	1
Enterobacter	1
Negative culture	18
Culture results unknown	13