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Hinged versus CCK revision arthroplasty for the stiff total knee

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ABSTRACT

Background: Total knee arthroplasty (TKA) remains the gold standard for end-stage knee osteoarthritis. The prevalence of stiffness after this procedure described in literature varies from 1.3% to 5.3%. The causes of arthrofibrosis after total knee arthroplasty are multifactorial. Revision TKA is a successful procedure when performed for loosening, instability, mechanical implant failure, or infection. The results of revision TKA for idiopathic arthrofibrosis and stiffening are however less favorable.
Purpose: It has been the authors' impression that the poor results in arthrofibrosis could be in part related to the use of traditional PS or CCK-type revision implants. Our hypothesis is that better results can be achieved in case a rotating hinge design (RHK) is used. The reason could be that RHK designs allow for much more aggressive capsuloligament debridement and therefore more adequate fibrosis removal, while securing optimal implant stability, tibiofemoral rotational freedom, and flexion-extension space stability. The purpose of our study was to investigate in our database whether this hypothesis is correct.
Methods: Retrospectively, 40 patients with the defined range of knee motion were identified. Patients with underlying mechanical malalignment, component malposition, soft-tissue imbalance or infections were excluded. Twenty-two patients received a hinged-type prosthetic device (18 Zimmer RHK, four Stryker RHK) and 18 patients received a less constrained condylar type prosthetic device (17 Legion CCK, one Vanguard CCK).
Results: Preoperative data were similar for RHK as CCK-type implants except for knee pain score, which was significantly worse for the RHK group (36 vs 44, $p = 0.049$). At two years of follow-up, compared to CCK, the RHK group demonstrated significantly better postoperative results for knee function scores (68.9 vs 54.2, $p = 0.0015$), knee function improvement (22.8 vs 4.8, $p = 0.0015$), knee pain improvement (26.4 vs 9.4, $p = 0.0050$), greater maximal flexion (99.9° vs 81.4°, $p = 0.0005$), better maximal extension (−1.9° vs −6.2°, $p = 0.0447$), greater flexion gain (35.8° vs 14.2°, $p = 0.0002$), and greater extension gain (8.6° vs 2.0°, $p = 0.0083$).
Conclusion: Our data show that revision arthroplasty of the stiff knee using a rotating hinged device can provide excellent results in selected cases. To date, this is the first study to describe the difference in outcome between revision total knee arthroplasty for idiopathic arthrofibrosis using a hinged or a constrained condylar knee device.

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1. Introduction

Total knee arthroplasty (TKA) remains the gold standard for end-stage knee osteoarthritis. The prevalence of stiffness after TKA described in literature varies from 1.3% to 5.3% [1,2]. Stiffness has been defined as a limited range of motion (ROM), often in combination with pain. Kim et al. defined stiffness as a flexion contracture >15° and a maximum flexion <75° [3], whereas Yercan et al. described stiffness as a postoperative ROM 10°-90° [1] and Christensen et al. defined stiffness as a maximum ROM <70° [4]. Recently, an international consensus on the definition and classification of fibrosis of the knee joint was reached. Post-operative fibrosis of the knee was defined as a limited range of movement (ROM) in flexion and/or extension attributable to soft-tissue fibrosis that was not present pre-operatively. Post-operative fibrosis of the knee is not attributable to an osseous or prosthetic block to movement from malaligned, malpositioned or incorrectly sized components, metal hardware, ligament reconstruction, infection (septic arthritis), pain, chronic regional pain syndrome (CRPS) or other specific causes. Limitation of movement was graded as mild, moderate or severe according to the range of flexion (90° to 100°, 70° to 89°, <70°) or extension deficit (five degrees to 10°, 11° to 20°, >20°) [5].

Arthrofibrosis is caused by abundant scar tissue between the extensor mechanism and the anterior femoral cortex. As a consequence of this scar tissue, the suprapatellar pouch, the medial and lateral gutter get obliterated resulting in a loss of ROM. Normal knee ROM ranges from 0° to 140°. A minimum of 90° of ROM in the knee is required for activities in daily living. 65° of knee flexion is required in the swing phase of normal gait, 70° to arise from a chair and 90° to descend stairs [6]. Kneeling requires 125° of flexion [7]. Full extension is important for a gait pattern without limping. Aggressive periarticular fibrosis and the unresolved healing process in patients with arthrofibrosis are results of an excessive accumulation of reactive oxygen and nitrogen species (RONS) and RONS-modified lipids and proteins [8]. The histopathology shows subsynovial fibrosis, synovial hyperplasia and unregulated proliferation of fibroblasts induced by oxidative stress and hypoxia.

The causes of arthrofibrosis after total knee arthroplasty are multifactorial. The exact etiology is unknown, but predisposing risk factors have been identified. These risk factors can be divided into preoperative, perioperative and postoperative. Preoperative flexion is the most important predictive risk factor of postoperative ROM [9]. Other preoperative risk factors include previous knee surgery, age, smoking, severe osteoarthritis of the ipsilateral hip and general pathologies like diabetes, obesity, juvenile rheumatoid arthritis, lung diseases, ankylosing spondylitis and reflex sympathetic dystrophy [10]. Perioperative risk factors include the type of prosthesis, incorrect flexion-extension gap, component malposition, inadequate patella height, overstuffing of the patellofemoral articulation, inadequate tibial or femoral resection, excessive joint line elevation, insufficient posterior condyles and osteophyte resection and errors in soft-tissue balancing. Post-operative risk factors include poor patient motivation, lack of patient compliance with the rehabilitation protocol, infection (*Staphylococcus epidermidis* can cause intense joint effusion and scar tissue production), heterotopic ossification, aggressive anticoagulation therapy and complex regional pain syndrome [11,12,2,13,14].

A post-operative stiff knee should always be considered as infected. Further investigations are necessary to exclude this possibility. Rehabilitation is very important during the first three months after TKA, but its effects decrease rapidly after this time period. As a consequence, manipulation under anesthesia (MUA) is advised starting from four weeks until three months postoperatively. A delay in mobilization until after this period results in less favorable results and an increased risk of fractures [15]. An optimal postoperative pain management can reduce the need for MUA. As fibrous tissue that forms after surgery needs six months to mature, the range of motion at six months post-TKA may represent the maximum flexion one can expect despite further non-operative measures [2,16]. Botulinum toxin injections, use of a custom knee device and peroneal nerve release can improve the range of motion in patients who have various soft-tissue dysfunctions [17]. Arthrolysis (arthroscopic or open) remains controversial in literature. However, good results can be obtained from three until six months postoperatively in the stiff and painless knee that has not improved despite adequate conservative treatment [11]. Following the exclusion of extrinsic sources of knee stiffness, the goal is to identify a specific intrinsic etiology that can be corrected [12]. In the case of well-documented surgical errors, revision surgery is a valid treatment [11]. Studies of revision arthroplasties performed to treat idiopathic arthrofibrosis have shown mixed results [17]. The lack of a previous standard definition for arthrofibrosis after TKA makes it difficult to compare results from different studies. To date, this is the first study to describe the difference in outcome between revision total knee arthroplasty for idiopathic arthrofibrosis using a hinged or a constrained condylar knee device.

2. Materials and methods

2.1. Study protocol

The study was performed using our prospectively collected database, which included the data for all 3278 knees (2896 patients) undergoing primary or revision TKA since 1/1/2000. Informed consent was obtained for all patients. All patients were initially treated with a posterior stabilized implant. ROM was measured using a goniometer as the angle between the axes through the center of the femur and the center of the tibia. The original ROM of the arthrotic knee was not known because of the referral nature of our practice. All patients had undergone a full clinical and radiographic evaluation prior to revision surgery. Standard and full leg standing X-rays were used to determine the coronal and sagittal alignment, a CT scan to determine rotation alignment and a bone scan to identify component loosening. Aspiration, cultures and blood tests (including erythrocyte sedimentation rate and C-reactive protein) were performed when an infection was suspected. Based on these investigations, patients with the defined range of motion caused by underlying mechanical malalignment, component malposition, soft-tissue imbalance or infections were excluded [5]. Forty cases fulfilled the inclusion criteria for idiopathic postoperative primary TKA arthrofibrosis: a flexion contracture >10° or a maximum flexion <80°. Subjects were divided in two groups, those revised using a CCK-type TKA design (CCK group), and those using an RHK-design (RHK group).

2.2. Surgical technique

All TKA revision procedures were performed at one institution by the same surgeon. Combined general and regional anesthesia were performed in all patients. The prior incision was used in all surgeries. A medial parapatellar approach was used for exposure. A thorough synovectomy was performed in all cases with excision of fibrosis. The components were removed using a micro sagittal saw and flexible osteotomes. After preparation of the flexion and extension gaps, the joint line and rotation of the components was restored. The choice of implant depended on the perioperative findings. Collateral ligament disruption, limited remaining bone stock and a severe gap imbalance were indications for the use of a hinged-type prosthetic device. Tranexamic acid was systematically administered in all patients at induction and six hours after surgery (dose 15 mg/kg). Before wound closure, three grams of tranexamic acid was administered in the joint.

2.3. Postoperative management

The rehabilitation program was the same for both groups. Isometric quadriceps tonification exercises were begun on the day of operation. Passive ROM exercises were begun on the 2nd day postoperative day after the removal of the drain, active ROM exercises one day later. During the first week after surgery a continuous passive motion (CPM) machine was used for several hours a day. Full weight bearing ambulation was permitted from the first day. Antibiotics (cefazoline or in case of penicilline allergy clindamycine) were administered during 24 h. All patients received routine prophylaxis against thromboembolism with use of low-molecular-weight heparin for 30 days postoperatively. Pain management was also the same in both groups. Analgesics, non-steroidal anti-inflammatory drugs, oral narcotics and regional blocks were used. Clinical and radiographic evaluations were available preoperatively, at six weeks, three months, six months and yearly after surgery. Knee Society pain and function scores (KS pain and KS function) were obtained preoperatively and at a minimum of two-year follow-up.

2.4. Statistical analysis

We used a parametric test (t-test) to compare the preoperative and two years post-operative extension, flexion, Knee Society pain and function scores. Because the data weren't symmetrically distributed around the mean, a non-parametric test (Wilcoxon Rank sum test) was added. The level for statistical significance was set to 0.05 for all tests.

3. Results

We identified 40 patients meeting the inclusion criteria. Constraint choice depended on the intraoperative stability. Twenty-two patients received a hinged-type prosthetic device: 18 Zimmer RHK (Zimmer, Warsaw, Indiana, USA) and four Stryker RHK (Stryker, Mahwah, New Jersey, USA). The remaining 18 patients received a less constrained condylar type prosthetic device: 17 Legion CCK (Smith & Nephew, Memphis, Tennessee, USA) and one Vanguard CCK (Vanguard, Warsaw, Indiana, USA). The first group consisted of 18 patients (14 females and four males) with a mean age at time of surgery of 57.5 years (range 44 to 70 years) and a mean follow-up of 41.5 months. The second group consisted of 22 patients (10 females and 14 males) with a mean age at time of surgery of 61.4 years (range 46 to 76 years) and a mean follow-up of 35.40 months.

Preoperative data were similar for RHK as CCK-type implants except for knee pain score, which was significantly worse for the RHK group (35.9 vs 44.4, $p = 0.0335$).

	CCK (N = 18)	RHK (N = 22)	P-value
Preop extension deficit	**8.2**	**10.5**	**0.4496**
Preop flexion	**67.2**	**64.1**	**0.5389**
Preop ROM	**59.0**	**53.6**	**0.3635**
Preop KS pain	**44.4**	**35.9**	**0.0335**
Preop KS function	**49.4**	**46.1**	**0.2668**
	CCK (N = 18)	RHK (N = 22)	P-value
Postop extension deficit	**6.2**	**1.9**	**0.0447**
Postop flexion	**81.4**	**99.9**	**0.0005**
Postop ROM	**75.2**	**98.0**	**0.0005**
Postop KS pain	**53.8**	**62.3**	**0.1655**
Postop KS function	**54.2**	**68.9**	**0.0015**
	CCK (N = 18)	RHK (N = 22)	P-value
Decrease extension deficit	**−2.0**	**−8.6**	**0.0083**
Gain flexion	**14.2**	**35.8**	**0.0002**
Gain ROM	**16.2**	**44.4**	**0.0001**
Improvement KS pain	**9.4**	**26.4**	**0.0050**
Improvement KS function	**4.8**	**22.8**	**0.0015**

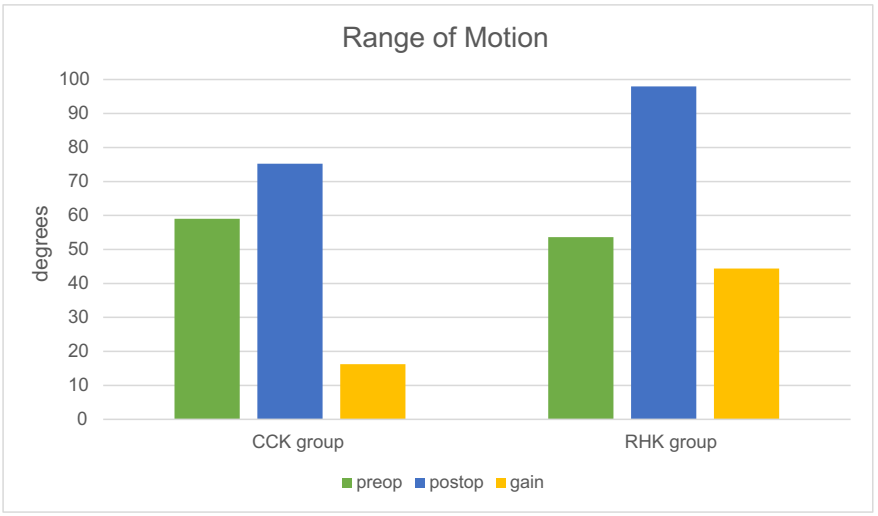

Figure 1. Comparison of the preoperative, postoperative and gain in range of motion in the CCK and RHK group.

The mean postoperative alignment was 0.6° varus in the CCK group and 1.2° valgus in the RHK group. At the final follow-up, the mean extension deficit decreased 2.0° for the CCK group compared to 8.6° for the RHK group. A mean increase of 14.2° of flexion was found for the CCK group compared to a mean increase 35.8° flexion for the RHK group. The mean range of motion increased with 16.2° (from 59.0° to 75.2°) in the CCK group and with 44.4° (from 53.6° to 98.0°) in the RHK group. The condylar constrained cohort showed a mean improvement in KS pain score of 9.4 points compared to 26.4 points in the rotating hinged cohort. The mean KS function score increased 4.8 points in the CKK group compared to 22.8 points in the RHK group.

In the constrained condylar cohort, five patients showed persistent stiffness. Four patients were treated with a MUA, one patient with a postoperative ROM of 35° (15°–50°) was revised using a RHK design. This specific patient showed a postoperative ROM of 95° (0–95°), a KS pain score of 74 points and a KS function score of 70 points at 18 months follow-up. In the rotating hinged cohort, no persistent stiffness was found. No infection was diagnosed in any of the patients. No radiographic abnormalities following revision surgery were observed (Figures 1–3).

4. Discussion

Arthrofibrosis after total knee arthroplasty is an invalidating complication as a minimum of 90° of ROM in the knee is required for activities in daily living. Preoperative flexion is the most important predictive factor of postoperative ROM [9]. In this study, only patients with idiopathic arthrofibrosis were included. The previous lack of a standard definition for arthrofibrosis after TKA makes it difficult to compare results from different studies [5].

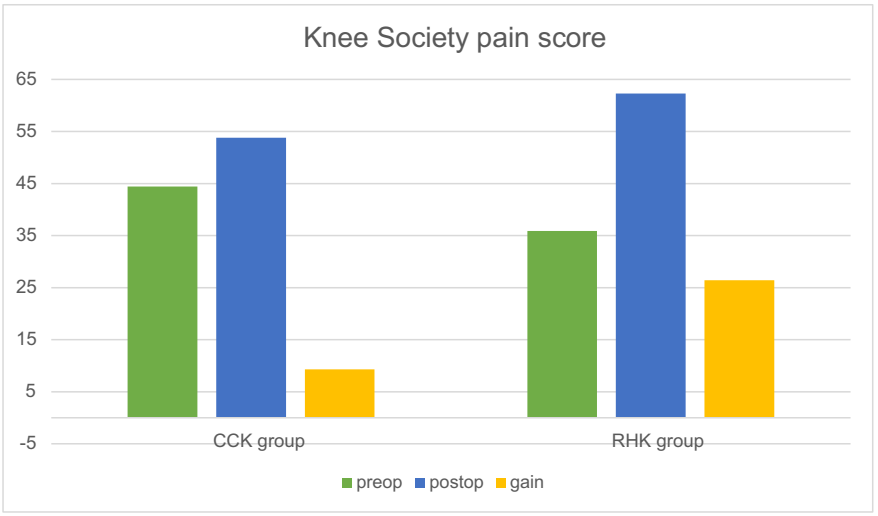

Figure 2. Comparison of the preoperative, postoperative and gain in Knee Society pain score in the CCK and RHK group.

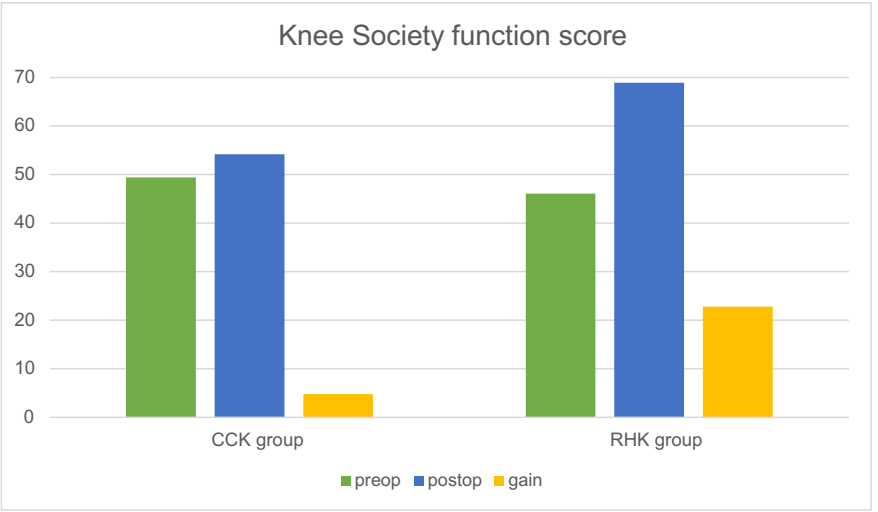

Figure 3. Comparison of the preoperative, postoperative and gain in Knee Society function score in the CCK and RHK group.

Christensen et al. showed in a study with 11 patients an improved range of motion of 43.5° after revision TKA. Knee Society pain and functional scores improved with a mean 39.6 and 53.7 points respectively. Stiffness was defined as a total range of active-assisted knee motion <70°. Exclusion criteria were infection and reflex sympathetic dystrophy. In six patients, a standard posterior stabilized condylar prosthesis was applied whereas in the remaining five, a CCK-type knee design with a longer central post was used. Three patients required MUA and one required revision surgery because of femoral component loosening [4].

Kim et al. performed revision surgery in 56 stiff knees (flexion contracture of ≥15° and/or <75° of flexion) after exclusion of revisions because of infection. The mean flexion contracture decreased from 11.3° to 3.2°, the mean flexion improved from 65.8° to 85.4°, and the mean arc of motion improved from 54.6° to 82.2°. The mean Knee Society pain and function scores improved from 15 to 47 points and from 39 to 87 points respectively. In 14% of the knees a CCK-type condylar knee device was used, while in the other 86% a less constrained type was applied [3].

In a study by Haidukewych et al., 16 stiff total knee arthroplasties with well-fixed and correctly aligned components were revised using a posterior stabilized condylar prosthesis. The arc of motion increased 33° (from 40° preoperatively to 73° postoperatively) while the Knee Society pain and function scores improved: from a mean of 37 to a mean of 13 respectively [18].

Moya-Angeler et al. showed a mean improvement of range of motion of 20° in 42 stiff knees revised with constrained condylar knee devices. Exclusion criteria were a previous infection or treatment with isolated polyethylene exchange. Mean Knee Society pain and function scores improved by 28.1 and 21.4 points respectively [19].

Donaldson et al. performed revision surgery in 48 cases (flexion contracture of ≥15° or flexion of <70°) after exclusion on grounds of infection and aseptic loosening. Based on the intra-operative stability, 50% of the patients received a legacy constrained condylar knee (LCCK) insert. The remaining 50% received a legacy posterior stabilized (LPS) insert. There was no difference in outcome between these two groups. Thorough evaluation showed only six cases with idiopathic arthrofibrosis. The mean improvement in ROM was 45.0° and the mean overall WOMAC scores improved from 58.3 to 36.9 [20].

Our less favorable results concerning the CCK type revisions compared to other studies can be explained by the fact that our population was already filtered for underlying mechanical malalignment, component malposition and soft-tissue imbalance.

A weakness of this study is the retrospective design. The choice of treatment depended on the perioperative findings like collateral ligament insufficiency and remaining bone stock. Another weakness is the fact that the preoperative ROM, the mean time interval from the index TKA to revision, and diagnosis for the primary total knee arthroplasty were not known due to the referral nature of our practice. Despite the relative small number of patients, statistically significant results were obtained concerning ROM, KS pain and KS function score. A third limitation of this study is the use of 4 different implants. However, 35 of the 40 patients were achieved were treated with only two different implants.

5. Conclusion

Our data show that revision arthroplasty of the idiopathic stiff knee using a rotating hinged device can provide excellent results compared with the traditional CCK-type revision implants. Based on these results, we recommend the use of a rotating hinged device for revision arthroplasty in the selected cases. The reason could be that RHK designs allow for much more aggressive capsuloligament debridement and therefore more adequate fibrosis removal, while securing optimal implant stability, tibiofemoral rotational freedom, and flexion-extension space stability. To date, this is the first study to describe the difference in outcome between revision total knee arthroplasty for idiopathic arthrofibrosis using a hinged or a constrained condylar knee device.

Conflict of interest

The authors declare that they have no conflict of interest.

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