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***Hinged knee prostheses: to be used with due consideration, but indispensable  
in complex situations.***

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Hinged prostheses, rotating or fixed, were the first total knee replacements (TKR), introduced in the 1970s. “Hinge” here refers to the type of tibiofemoral fixation, with a fixed axis in knee flexion-extension. Initially used in all indications, they were abandoned in simple primary TKR due to high rates of mechanical complications and infection [1,2].

They soon became reserved to rare primary indications in complex ligament instability or severe deformity. However, they remained widely used in tumor resection around the knee, leading to technical innovations such as modularity to deal with resection of varying size [3]. The development of revision surgery as TKR became more widespread involved cases with large metaphyseal defects, requiring constrained hinged prostheses to complete metaphyseal reconstruction [4,5]. Revision surgery for infection has the same reconstruction requirements in fragile bone and is another indication. The last, and most recent, indication concerns knee fracture and periprosthetic fracture in geriatric traumatology.

These indications were reviewed in the 2017 symposium organized by the French Society of Orthopedic Surgery and Traumatology (SoFCOT), which reported underestimation of the use of hinged prostheses and the appearance on the market of a wide variety of types, poorly assessed because of heterogeneity in series. Hinged prostheses account for 2-3% of TKRs.

## **1. Biomechanics and developments**

The first hinged prostheses were unidirectional, allowing only flexion-extension, and led to early loosening and mechanical complications by femorotibial hinge wear due to excessive local stress [6]. Introducing rotation reduced local stress and provided more nearly natural knee kinematics. Hinges with 1 degree of freedom (flexion-extension) remain indicated in some cases of neurologic deficit such as polio sequelae and post-tumoral surgery, but more than 90% of hinged prostheses are rotating, with 2 degrees of freedom.

Rotating hinges have also progressed: the hinge can be blocked (anti-dislocation system) or sliding in the femorotibial junction, with, however, risk of femorotibial dislocation.

A hinged prosthesis may be the essential part of the joint or the articular part of a segmental reconstruction or total femoral prosthesis [7].

This variety calls for caution in reading the literature: to collect enough cases for a given type of prosthesis, studies may combine several etiologies, making any conclusion difficult to draw, as when septic and aseptic cases are collated together in revision surgery [8]. Prostheses used in complex cases need to be assessed more selectively.

## **2. Hinged prostheses in tumoral reconstruction**

Initially, hinged prostheses were seen as a palliative solution. With the introduction of neo-adjuvant chemotherapy, custom-made reconstruction prostheses came to be developed. The introduction of modular designs and rotation were two major advances in hinged prostheses, accompanying modern multidisciplinary management in specialist centers.

This highly structured management applies to a surgery where prognosis is poor and complications are frequent, due no longer to the type of prosthesis but to local conditions [9]. Infection is the most feared complication [10,11]. Extensor system reconstruction with local flap coverage, such as medial gastrocnemius flap, has improved prognosis, conserving extensor system function in tibial metaphysis reconstruction [10].

Modular prostheses are now the rule, and junction rings with a coating to promote bone fixation represent a further improvement [12]. Such medical and surgical progress now makes cure a feasible objective, whence the need to conserve function. However, tibial locations are still the most problematic, due to the high rate of mechanical complications,

although improvements in surgical technique have considerably reduced the risk of amputation [13].

### **3. Hinged prostheses in prosthesis revision**

In revision surgery, hinged TKR prostheses are associated with impaired autonomy and function but with less pain. Eight out of 10 survive at 5 years, although revision surgery is rare for complications such as pain and stiffness, unlike for mechanical complications, infection or fracture, biasing survival estimation [3,6].

### **4. The particular case of traumatology**

Complex fractures around the knee are particularly difficult to treat, especially in elderly osteoporotic patients [14]. Hinged TKR is an option in complex fracture, but there are few series reported. One multicenter series of 48 knees at 5 years' follow-up found acceptable functional results, but with a 40% rate of complications and 33% of revision surgery [14]. Infection in particular is implicated in 50% of revision surgeries. Hinged TKR is a validated option in knee fracture on native bone (distal femur or proximal tibia) and periprosthetic knee fracture in over-75 year-olds [15,16], although the high complications rate and non-negligible mortality call for caution [16]. Even without complications, autonomy is impaired, although knee function is fairly well conserved. Hinged prostheses are a possible resort, but internal fixation is to be preferred if bone quality permits.

### **5. Infection on hinged prosthesis**

Infection is the most frequent cause of failure, in more than 30% of cases, whether tumoral or not [9,11,12]. Identifying at-risk patients is contributive [17]. Particular precautions can

then be taken: an article on local vancomycin application reported reduced risk of infection in such indications [18].

## **6. Specific complications in hinged resection prostheses**

Severe bone defect requires a megaprosthesis, for which few results have been reported. In a series of 57 reconstruction prostheses, 26 of which for the tibia, the complications rate was 45%, with some mechanical failures requiring altering the prosthesis [13]. This was confirmed in the very large SoFCOT multicenter series of tumor resection in 161 knees at 9 years' follow-up [12]. There was a high risk of complications (loosening and infection) and a higher failure rate in proximal tibial reconstruction. Distal femoral resection and reconstruction by hinged prosthesis is difficult, with complications and failures. The patient needs to be informed of this, and multidisciplinary discussion should precede any such surgery [12,13].

## **7. Conclusion**

Hinged TKRs are a family of palliative knee prostheses used in case of ligament incompetence and/or severe bone defect when a less constrained prosthesis would fail to ensure stability. They are often criticized and rarely analyzed. The variety of models makes them the salvage solution for the knee, and sometimes the salvation of the patient (in tumoral surgery). They need to be part of the therapeutic armamentarium, and are technically more demanding than with the usual type of TKR. The limitations of each model need to be understood, to avoid implanting an unsuitable prosthesis and incurring mechanical complications.

Each case should be analyzed taking account of the environment: primary hinged TKR incurs a higher risk of general complications than in revision, where on the other hand local complications are more frequent. Periprosthetic fracture is likewise a surgical challenge, requiring solid and functional reconstruction in an unfavorable environment, notably to respect limb length and extensor system tension.

Better knowledge of biomechanics and understanding of indications have improved the image of this kind of prosthesis. The SoFCOT took an interest in the subject, with a dedicated symposium highlighting current results, two articles from which are to be found in the present issue of OTSR.

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