



# The role of rotating hinge implants in revision total knee arthroplasty

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- Hinged implants are the most constrained knee replacement prostheses. They are very useful in complex cases of total knee arthroplasty (TKA) revision.
- Hinged implants have evolved with rotating bearings and modularity that allows local joint reconstruction or segmental bone replacement.
- They are required when significant instability persists in cases with inadequate collateral ligaments and significant flexion laxity.
- They are now used when a large bone defect is reconstructed, or when bone fixation of the implant is questionable especially in the metaphyseal zone.
- The use of hinged implants in TKA revision is associated with high complication rates. Published outcomes differ based on the patients' aetiology.
- The outcomes of rotating-hinged implants used in septic revisions or salvage situations are poorer than other types of revision and have a higher complication rate.
- The poor general health of these patients is often a limitation.
- Despite these relatively poor results, hinged implants continue to have a place in revision surgery to solve major instability or to obtain stable bone fixation of an implant when the metaphysis is filled with bone grafts or porous devices.

**Keywords:** complications; hinge-rotation TKA; indications; knee arthroplasty; TKA revision

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## Introduction

The number of surgical revisions of total knee arthroplasty (TKA) is increasing<sup>1</sup> due to the steady increase in the number of TKA procedures.<sup>2,3</sup> The principal reasons for TKA

revision are aseptic loosening, infection, stiffness and extensor mechanism complications.<sup>4</sup> TKA revision often requires the use of more constrained implants. In the literature, hinged implants characterize the tibiofemoral junction. They are the most constrained types of implants. They are used when the capsule and ligament constraints have failed completely<sup>5</sup> or when massive bone defects are present.<sup>6</sup> It is uncertain whether the evolution in bone loss reconstruction<sup>7,8</sup> and bone fixation methods, or the introduction of rotation and high modularity have improved the outcomes for hinged knee implants.<sup>9</sup> While there is abundant literature on the outcomes of TKA revision, only a few reports focus on the benefits of hinged implants in revision surgery, and even fewer focus on their indications. Should hinged implants be used only for lower-limb salvage surgery or should they be a regular choice for TKA revision surgery? Are their outcomes improving, or do they remain unsatisfactory?

## Implant constraints and the levels of constraint

### Constraints

A constrained implant is necessary when the soft tissues fail (ligaments, capsular elements and muscles) or when the bone structure is insufficient to support the load or ligament tension. A constrained prosthesis is defined as having a limitation of the range of motion of the implant due to the design of the components or the use of mechanical tricks.

Different factors determine knee motion: flexion–extension, mediolateral laxity, axial rotation and roll-back of the femur on the tibia are the main factors involved in this phenomenon. The persistence of a single movement such as flexion–extension defines one degree of freedom. Adding axial rotation defines a second degree of freedom.

### Constrained implants

Constraint implies a restriction of rotation or translational movement. This can be achieved with linked and non-linked



**Fig. 1** Hinged mechanism of a knee implant.

implants. Non-linked implants provide a close fit between the elevated tibial spine and the intercondylar box on the femur, restricting varus/valgus and rotational movements. These types of implants are posterior stabilized. They provide minimal constraint through a congruent tibiofemoral articular surface and an elevated cam mechanism. Conforming articular surfaces minimize the contact stress by maximizing surface area. Any peripheral ligament deficiency must be countered by repairing the damaged ligament or by using a supporting system such as the varus/valgus constrained implant. Deficiency of several ligaments (mediolateral and anteroposterior for example) or significant tibiofemoral instability requires full guiding of the tibiofemoral motion by a linked implant<sup>5</sup> which is achieved with a hinged implant rather than a constrained condylar implant.

### Different types of hinged implants

The mechanical tibiofemoral junction with an axis which guides the flexion–extension motion characterizes the link of a hinged implant (Fig. 1).

#### *First-generation hinged implants*

A single-hinge implant, which has only flexion–extension motion or one degree of freedom, can do without the capsule and the ligaments for these movements. Its hinge stops knee extension before the appearance of genu recurvatum. This type of strong constraint can be required after a tumour-related metaphyseal resection in which the peripheral ligament insertions are also resected. Because this type of implant has to support the body weight as well as the weight of the lower limb and is subjected to



**Fig. 2** Rotatory hinge prostheses with a femoral hinge and a rotatory tibial system.

multidirectional stresses, they often have complications: wear of the bearings, loosening or patellar complications.<sup>10</sup> Their worse outcomes compared to unconstrained implants, as well as higher infection rates, have reduced their use in some neurological situations or tumoral reconstructions.

#### *Second-generation hinged implants*

The second generation of hinged implants added axial rotation to the existing flexion–extension motion. Thus they have two degrees of freedom (Fig. 2). They were introduced during the 1990s and used in salvage revision TKA.<sup>11</sup> Their mobile bearings are less constrained, and the use of a polyethylene insert decreases local wear. The rotation decreases the risk of patellar instability. They maintain control over genu recurvatum (in cases where the posterior capsular elements fail). Despite this, rotating-hinged implants are subjected to higher pressures than unconstrained gliding implants.

Current hinged implants are rotating and have two degrees of freedom. Numerous models are available: implants with long and tibial rotating tibiofemoral axes (Fig. 3), or short and intraarticular ones (Fig. 2), or sometimes with a fixed longitudinal axis. The mobile part that allows rotation can have different shapes and lengths (Fig. 4). This may explain why the reported outcomes vary and the possibility of tibiofemoral dislocation exists.<sup>12,13</sup> These different combinations explain the wide range of implants offered by orthopaedic device manufacturers.

#### *Indications for hinged knee implants*

Implants with specific tibiofemoral junctions are used in cases with non-repairable ligament weakness or in cases with poor bone quality which does not allow for normal knee function.<sup>14</sup> The principal indication for hinged knee



**Fig. 3** Hinged prostheses with, on the left, rotatory tibiofemoral system and, on the right, non-rotatory hinged tibial prosthesis.

implants remains in oncology,<sup>15</sup> which requires regional reconstruction after tumour resection. The hinge mechanism associated with the modular characteristics of the reconstruction implant helps to preserve proper flexion–extension motion and walking.<sup>16,17</sup>

In primary surgery,<sup>18</sup> this type of implant is not suitable for the standard knee osteoarthritis patient. Its place is in managing large deformities which require significant ligament release, notably in cases of large valgus deformities (rheumatoid arthritis, neurological diseases), as well as in obese patients with significant laxity<sup>19</sup> or in some complex primary post-traumatic cases. These patients are challenging to treat due to their more fragile general condition. Good functional outcomes have been obtained but they are still inferior to those of gliding implants and have a higher revision rate.

### Outcomes of hinged implants in TKA revision (Table 1)

This type of implant is indicated in cases with significant instability, or large bone defects which can compromise the bone fixation of the implant. The hinged implant can be combined with metaphyseal reconstruction and variable diaphyseal fixation depending on the type of pathology and its extent. A similar surgical indication is the treatment of periprosthetic fractures in older patients.

There is a renewal of interest in this type of implant in TKA revision surgery because of the increasing number of TKA procedures and subsequent revisions. Recent published studies on rotating-hinged implants and their outcomes are difficult to analyse because of their heterogeneity. To establish a case series of sufficient size or a follow-up of more than two years, the authors frequently analyse a single type of hinged implant by combining the



**Fig. 4** Salvage rotatory revision hinged prostheses with modular stems.

indications that led to its use. For this review, we differentiated between studies of TKA revisions with hinged implants due to aseptic loosening, studies of TKA revisions combining septic with aseptic cases, studies of hinged implants used in complex primary cases or revisions, and studies of hinged implants in salvage situations.

#### *TKA revision for aseptic loosening*

A few studies report results of TKA revision for aseptic causes.<sup>20–23</sup> They have followed Barrack et al's study<sup>9</sup> which showed good functional outcomes and radiographic results after the use of a modular rotating-hinged implant in revision surgery. The outcomes of 16 knees used in salvage situations were compared with simpler cases of TKA revision carried out with less constrained implants. They found good clinical and radiographic outcomes in the short term with a notable improvement in functional scores.

Joshi and Navarro-Quilis<sup>20</sup> in their study of 78 cases analysed the outcomes of the Endo-Model® hinged



**Table 1.** Summary of published studies on the use of rotating-hinge knee implants for total knee arthroplasty revision

Type of study	Authors	No. of patients	Follow-up (years)	Mean age	Aseptic loosening	Implant revision	KSS Total (/200) (PreOp/Final)	KSS Knee (/100) (PreOp/Final)	KSS Function (/100) (PreOp/Final)	HSS (/100) (PreOp/Final)	Flexion (°) (PreOp/Final)	Complications (%)
Aseptic revision	Barrack et al (2000) <sup>9</sup>	16	4.3	69			41 / 131				78°/93°	20%
	Joshi and Navarro-Quilis (2008) <sup>20</sup>	78	5.0	72				38/86	33/61		103°/97°	27%
	Gudnason et al (2011) <sup>23</sup>	42	8.8	72	89.2% (10 y)	65.1% (10 y)		/85	29/67			10%
	Neumann et al (2012) <sup>21</sup>	24	4.6	67				25/91	35/85		72°/116°	10%
	Rodríguez-Merchán et al (2015) <sup>22</sup>	96	7.3	79				37/79	34/53		80°/120°	
Aseptic and septic revisions	Pour et al (2007) <sup>18</sup>	44	4.2	72		68.2% (5 y)		29/76	40/43			
	Bistolfi et al (2013) <sup>19</sup>	53	12.9	60	80.0% (12.5 y)			/85	/29	58/85	81°/103°	32%
Complex primary and revisions	Cottino et al (2017) <sup>26</sup>	408	4.0	69	4.5% (CI)	10.5% (CI)		51/81	26/36			12%
	Westrich et al (2000) <sup>24</sup>	24	2.8	63				44/83	10/45			12%
	Dehan et al (2008) <sup>25</sup>	72	10.0	69	90.0% (10 y)							36%
	Ghenoun et al (2009) <sup>12</sup>	85	3.0	72								28%
	Smith et al (2013) <sup>27</sup>	111	6.9	68	52.0% (5 y)							45%
Salvage revisions	Sanguineti et al (2014) <sup>28</sup>	45	3.5	74		95.0% (5 y)		/92	/78		/102°	
	Kearns et al (2018) <sup>29</sup>	79	4.5	67		70.7% (5 y)		36/67				38%
	Pradhan et al (2004) <sup>30</sup>	51	4.0	70						36/72	/90°	
	Berend and Lombardi (2009) <sup>31</sup>	39	3.8	76	87.0% (3.8 y)			39/87	13/35		/106°	

Note. Aseptic loosening, survivorship free of revision for aseptic loosening (follow-up), (CI) for cumulative incidence at follow-up; implant revision, survivorship free of implant revision for any reason (follow-up), (CI) for cumulative incidence at follow-up.

rotational knee prosthesis (Link®) at a mean of five years' follow-up (FU). They found a significant improvement in the functional outcomes. The Knee Society Score (KSS) went from 38 to 86/100, while the KSS function increased from 33 to 61. At the final follow-up, 57 patients (73%) had no problems. Complications requiring revision were four instabilities, three dislocations, one rupture of the extensor mechanism and two infections that required an arthrodesis.

Neuman et al<sup>21</sup> reported on 24 cases of rotating-hinge knee implants (Zimmer Biomet®) with a large total distraction distance to decrease the risk of dislocation seen with the Endo-Model® in cases with soft tissue loosening. They reported similar significant clinical improvements with a mean 4.5 years' FU. The patients had better motion in flexion, while on X-rays, they had some progressive radiolucent lines without loosening. One required a surgical procedure because of patellar instability.

Rodríguez-Merchán et al,<sup>22</sup> in their study of 96 cases with a mean follow-up of 7.3 years, also noted this significant clinical improvement even though their patients were older: the KSS knee improved from 37 to 79, and the KSS function from 34 to 53.

Gudnason et al<sup>23</sup> in their study of 42 patients at 8.8 years of mean FU, used the Endo-Model® hinged rotational

knee prosthesis. They reported high early mortality (42% of patients). At the last FU, the remaining patients were greatly improved with an HSS score of 67/100, a KSS knee of 85 and a KSS function of 29. They carried out nine revisions: four for aseptic loosening and five for other causes. At 10 years' FU, implant survival was 89.2% and no surgical revision was required in 65.1%.

These studies confirm the good functional outcomes with this type of implant with a high survival rate in aseptic loosening revision cases associated with instability. These studies had the lowest rate of complications.

*Combination of septic and aseptic revisions*

In studies that combined aseptic and septic cases, the septic cases were the second stage of a two-stage procedure after an undefined period of time with a spacer.

Pour et al,<sup>18</sup> in their cohort of 44 patients with 13 septic cases and a mean FU of four years, noted a non-revision rate of 68.2% at five years with a smaller improvement in the KSS function (from 40 to 43). They reported 15 surgical revisions for complications or mechanical failures including three fractures related to infected implants, four cases of aseptic loosening, and one periprosthetic fracture. These complications occurred during the first two years post operatively. The authors recommended only

using this type of implant for salvage cases in older or sedentary patients.

Bistolfi et al<sup>19</sup> reported their results of 53 Endo-Model® knees with a mean FU of 13 years. The implant survival rate was 80% at 12.5 years' FU. They noticed a progression in the periprosthetic radiolucent lines in eight knees. They also noted aseptic loosening in 11 knees. Filling of large bone defects (most cases were Anderson Orthopedics Research Institute (AORI) 2B or 3) was carried out using cement. Revision surgery was needed again in 11 cases: two amputations, two arthrodesis, three periprosthetic infections, two dislocations with mechanical failure of the hinge, one periprosthetic fracture and one case of extensor mechanism rupture. The authors placed emphasis on the risk of early complications with surgical revision (eight knees) or late complications. The occurrence of an infection negatively affected the outcome. For these authors, this salvage prosthesis was an alternative to knee arthrodesis despite a significant local and general risk of complications (36%), particularly a high septic risk (7%).

Cottino et al<sup>26</sup> reported the outcomes of 408 consecutive cases of various rotating-hinged implants used for aseptic failure in 65% of cases (264 knees) and for septic failure in 35% of cases (144 knees). A hinged implant was used in 18% of primary complex knees (74 knees) and in 82% of revision cases (334 knees). The mean FU was four years. They reported a significant improvement in the function of the knee and a low revision rate in these difficult cases: 3.7% for aseptic loosening (13 knees) at four years' FU. At the last FU, there were 59 surgical revisions for all causes and 15 cases of implant revision. The cumulative incidence for aseptic loosening was 1.7% at two years and 4.5% at 10 years. The cumulative incidence for any surgical revision was 9.7% at two years and 22% at 10 years. The use of metaphyseal porous cones was associated with a lower risk of re-operation.

The infected revision cases (35%) consisted of the second-stage re-implantation after the initial excision and spacer stage. In the aseptic revision cases, the more frequent causes were prosthetic instability in 15% (62 knees), aseptic loosening in 13% (55 knees) and periprosthetic fractures in 13% (55 knees). The other causes varied: non-union of periprosthetic fracture in 5% (19 knees), mechanical failure in 4% (16 knees), stiffness in 4% (15 knees) and malrotation in 3% (14 knees).

Bone defects were filled with bone allografts in 13.5% (56 knees) and cones in 28% (114 knees). Revisions were required in 21 cases for infection, 11 for periprosthetic fracture, 10 for aseptic loosening, 10 for mechanical failure, and four for rupture of the extensor mechanism. Revisions occurred more often during the first two postoperative years. In some cases, re-operation was required without removal of the implant components: 24 surgical debridements due to infected TKA, one reduction of a dislocated

implant, 22 intraoperative problems with 18 perioperative fractures, two patellar fractures and one patellar tendon rupture. The authors reported an 11% complication rate.

#### *Complex primary or revision cases*

Westrich et al,<sup>24</sup> in a cohort of 24 consecutive knees, reported good functional outcomes at three years' FU with a rotating-hinged implant despite a high rate of complications (12.5%). This study, carried out on complex cases, showed the possibility of immediate weight-bearing with a decreased level of pain and no major problems: the main complications were two periprosthetic fractures.

Deehan et al<sup>25</sup> noted the same improvement in patient function after a rotating-hinged implant which was used in salvage conditions; the best cases had an implant survival of 90% at 10 years' FU. They reported that 10 of 72 patients died of causes unrelated to their knee pathology. They emphasized the poor health of these patients with numerous co-morbidities. Their series included 15 primary cases and 57 revision cases. In half of the cases, bone defects were AORI 2 or 3. They had eight infections and three periprosthetic fractures which required surgical revision. The occurrence of an infection negatively affected the outcome. For these authors, this salvage prosthesis was an alternative to knee arthrodesis despite significant local and general risks (36%), particularly a high septic risk (7%).

Ghenoun et al,<sup>12</sup> in their series of 85 Endo-Model® implants, reported a large number of complications (28%) led by nine infections, four patellar failures and three aseptic loosening cases without differences between primary and revision cases. They reported that having several co-morbidities such as obesity, heart disease and diabetes increased the risk of complications.

Smith et al<sup>27</sup> compared rotating-hinged implants ( $n = 111$  patients) to distal femoral replacement pure-hinged implants used in non-cancer situations ( $n = 174$  patients). A failure occurred in 51/111 rotating-hinged cases (46%) that required re-operation, with more than half of these cases (29/51) having a non-mechanical cause of failure. Infection was the major cause (27/51, 24% of patients). Twenty-one patients had multiple complications. The median Kaplan–Meier survival for the rotating-hinge TKA group was 6.9 years and exceeded the median Kaplan–Meier survival for distal femoral replacement (4.1 years). In the two groups, undergoing a hinged TKA replacement secondary to trauma was associated with a higher risk of failure.

Sanguineti et al<sup>28</sup> compared the clinical outcomes of 45 rotating-hinge Endo-Model® implants used in complex primary ( $n = 25$ ) and revision cases ( $n = 20$ ). They reported a mean survival of 93% at five years with significant improvement in the outcomes (Table 1). They reported

three failures: one mechanical dislocation and two cases of infection requiring re-operation.

Kearns et al,<sup>29</sup> in their study of 79 knees (14 primary and 65 revision cases), found a high mortality and complication rate (38.7%). At five years, the probability of not undergoing re-operation was 70%. They reported various causes of failure: six periprosthetic fractures, five extensor mechanism ruptures, four infections, three mechanical failures, one peroneal nerve palsy. They were surprised by the frequency of extensor mechanism complications and the fracture rate. They noted a high rate of early complications with 13 deceased patients and eight revised failures during the first two years of FU.

These studies highlight the impact of the poor health conditions of these patients with local bone fragility, which contributed to complications such as infection. In these complex primary or revision cases, TKA with a rotating-hinge implant was an alternative to arthrodesis. Several studies emphasized the risk of early complications in fragile patients.

#### *Salvage situations*

Pradhan et al<sup>30</sup> reported 51 cases of salvage revision by rotating hinge Endo-Model® prosthesis at four years' FU. They had to deal with two major complications: infection in 23 cases and aseptic loosening in 23 cases. The outcomes were poor and another revision surgery in infected cases led to better outcomes.

Berend and Lombardi<sup>31</sup> reviewed 39 cases of rotating-hinge distal femoral replacement devices used for 11 revision TKA, 13 periprosthetic fractures, 11 re-implantations of infected TKA, two complex primary TKA and two traumatic cases. These salvage cases represented 0.7% of their total cohort. They carried out five re-operations: two re-infections, one acute infection, one periprosthetic fracture and one bearing exchange due to hyperextension. Implant survivorship free of any re-operation was 87% at four years. Kaplan–Meier survival was estimated at 83% at four years' FU.

These studies of salvage cases carried out as repeat revisions, often in the context of infection, reported good outcomes when the surgery had no infection-related complications and when the patients had good preoperative local conditions. In salvage cases, hinged implants are an alternative to arthrodesis or amputation. However, the modularity of these systems was not sufficient to prevent local complications such as infection, periprosthetic fracture or extensor rupture.<sup>32</sup>

### **Are hinged implants still an attractive option in TKA revision?**

The majority of patients who undergo TKA revision will not receive a hinged implant but rather a gliding implant

that may be partially constrained. TKA revision that requires the use of hinged implants remains the most complex situation with a persistent instability or major isolated instability, or combined with a large bone defect, or repeated revision of a constrained implant, or in older patients with bone fragility.

#### *Management of instability*

Flexion instability or 'gap mismatch', which results from poor ligament balancing, rarely requires the use of hinged implants, except if it results in major instability.<sup>33</sup> Isolated instability in varus/valgus knees due to inefficiency of a collateral ligament is generally resolved with a posterior-stabilized implant with condylar constraint. Some cases of valgus laxity with medial collateral ligament distention and some cases of post-traumatic laxity will require the use of hinged implants. Likewise, frontal instability associated with an AORI 2 or 3 metaphyseal bone defect will require a hinged implant.<sup>34,35</sup> Flexion instability when the posterior capsule is distended could require a hinged implant. A large imbalance of extension and flexion gaps with a bigger gap in flexion or a very thick polyethylene tibial component (>15 mm) will favour this choice.

A hinged implant is required when all the ligament-related solutions or when ligament balancing are not possible after the technical problems are corrected, with persistence of flexion or extension instability.<sup>36</sup> In practice, after an excessive distal femoral re-cut or during an insufficient distal reconstruction, a common mistake is to increase the thickness of the polyethylene insert, which will shift the joint line upward and put the patella in a low position. The same mistake can be made in flexion when the posterior condyles are not reconstructed, and the posterior offset is not restored.<sup>24</sup>

Sagittal instability can require revision for major contracture – arthrolysis accompanied by extensive release of the collateral ligaments will be supported by a hinged implant. Dislocation, which represents its most dramatic form and often occurs in obese patients, can be resolved when excessive posterior femoral resection has occurred.<sup>33,35</sup>

#### *Reconstruction of bone defects*

The size of bone defects during TKA revision influences the amount of constraint required. Large defects or breaking of cortical walls require local reconstruction to restore bone integrity, facilitate the implant's bone fixation and restore the position of the joint line. A solid construct is essential to allow early rehabilitation and improve the longevity of the implant.<sup>37</sup>

The most used classification to characterize the size of bone defects and their reconstruction options is the AORI classification:<sup>38</sup> type I is intact metaphyseal bone, type II(a) is metaphyseal damage of one condyle and

type II(b) of the two condyles, type III means the majority of one condyle or the tibial plateau are damaged with possible damage at the bony insertion of the patellar tendon or collateral ligament. This classification is useful after removal of the existing implants. The presence of bone defects including ligament insertions, cortical zones or osteoporotic bone must lead to a hinge implant being chosen, as it will act as a substitute for the inefficient peripheral ligaments and reinforce the fragile bone.

The anatomical fixation zone of the revision implant described by Morgan-Jones et al<sup>39</sup> allows us to predict the modular assembly of the revision components according to the degree of bone damage in the epiphysis, metaphysis, and diaphysis.

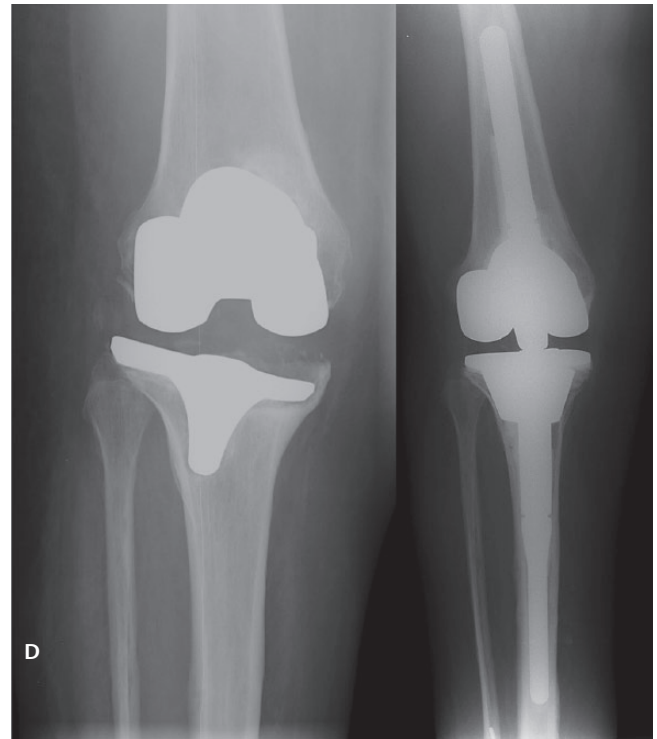
Isolated damage in the epiphysis does not require a constrained implant. Small defects filled with cement, bone graft or wedges<sup>40</sup> do not need a constrained implant except if they are associated with ligament insufficiency or joint instability.

Damage to the metaphysis, which is the fixation zone for most revision implant systems, guides the choice of the constraint. If the fixation in this zone is solid, a non-constrained or a partially constrained implant can be used. If reconstruction in the metaphyseal zone is necessary, the level of constraint depends of the type of reconstruction used. When the reconstruction uses metaphyseal sleeves or porous cones,<sup>41,42</sup> which provide direct stability to the construct, a short intramedullary stem can be associated with a partial constraint if the ligaments are in good condition (Fig. 5). On the other hand, a large bone defect reconstructed using an allograft, which requires integration time, needs a constrained implant such as a constrained condylar knee (CCK) or a hinged implant depending on the size of the bone defect and the condition of the ligaments.<sup>43</sup>

A moderate metaphyseal fixation will require fixation in the diaphyseal zone using an intramedullary stem, associated with a hinged implant. In salvage situations, the hinge mechanism will be mounted on a reconstruction segmental prosthesis.

Defect filling and bone reinforcement by sleeves and porous metal cones ensure immediate solidity of the metaphyseal zone, limiting the use of hinged implants following graft filling. Their strength allows immediate weight-bearing and walking and they can be combined with a short construct in cases with good metaphyseal fixation.<sup>44,45</sup> Their preoperative availability is good<sup>46</sup> and they can be used in combination with grafts.<sup>47</sup>

Fixation in the diaphyseal zone to unload the metaphyseal zone and protect the bone-implant interphase is carried out using intramedullary stems.<sup>48</sup> Cemented stems are used in case of local osteoporosis or incompatible geometry for stable cementless fixation. The filling they



**Fig. 5** Aseptic loosening with tibial an important bone defect, tibial reconstruction with tibial augment and hinged knee prosthesis.

provide allows the construct to be shortened. Cementless stems are preferred in the revision of periprosthetic fractures.<sup>49</sup> Intramedullary stems are used systematically with a hinged implant in a revision TKA.

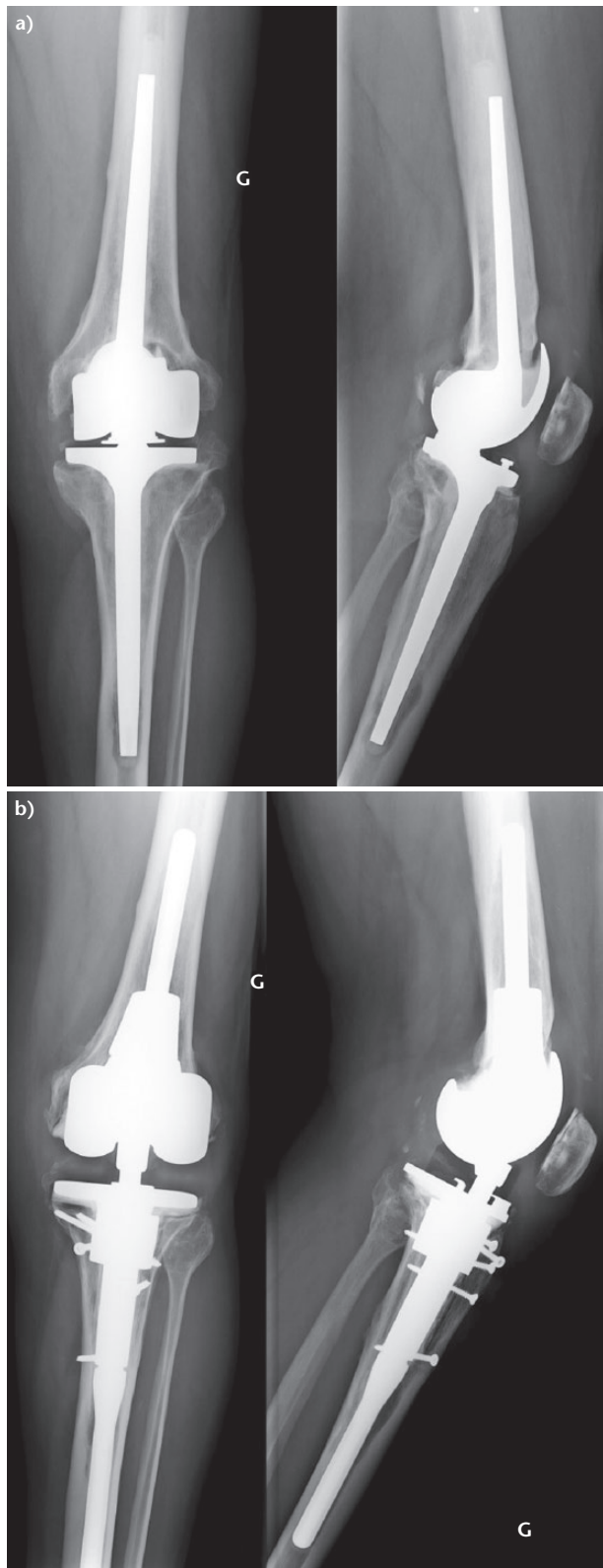
In summary, mediocre epiphyseal bone fixation encourages the use of a partially constrained implant such as the CCK. Moderate metaphyseal fixation encourages the use of a hinged implant. In the absence of metaphyseal fixation, the logical choice being a segmental reconstruction hinged implant.

#### *When should a hinged implant be used?*

While the number of TKA revisions will continue to increase,<sup>50</sup> the majority of cases can still be treated with unconstrained implants or condylar constrained implants.<sup>51</sup> However, hinged implants are an attractive option for cases where gliding implants and condylar constrained implants are not suitable for treating major TKA instability.

Despite the progress in bone reconstruction during revision surgery through the use of sleeves or porous metallic cones,<sup>52-58</sup> the persistence of instability in the metaphyseal zone caused by damage to the peripheral ligaments or local bone fragility drive us to select a hinged implant. Likewise, the risk of poor implant fixation in the metaphyseal bone forces us to secure the metaphyseal bridging by a diaphyseal stem associated





**Fig. 6 (a)** Aseptic loosening on hinged knee prosthesis with important femoral bone defect; **(b)** femoral reconstruction by porous augments and new hinged prosthesis, radiographic aspects at four years.

with a hinged implant.<sup>56</sup> Re-operations of revision cases with constrained or hinged implants are carried out using hinged implants to address instability and bone defects problems (Fig. 6). Periprosthetic fractures or fractures with loosened implants are indications for hinged implants in older patients due to local bone fragility. The implant stage of a two-stage septic revision, when it is accompanied by stiffness, is a strong indication for a hinged TKA if local bone weakness is present. A hinged implant is the constrained prosthesis of last resort as it increases the stresses on the bone–implant interface. It remains a viable option, even if it is often accompanied by a high number of complications in salvage or infection cases, due to local risks, not due to the implant itself.<sup>59,60</sup> The rotational aspect of the hinge is necessary except in very rare neurological cases where the movement must be restricted to flexion–extension.<sup>61</sup>

The presence of preoperative instability before the revision requires that it be characterized with X-rays under stress to determine whether there is mediolateral or anteroposterior instability. It is recommended to have a hinged implant available in the operating room when this instability is identified.

#### *Selecting a hinged implant intraoperatively*

When the peripheral ligaments are distended during a revision or after an extensive release around the implants, or because of loosening, or because of a polyethylene bearing failure, a hinged implant is indicated. In the last two cases, if the gaps in flexion or extension are identical, and if the mediolateral balance is symmetrical, a posterior-stabilized implant will be sufficient, with the potential addition of distal and posterior femoral wedges, tibial wedges and a thicker polyethylene insert.

If instability remains after restoring the height of the joint space with wedges and appropriate polyethylene inserts, a rotating-hinge implant is indicated, especially in older patients.

In cases with instability with a larger flexion gap than extension gap, another distal femoral resection would deplete the bone stock and the metaphyseal fixation zone. Likewise, increasing the polyethylene insert thickness could cause a flexion deformity and patella infera with altered knee kinematics. In practice, the magnitude of the difference between the flexion and extension gaps is used to choose the level of constraint: if the difference is less than 10 mm, a CCK-type implant will be sufficient; if the difference is more than 10 mm, a rotating-hinged implant is necessary.

In cases with bone defects with possible damage to the collateral ligament insertion, a rotating-hinged implant must be used with caution and primarily to secure the construct.



## Conclusions

The outcomes with hinged implants have improved since the introduction of the rotating-hinged design. However, its use remains limited to complex revisions. Extensive planning is required to use hinged implants in the revision of a TKA. It is a good choice in cases of significant instability or moderate metaphyseal bone fixation. This choice implicates a more constrained implant system, often modular. Complications in these complex revision cases are common and daunting. Infection and periprosthetic fractures that require re-operations can negatively impact the outcomes.

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ME is an educational partner for Depuy-synthes, lepine, newclip, amplitude.

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### LICENCE

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