Medial pivot knee in primary total knee arthroplasty

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Contributions: (I) Conception and design: All authors; (II) Administrative support: None; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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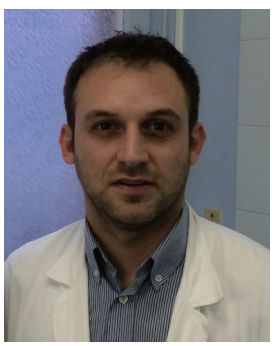

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Abstract: Total knee arthroplasty (TKA) with a medial pivot design was developed in order to mimic normal knee kinematics; the highly congruent medial compartment implant should improve clinical results and decrease contact stresses. Clinical and radiographic mid-term outcomes are satisfactory, but we need other studies to evaluate long-term results and indications for unusual cases.

Keywords: Knee kinematics; medial pivot design; total knee arthroplasty (TKA)

Submitted Nov 23, 2015. Accepted for publication Nov 23, 2015.
doi: 10.3978/j.issn.2305-5839.2015.12.20
View this article at: http://dx.doi.org/10.3978/j.issn.2305-5839.2015.12.20

Total knee arthroplasty (TKA) shows generally excellent clinical results, but knee kinematics after TKA is different from physiological kinematics. Classic model of knee joint motion is the so called "four-bar link model", in which knee kinematics is described as uniform rollback of the femur on the tibia during flexion; the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) represent the gear enabling the femur rolling and gliding on the tibia. Normal knee kinematics has shown that knee doesn't work following this concept. The four-bar link model applied to total knee implant design involves antero-posterior motion of the femur on the tibia (paradoxical anterior sliding of the femur) to avoid "kinematic conflict" (1): J-curve femoral components are characterized by decreasing radii from full extension to flexion exactly to allow this kinematic concept. Paradoxical anterior slide of the femur on the tibia moves anteriorly the knee axis of flexion and lessens maximum knee flexion; the quadriceps efficiency is decreased, because the quadriceps moment arm is reduced (2). Unfortunately, it seems that paradoxical anterior sliding of the femur on tibia can sometimes occur in both posterior cruciate-retaining (CR) and posterior stabilized (PS) prosthesis (3).

The physiological knee kinematics reveals that the knee moves with the medial compartment staying very nearly stable like a ball and socket joint, while the external femoral condyle moves front to back rotating around the centre of the medial side during knee flexion (4). *In vivo* fluoroscopic analyses of the normal human knee have however proved the medial compartment is more stable and congruent to translation than the lateral, producing a "medial pivot" motion (2). So, probably, reproducing not only posterior femoral rollback but also medial pivot motion becomes important in modern TKA (5), because a paradoxical sliding forward or paradoxical rolling forward are not physiological motions.

The medial pivot philosophy pushed since late 1990s several orthopaedics companies to create an asymmetric tibial insert with a highly congruent medial compartment and a less conforming lateral compartment; in this way anterior motion and posterior motion are limited in the ultra-congruent medial compartment, which has a ball-and-socket joint and translation in the lateral compartment in unrestricted (3). The femoral component has a single radius curvature and high conformity in the medial compartment about which it rotates; in this way the femoral implant does not roll back as in PS arthroplasty with post and cam mechanism (4) and quadriceps force is improved especially in early flexion (6). In this design antero-posterior stability is achieved with a raised anterior lip of the polyethylene insert, while is minimized the potential for condylar liftoff (3). Furthermore, radiological studies in medial pivot CR implants have demonstrated a posterior femoral translation during knee flexion: this phenomenon is considered an important kinematic factor (7). Otherwise, other authors have shown no clinical different outcome of medial pivot TKA whether the PCL was retained or sacrificed (8): they suggest to sacrifice PCL in case of difficult soft tissue balancing procedure and to increase femoral component external rotation to compensate possible medial tightening due to thickness of medial portion of the polyethylene insert. The philosophy to copy normal knee kinematics should increase stability and reduce polyethylene wear. Finally, Barnes and Blaha showed in a cadaveric knee model that kinematic performance of medial pivot implant is similar to that in normal state knee, with no difference in quadriceps extensor forces (9).

Midterm clinical and radiographic results of the medial pivot total knee system have been reported as satisfactory or excellent (5). Schmidt and Blaha published 98% excellent or good results at 5 years, with increasing range of motion from 115° at preoperative analysis to 119° at final follow-up and 96.6% component survivorship (1); according to Youm *et al*., this last value increases to 98.1% at 7-year follow-up with clinical satisfactory results (10). Karachalios *et al*. reported satisfactory clinical results with a mean knee flexion of 117° (11). A recent systematic review and meta-analysis of 1,146 medial pivot implants performed in six countries shows survivorship and Knee Society Score (KSS) similar or better than that recorded for other TKA systems (12). Medial pivot implants demonstrate a superior prognosis compared with a PS implant (13). Patients with different bilateral TKAs feel the medial pivot implant as more stable and more normal, also for highly demanding tasks as rising from a chair without compensation from non-operated limb: they prefer the medial pivot rather than mobile-bearing, CR or posterior-stabilized prostheses (3). Similarly in case of bilateral TKAs, Pritchett stressed patient's preference at 2-year follow-up for retention of both cruciates with use of the ACL-PCL prosthesis or substituting with a medial pivot implant (6). So it seems that medial pivot knee may have advantages in terms of contact area and kinematics but not real advantage in terms of post-operative knee flexion (14). On the other hand, *in vivo* image registration technique of tibiofemoral contact indicates that kneeling is safe without risk of subluxation or dislocation in medial pivot implant without cam-post or PCL (15).

Fluoroscopic analyses *in vivo* of medial pivot implant have demonstrated similar knee kinematic to physiological motion (3), as posterior translation of the lateral femoral condyle during knee flexion, and partial restoration of normal knee kinematics after medial pivot design implant in difficult knees, as severe valgus deformity (16); particularly, kinematics are similar in pattern to normal functional knees, even if smaller in magnitude, and during normal different weight bearing activities (stepping, kneeling, pivoting and lunging) no paradoxical anterior slide of the femur was demonstrated (17). Polyethylene wear particles in synovial fluid obtained 1 year after TKA appear fewer in a medial pivot implant than in a posterior-stabilized prosthesis (6); however, other studies are necessary to reach a design of tibial insert that copy knee physiological kinematics (5). Chinzei *et al*. demonstrated with three-dimensional digital template software that implanting a medial pivot TKA can change patello-femoral joint kinematics compared to pre-surgery kinematics (18). For some Authors the constraining shape of the polyethylene insert of medial pivot TKA can substitute the function of the PCL, but Fang *et al*. showed that a CR knee solely constrained by a medial pivot is not stable enough to substitute the PCL and that for regaining a normal knee motion is necessary with medial pivot implant retention of the PCL or a post-cam mechanism (19).

The benefits of medial pivot implant are antero-posterior stability, large contact area with low contact stress and high component's compliance. Mid-term clinical and radiological results are satisfactory with elevate survival rates and no serious implant related failure. Other studies are necessary to evaluate long-term results and indications for unusual cases, as post-traumatic arthritis or severe incorrigible valgus deviation.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Atzori F, Salama W, Sabatini L, Mousa S, Khalefa A. Medial pivot knee in primary total knee arthroplasty. Ann Transl Med 2016;4(1):6. doi: 10.3978/j.issn.2305-5839.2015.12.20

