Cementless total knee arthroplasty

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Abstract: Interest for uncemented total knee arthroplasty (TKA) has greatly increased in recent years. This technique, less used than cemented knee replacement in the last decades, sees a revival thanks an advance in prosthetic design, instrumentation and operative technique. The related literature in some cases shows conflicting data on survival and on the revision's rate, but in most cases a success rate comparable to cemented TKA is reported. The optimal fixation in TKA is a subject of debate with the majority of surgeons favouring cemented fixation.

Keywords: Cementless total knee arthroplasty (TKA); uncemented total knee arthroplasty (TKA); total knee replacement

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Introduction

Total knee arthroplasty (TKA) has become one of the most effective, reliable and predictable procedures in modern orthopaedic surgery. This surgical procedure is associated with low morbidity and mortality and its effectiveness in reducing joint pain and in improving range-of-motion is well established. The main goals of TKA are to obtain an implant that relieve pain and recover function, meeting the requests of patients; then the survivor of the implant has to be almost in 90% of cases at least 15–20 years. A number of issues such as surgical approach, device attachment technique, ligament preservation or resection and the optimum biomaterials for individual component manufacturing remain controversial; between these the use of cemented versus cementless prosthesis is still a dispute.

The ideal fixation of a TKA is still debated. The main question is whether the use of cement is more efficient than press-fit fixation in terms of ensuring durable stability. The use of cement in TKAs has been associated with excellent clinical outcomes and low rates of aseptic loosening at long-term follow-up, and it is the most widespread method of fixation in knee replacement. However, alterations of the bone/cement interface leading to osteolysis prompted orthopaedic surgeons to look for a new method of fixation that would avoid this complication, particularly in younger patients.

The basis for the use, since the mid-80s (both in Italy and in Europe), of cementless TKAs in young patients with adequate bone stock is the concept that osteoconductive component surfaces, in the presence of a very active bone metabolism, show high biological properties. Many authors proposed a "hybrid" fixation technique, consisting of a cementless femoral component and a tibial component fixed with a cemented baseplate and a press fit keel. However, the demonstration, in short- and medium-term studies, of a high rate of early loosening related to micromotion led to a return to standard cemented TKAs. This problem was related to the first cementless designs and the geometry of the early components, characterized by poor osteoconductive surfaces or inadequate fixation devices (pins, screws). Modern implants incorporate effective

solutions (porous coatings, plasma spray, and rotating platforms) able to reduce stress conditions and micromotion at the bone/metal interfaces. Various reports have described the successes and problems of TKA using cemented and non-cemented systems. Complications in TKA can be many like patellar fracture and subluxation, component loosening, stress-shielding, metal corrosion, local and systemic exposure to metal ions, failure of bone growth and many of these have different rates depending on the technique used. Also periprosthetic particulate debris (i.e., ultra-high molecular weight polyethylene or polymethylmethacrylate) and the associated osteoclastic bone resorption (osteolysis) phenomena, now postulated to be the result of cytokine release by macrophages, remains under intense scientific scrutiny (1).

In past literature there have been previous reports indicating that both clinical outcomes and long term survival are inferior for cementless components, especially on the tibial side.

But aseptic loosening continues to be a leading cause of revision TKA and theoretically cementless components could minimize this cause of failure like in total hip arthroplasty (2).

Cementless total knee arthroplasty (TKA)

The theoretical benefits of using cementless knee prostheses are many: shorter operating room time, preservation of bone stock, ease of revision, and elimination of complications associated with cemented fixation like third body wear and retained loose fragments. Osteolysis patterns also differ depending on the mode of fixation. Among cemented components, loosening is characteristically preceded by the development of a linear radiolucency at the cement bone interface. In contrast, osteolysis associated with cementless implants typically demonstrates an expansile pattern in the metaphyseal bone that rarely interferes with component fixation.

One of the main indications for using a cementless TKA is good bone quality with high metabolic activity, in order to promote biological fixation. Indeed, a younger age (under 65 years old) and an adequate bone stock are the most typical indications.

To ensure good primary stability of the implant, the bone resections must be performed accurately, avoiding any gaps between the host bone and the components. In cemented TKAs, the cement mantle can easily fill small defects in resections without affecting the stability.

Radiostereometric analyses (RSA) have made it possible to understand the different migration patterns shown by the TKA components with the two different fixation methods. Cementless tibial baseplates may migrate early, i.e., in the first three months postoperatively, usually reaching stability after this interval; cemented tibial components, on the other hand, do not migrate in the immediate postoperative period, while they may show micromotion over 60 months. No differences have been demonstrated in the migration pattern of cemented with respect to cementless femoral components.

Cementless implants are up to three times more expensive than cemented ones due to the high technology required to produce bioactive surfaces: supporters of cemented TKAs maintain that it is not reasonable to use an expensive cementless system that gives the same overall clinical results as a cheaper implant, even in younger patients.

However, using cementless TKAs is undoubtedly time-saving, it reduces the pneumatic ischemia time (there is no need for complete exposure of the trabecular bone ready to receive the cement), and finally it allows an easier bone-sparing revision in the event of failure (3).

Shorter operative time is an important factor to consider; in fact this reduces the costs associated with intervention. Generally, cementless prostheses are more expensive than cemented implants, although the prices vary between companies. Kamath *et al*. found that, in their institution, it cost $596 more to use the NexGen (Zimmer) uncemented tantalum metal *vs.* the cemented posterior stabilized tibial component. However when accounting for cement, less operative time and equipment cost related, the differences in cost was only $150 more for NexGen implant (4).

The failure of the first generations of uncemented knee replacement led orthopaedic surgeons to abandon this technique for many years and today the percentage rate of preference usage by the surgeons in cemented and cementless fixation based on registry data is strongly in favour of the first in many states (5). The less optimal results obtained in the past by the cementless prostheses have been attributed to press fit design failed, but today thanks to the use of new technologies, such as hydroxyapatite coatings or trabecular and porous metal, these implants offer more reliability.

New generation prosthesis results in a better osteo-integration than past, with creation of biological interface between the bone and the prosthetic component that may provide better long-term results (6). In fact when using the cementless option the ability of bone to withstand

direct prosthesis-bone load transmission and to stabilize especially the tibial component must be assessed. For this reason in the past this option is preferred in young patients that have a good bone stock and rapid capacity of bone healing but it is showed that coats like Hydroxyapatite are able to reduce micromotions and improve integration between bone and prosthetic component and this happens without any significant difference in patients over the age of 75 years old (7).

Certainly young patients constitute a challenge to orthopaedic surgeons because they expect their activity level to be higher postoperatively and their life expectancy is longer. Moreover, because the younger patients' activity level is higher, greater stress will be placed on the implant, and revision surgery is a likely consequence (6). Several authors have shown that the mean age of patients undergoing TKA is decreasing and the proportion of the patients younger than 65 years is increasing and despite recent advances in operative technique, prosthetic design and instrumentation, there is still concern that these implants will not last for the lifetime of many patients (8).

The aseptic loosening should be considered the parameter most influential in evaluating which is the better method of fixation in total knee replacement and this could be studied with radiostereographic analysis that have claimed to have the ability to detect changes earlier than what would have been possible by following the implants for the necessary time span to detect loosening.

This is a technique in which the movement between implants and bone may be measured. Radiopaque beads are scattered in the area of interest, and cameras record their position at time intervals. Thus, small changes in position may be recorded and, due to the high level of precision, small numbers of participants are needed to detect meaningful differences between implants or surgical techniques. In the realm of implant research, continuous movement between implants and bone at 2 years is regarded as predictive of late aseptic loosening of the implant (9).

For patella in TKA a cementless fixation is a practice rarely used, the patellar polyethylene cemented prosthesis has shown excellent results in the long term (10) and is often associated in TKA with cementless femoral and tibial components. Patellar replacement that uses a metal-backed component is often a cause of complication and failure like an early loosening and rapid wear of the polyethylene articular surface. In these cases a metal on metal wear damages the prosthesis and it can cause local exposure to metal ions.

Several studies confirm excellent results with an uncemented femoral component and confirm that cementing the femoral component of a TKA does not appear to influence the clinical results (11).

Instead the use of cementless tibial component show conflicting data in literature and this explains hybrid implants. Several studies show that in cementless TKA the loosening of tibial component is more frequent in the first 6 months compared to the cemented prosthesis, but after the osseo-integration, the percentage is lower in fact in cemented fixation, subsidence is initially small but continuously increasing (12).

Survivorship, revision rate and functional outcomes of cementless TKA in literature

Over the decades, *in vitro* studies have demonstrated that the use of rotating platforms in cementless TKAs is associated with a better tribologic performance and survival of the implant, related to the reduction of stresses at the bone/metal interface. Several studies in the clinical setting have also shown long-term survivorship of press fit TKAs with rotating platforms, ranging from 83% to as high as 99.4%.

Hybrid fixation, which combines a cemented component (generally the tibial plate) with a cementless one (usually the femoral component), has been proposed on the strength of the high osteoconductive properties of the modern component coatings.

Whiteside reported his case study on cementless fixation and he evaluated the successful of this technique with a long follow-up: 9 to 11 years. He considered 163 uncemented knee prosthesis and showed survivor rate at ten years of 94%. Revision rate was 6.7% and it was due to wear of patellar and tibial component and infection. Considering pain, 83.7% of patients had not pain 10 years after surgery (13).

Sorrells shows a study with 528 uncemented knee replacements. He reported that clinical scores improved significantly compared with the preoperative scores for the first 12 months postoperatively and then plateaued. Implant survival at 12 years was 89.5% and revision rate was 5.5% (14).

A study with 109 primary uncemented knee arthroplasty was shown by MS Ali. He evaluated this case 4 to 12 years after operations. The mean of knee scores and functional outcome was 86.4 and 65.1 respectively. The survival rate was excellent, with 99% at 10 years after surgery. The revision rate was 0.9% and there were no evidence of radiological loosening (15).

Hardeman *et al*. (1) analysed a consecutive series of 115 cementless Profix (Smith and Nephew, Memphis, USA) Total Knee Arthroplasties performed in 113 patients in order to determine the functional results and survivorship at 8 to 10 years. Patients overall satisfaction was excellent or good in 91.3% of cases. The mean Knee Society's knee and function scores increased respectively from 49.3 and 36.7 preoperatively to 93.1 and 82.2 postoperatively. The Kaplan-Meier estimate of implant survival at 10 years was 97.1%. On the basis of this long-term follow-up study, Authors can conclude that the Profix Total Knee System is effective and safe.

Yang *et al*. (16), following up 235 TKAs, performed with a hybrid fixation technique and using five different knee systems, reported a survival rate of 95% at 10 years, and then of 92% at 15 years.

To cement or not, literature review for cemented *vs*. cementless TKA

Ranawat in one of his work underlined that the results based on level III and IV evidence show similar survivorship rates between the two types of fixation, but level I and II evidence strongly support cemented fixation. United Kingdom, Australia, Sweden, and New Zealand registry data show lower failure rates and greater usage of cemented than non-cemented fixation. Case series studies have also indicated greater functional outcomes and lower revision rates among cemented TKAs. Non-cemented fixation involves more patellofemoral complications, including increased susceptibility to wear due to a thinner polyethylene bearing on the cementless metal-backed component. For Ranawat the combination of results from registry data, prospective randomised studies, and meta-analyses support the current superiority of cemented fixation in TKAs (5).

Pijls *et al*. in a meta-analysis confirmed that uncoated Interax components showed the highest migration and turned out to have the highest revision rate for aseptic loosening (17).

Carlsson *et al*. compared 3 types of fixation (cemented, uncemented porous and uncemented porous hydroxyapatite fixation); they reported that cementing of the tibial component offers more stable bone-implant contact for 5 years compared to uncemented fixation. When using uncemented components, however, there is evidence that augmenting a porous surface with hydroxyapatite may mean less motion between implant and bone after the initial postoperative year (18).

In favor of cementless fixation there are many recent works

In a recent review by Mont *et al*., 37 studies (2,940 patients and 3,568 TKAs) were identified and used, comparing cementless to cemented TKA. Pooled implant survivorship was compared using a fixed-effect meta-analysis between cementless and cemented TKA, and between cementless TKA with and without screw fixation. Cementless TKA had implant survivorship comparable to cemented TKA [odds ratio (OR), 1.1; 95% confidence interval (CI), 0.62–2.00]. The mean survivorship at 10 years for cementless TKA was 95.6% compared with 95.3% for cemented TKA. At 20-year follow-up, implant survivorship decreased to 76% and 71%, respectively. No difference was observed between fixation with or without screws (OR, 1.1; 95% CI, 0.16–7.5). So implant survivorship for cementless TKA was comparable to the current gold standard cemented TKAs (19).

Lass *et al*. evaluate the outcome of titanium-coated cementless implants compared with hybrid TKA implants with a cemented tibial and a cementless femoral component. The authors performed a case-control study of 120 TKAs, including 60 cementless and 60 hybrid cemented TKAs. The authors analyzed the radiographic and clinical data and the survivorship of the implants at a minimum follow-up of 5 years. Ninety patients who underwent TKA completed the 5-year assessment. Knee Society Scores increased significantly in both groups ($P<0.001$). In both groups, 2 patients underwent revision due to aseptic tibial component loosening, resulting in a 96% implant survival rate. Radiographs showed significantly less radiolucent lines around the tibial baseplate in the cementless group (n=12) than in the hybrid cemented group (n=26) ($P=0.009$). At 6-year mean follow-up, no significant difference existed between the cementless and hybrid cemented tibial components in TKA in terms of clinical and functional results and postoperative complications. The significantly smaller number of radiolucent lines in the cementless group is an indicator of primary stability with the benefit of long-term fixation durability of TKA (20).

Beaupré *et al*. performed a prospective, randomized clinical trial that included 81 patients who underwent primary TKA when they were less than 70 years of age. The subjects were randomized to be treated with either cementless tibial fixation with hydroxyapatite or cemented tibial fixation. Evaluations were performed preoperatively and at 6 months, 1 year, and 5 years postoperatively. Seventy subjects (86%) completed the 5-year assessment.

Slightly more pain was reported in the hydroxyapatite group at 6 months as measured with both the WOMAC and the RAND-36, a difference that disappeared by 1 year postoperatively. No differences were seen in function, radiographic findings, or complications. No subject required revision of the tibial prosthesis during the study. At 5 years postoperatively, there is no difference between cementless tibial fixation with hydroxyapatite and cemented tibial fixation in terms of self-reported pain, function, health-related quality of life, postoperative complications, or radiographic scores (21).

Bercovy *et al*. compared the outcome of 157 hydroxyapatite (HA)-coated tibial components with 164 cemented components in the ROCC Rotating Platform total knee replacement in 291 patients. The mean follow-up was 7.6 years (range, 5.2–11.0 years). There were two revisions for loosening: one for an HA-coated and one for a cemented tibial component. Radiological evaluation demonstrated no radiolucent lines with the HA-coated femoral components. A total of three HA-coated tibial components exhibited radiolucent lines at three months post-operatively and these disappeared after three further months of protected weight-bearing. With HA-coated components the operating time was shorter (P<0.006) and the radiological assessment of the tibial interface was more stable (P<0.01). The survival rates at 9 years were identical for both groups at 99.1%. Their results suggest that HA-coated components perform at least as well as the same design with cemented components and compare favourably with those of series describing cemented or porous-coated knee replacements, suggesting that fixation of both components with hydroxyapatite is a reliable option in primary total knee replacement (22).

Fricka *et al.* (2) enrolled 100 TKA patients randomized to cemented or cementless fixation. At 2 years, the KSS functional scores, Oxford scores, and self-reported questions for satisfaction, less pain and better function were similar but the cemented group had higher KSS clinical scores (96.4 *vs*. 92.3, P=0.03). More radiolucencies were seen in cementless knees (P<0.001). The cementless group had one revision for instability and one cemented knee was revised for infection. Cementless TKA showed equivalent survivorship (revision for any reason as the endpoint) compared to cemented TKA at this early follow-up.

In a randomized controlled study, Gao *et al*. (23), using RSA, found similar results in terms of migration, clinical outcomes, and survival rates of 41 TKAs in young patients (<60 years) undergoing knee replacement (NexGen, Zimmer, Warsaw, USA): 22 with fully cemented implants and 19 with hybrid fixated implants.

Duffy *et al.* compared 55 cementless TKA with 51 cemented TKA with a follow up of 10 years. In first group pain and functional knee scores improved from 33 and 50 before surgery to 93 and 60 after surgery respectively. Revision rate was 18.1% for femoral or tibial aseptic loosening or osteolysis whereas survival rate was 72% of 10 years after surgery (24).

Nakama *et al*. in his systematic review conclude that there was a smaller displacement of the cemented tibial component in relation to the cementless fixation in studies with osteoarthritis and rheumatoid arthritis participants who underwent primary total knee prosthesis with a follow-up of 2 years; however, the cemented fixation presented a greater risk of future aseptic loosening than cementless fixation (25).

Voigt *et al*. in his systematic review and meta-analysis reported that in patients >65 years of age an HA-coated tibial implant may provide better durability than other forms of tibial fixation. Authors also declared that larger trials should be undertaken comparing the long-term durability, function, and adverse events of HA-coated implants with those of other porous-coated tibial implants in younger, more active OA patients (26).

Conclusions

The question of whether to use cemented or cement-less fixation for TKA is still debated. Discouraging preliminary results of cement-less TKAs have determined the worldwide use of cemented implants. However, with the development of biotechnologies and new biomaterials with high osteo-conductive properties, biological fixation is now becoming an attractive option for improving the longevity of TKAs, especially in young patients.

There is no evidence in the current literature to support the use of one method of fixation. The extensive clinical experience with cemented implants gathered over the years justifies their widespread use. New randomized clinical trials are necessary to compare cementless fixation based on the new ingrowth surfaces with standard cemented implants. As the demand for TKA is continuously increasing and the current age population with osteoarthritis is getting younger, cemented fixation may not provide adequate long-term outcomes due to failure of fixation. Thus, there has been a re-emergence of the development and use of cementless TKA. Recent short-term trials have

demonstrated that modern cementless TKA has comparable survivorship and functional outcomes as cemented prostheses. However, more prospective, randomized trials are needed to clearly delineate any differences between these two fixation options.

Cementation of the patellar component is crucial: it is now clear that cementless patellas are associated with a high risk of failure due to early loosening of the component.

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Footnote

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References

1. Hardeman F, Vandenneucker H, Van Lauwe J, et al. Cementless total knee arthroplasty with Profix: a 8- to 10-year follow-up study. Knee 2006;13:419-21.
2. Fricka KB, Sritulanondha S, McAsey CJ. To cement or not? Two-year results of a prospective, randomized study comparing cemented vs. cementless total knee arthroplasty (TKA). J Arthroplasty 2015;30:55-8.
3. Matassi F, Carulli C, Civinini R, et al. Cemented versus cementless fixation in total knee arthroplasty. Joints 2014;1:121-5.
4. Kamath AF, Lee GC, Sheth NP, et al. Prospective results of uncemented tantalum monoblock tibia in total knee arthroplasty: minimum 5-year follow-up in patients younger than 55 years. J Arthroplasty 2011;26:1390-5.
5. Ranawat CS, Meftah M, Windsor EN, et al. Cementless fixation in total knee arthroplasty: down the boulevard of broken dreams - affirms. J Bone Joint Surg Br 2012;94:82-4.
6. Brown TE, Harper BL, Bjorgul K. Comparison of cemented and uncemented fixation in total knee arthroplasty. Orthopedics 2013;36:380-7.
7. Dixon P, Parish EN, Chan B, et al. Hydroxyapatite-coated, cementless total knee replacement in patients aged 75 years and over. J Bone Joint Surg Br 2004;86:200-4.
8. Kurtz SM, Lau E, Ong K, et al. Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030. Clin Orthop Relat Res 2009;467:2606-12.
9. Ryd L, Albrektsson BE, Carlsson L, et al. Roentgen stereophotogrammetric analysis as a predictor of mechanical loosening of knee prostheses. J Bone Joint Surg Br 1995;77:377-83.
10. Meftah M, Jhurani A, Bhat JA, et al. The effect of patellar replacement technique on patellofemoral complications and anterior knee pain. J Arthroplasty 2012;27:1075-80.e1.
11. Rorabeck CH. Total knee replacement: should it be cemented or hybrid? Can J Surg 1999;42:21-6.
12. Li MG, Nilsson KG. The effect of the preoperative bone quality on the fixation of the tibial component in total knee arthroplasty. J Arthroplasty 2000;15:744-53.
13. Whiteside LA. Cementless total knee replacement. Nine- to 11-year results and 10-year survivorship analysis. Clin Orthop Relat Res 1994:185-92.
14. Sorrells RB, Voorhorst PE, Murphy JA, et al. Uncemented rotating-platform total knee replacement: a five to twelve-year follow-up study. J Bone Joint Surg Am 2004;86:2156-62.
15. Ali MS, Mangaleshkar SR. Uncemented rotating-platform total knee arthroplasty: a 4-year to 12-year follow-up. J Arthroplasty 2006;21:80-4.
16. Yang JH, Yoon JR, Oh CH, et al. Hybrid component fixation in total knee arthroplasty: minimum of 10-year follow-up study. J Arthroplasty 2012;27:1111-8.
17. Pijls BG, Nieuwenhuijse MJ, Schoones JW, et al. RSA prediction of high failure rate for the uncoated Interax TKA confirmed by meta-analysis. Acta Orthop 2012;83:142-7.
18. Carlsson A, Björkman A, Besjakov J, et al. Cemented tibial component fixation performs better than cementless fixation: a randomized radiostereometric study comparing porous-coated, hydroxyapatite-coated and cemented tibial components over 5 years. Acta Orthop 2005;76:362-9.
19. Mont MA, Pivec R, Issa K, et al. Long-term implant survivorship of cementless total knee arthroplasty: a systematic review of the literature and meta-analysis. J Knee Surg 2014;27:369-76.
20. Lass R, Kubista B, Holinka J, et al. Comparison of cementless and hybrid cemented total knee arthroplasty. Orthopedics 2013;36:e420-7.
21. Beaupré LA, al-Yamani M, Huckell JR, et al. Hydroxyapatite-coated tibial implants compared with cemented tibial fixation in primary total knee arthroplasty. A randomized trial of outcomes at five years. J Bone Joint Surg Am 2007;89:2204-11.
22. Bercovy M, Beldame J, Lefebvre B, et al. A prospective clinical and radiological study comparing hydroxyapatite-coated with cemented tibial components in total knee

replacement. J Bone Joint Surg Br 2012;94:497-503.
23. Gao F, Henricson A, Nilsson KG. Cemented versus uncemented fixation of the femoral component of the NexGen CR total knee replacement in patients younger than 60 years: a prospective randomised controlled RSA study. Knee 2009;16:200-6.
24. Duffy GP, Berry DJ, Rand JA. Cement versus cementless fixation in total knee arthroplasty. Clin Orthop Relat Res 1998;(356):66-72.
25. Nakama GY, Peccin MS, Almeida GJ, et al. Cemented, cementless or hybrid fixation options in total knee arthroplasty for osteoarthritis and other non-traumatic diseases. Cochrane Database Syst Rev 2012;10:CD006193.
26. Voigt JD, Mosier M. Hydroxyapatite (HA) coating appears to be of benefit for implant durability of tibial components in primary total knee arthroplasty. Acta Orthop 2011;82:448-59.

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