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Review

Tibial Stems in Primary Total Knee Arthroplasty: A literature Review

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Abstract: This article displays a review of the specialty literature regarding the surgery of primary total knee arthroplasty (TKA), and more specifically refers to the complicated cases of primary total knee replacement where due to some preexisting pathologic circumstances, the orthopaedic surgeon must anticipate the risks and enhance the stability of the implant to obtain a long lifespan without revision surgeries. We collected the findings throught literature and compared them to our own surgical experience to create a rationale for the selection of the best knee prosthesis in surgical practice.

Keywords: total knee arthroplasty; primary total knee arthroplasty; implant; prosthesis; tibial stem extension;

1. Introduction

Instability and wear are an important issue and common causes of failure of Total Knee Arthroplasty (TKA). To achieve a successful outcome of TKA, factors like optimum alignment, adequate balance, and deformity correction remain the key [1].

According to Wolff's Law, the bone responds to the actual strains that are applied to it and a remodeling process takes place through its structure. The normal physiological range of strains and stress is between 50 με to 1500 με. Some areas where stress is lower than the physiological range suffer a process of bone resorption, and areas where stress is above 1500 με are in risk of microfractures, or even collapse [2].

During normal activity, the knee implant – bone assembly is subject to forces of axial compression, shear, varus and valgus moments. When a patient has preexisting knee pathologies, the bone structural quality is affected, so in order to reduce the effects of these forces, extensions or stems can be added to the primary implant.

Currently there are more than 150 designs of total knee implants being used worldwide by orthopaedic surgeons [3], some of them offering modularity, so that to the femoral or tibial components, an intramedullary stem extension can be attached.

The failure of the knee implant is most often linked to the tibial part of the component [4], therefore, a tibial stem is usually used in the primary complicated TKA's more often than a femoral stem.

Tibial stems play a huge role in improving the mechanical stability of the tibial components in total knee replacement. This comes with a cost associated with stress in line with their length. The surgeons often preserves tibial stems for revision total knee

arthroplasty. However, there have been instances whereby a primary total knee arthroplasty has been performed by incorporating the tibial stems [5]. There is a rationale for the selection process to either identify patient's fit for stems in primary TKA or those unfit. The longer the stem, the lower the stress of the bone implant contact area. The disadvantages are well known and consist of proximal stress shielding and distal end of stem pain, and also a more lengthy and invasive surgery. According to Scott et al usually in a primary TKA a short stem is sufficient [2].

2. Results

2.1. Rationale

In a very comprehensive recent matched cohort study [6] using the Total Joint Replacement Registry, it was concluded that the usage of a modular tibial stem was associated with fewer cases of aseptic loosening and as a consequence, lower revision surgery rates. Furthermore, assessing the cost effectiveness of both situations, it was indicated that not using a stem may not be effective in comparison to using one in a primary TKA.

An important rationale for the surgical treatment type is to provide a form of anteroposterior stability, rotational stability, which is located at the base-plate bone interface when there is also a need to have stability in forces of varus-valgus from the stem to prevent base-plate liftoff [7].

2.2. Indications for using a tibial stem in a primary TKA

2.2.1. Severe varus

Samy et al [8] found a statistical important improvement of the knee scores (Knee Society Score and Knee Society Functional Score) when using a tibial stem in patients with a severe valgus deformity. Also, this finding is backed by the study of Rawlinson et al where it was also found that the stress in reduced by 30% by adding a tibial extension stem to the tibial implant [9].

A more recent study by Hedge et al [10] examined cases in which there was a preexisting varus deformity of 8 degrees or more, challenging for a surgeon because of the ligament imbalance that has to be addressed intraoperatively, bone loss, increased varus loads in midstance phase of the gait cycle postoperatively. The solution adopted was using a stemmed tibial component, evaluating patients radiologically at a minimum of 2-years follow-up and searching for radiolucent lines at the tibial component. The results indicated that using stems significantly reduces the aseptic loosening of the tibial component requiring revision.

Fournier et al's studied the use of tibial, short extension stem in comparison to the normal tibial tray without one, for the primary operation of TKA [11]. This is found to be useful in varus deformities of more than 10 degrees by reducing the aseptic loosening of the tibial component. At the same time, the same study shows that 3% of patients with big varus deformities that undergone the TKA without stem experience the tibial implant loosening. The study's evidence level was found to be level III. The short tibial stem used in this situation by was 30mm.

It was also reported in the literature by Park et al that when a varus deformity of more than 8 degrees is present, a valuable surgical option is represented by a short stemmed tibial implant. The limitation of the study mentioned amongst others are that they did not consider the bone density as an important factor that can alter the outcome [12].

2.2.2 Obesity

The Body Mass Index (BMI) is another predictor of the lifespan of a total knee implant, many studies showing that obesity has a negative effect on it. A patient with a BMI ≥30 kg/m2 is considered obese by the definition of the World Health Organization. In orthopaedic knee surgery, there is a threshold of 35 kg/m2 BMI, any patient above this value having a twofold higher risk of implant early failure than below this value. Most studies through specialty literature use this threshold as a reference for analysis.

A study by Abdel et al [13] assessed the probability of failure and aseptic revision following a TKA in patients with a BMI ≥ 35/m2 at 5 and 15 years postoperatively and found that it is two times higher than for a patient with a BMI < 35 kg/m2. Even if none of the patients had supplemental stem intramedullary extensions, it is concluded that to reduce this higher risk, consideration should be given to alternative fixation aids like biologic fixation or short cemented stems.

Steere et al [14] in a recent study state that at their institution it became a standard practice to use a short stem extension in their patients with BMI ≥35 kg/m2. However, the conclusions of their short-term cohort study were that there was no significant difference between the group with stem and the group without a tibial stem, but do not recommend against using it.

Over time, the literature has been displaying recommendations about using a stem in morbid obesity. It is also the case of the work done by Schultz et al [15], that advised using a short stem in all patients with BMI>40/m2, and in any case of a patient with weak bone quality, regardless of BMI.

Fehring et al [16] found that at the level of the bone-cement implant interface the stress can be reduced by 136% when using a prophylactic stem.

This finding was similar to Berend et al [17], who studied aseptic loosening with radiostereometric analysis, and also states that using an intramedullary stem can be of benefit in reducing stress and strain.

2.2.3 Tibial bone defects

An important indication for tibial stems in primary TKA is the presence of the large tibial bone defects [7]. In cases like this, the stemmed components of the implants help to endure the load magnitudes, thereby decreasing proximal stresses which ultimately helps in enhancing the base-plate stability.

Another study that supported the presence of bony defects as an indication shows that existing peripheral tibial defects warrant the need for modular metal block augmentation in primary total knee arthroplasty to helps restore mechanical alignment, balance ligaments and restore function [18].

Another author, Emad et al concludes that medullary modular stems as a component of the implant can be used in cases of proximal tibial defects for primary total knee arthroplasty [19].

2.2.4 Osteoporosis

Samy et al [8] conclude and recommend that using a stem attached to the tibial tray can be safe and have beneficial outcomes in the following pathologies: obesity, extreme varus deformity, osteoporosis.

2.2.5 Fractures

A rare indication found through literature of using a stem attached to the tibial tray is periarticular fractures of the tibia and femur associated with osteoporosis [20]. This study although including a small number of patients is one of the largest existing with this specific indication. Medium term results recommended this approach as a suitable one in select cases where tissue quality was good and especially in the elderly patients.

A similar finding was displayed by Dhillon [21] treating a group of 8 patients with osteoarthritis and diaphyseal tibial stress fractures in a single stage surgery, using a modular total knee implant with stems and if needed the addition of plates with good results.

2.2.6 Younger age

The TKA survivorship of a patient less than 55 years of age was demonstrated to be lower than that of older age groups at 5 and 10 years postoperatively [22], even if the clinical KSS, WOMAC and SF12 scores were higher meaning a higher satisfaction postoperatively.

2.2.7 Post-traumatic arthritis

Posterior Stabilized (PS) design utilized in primary TKA by Saroj et al [23], helped achive a successful outcome efficiently. However, there are situations where post-traumatic arthritis occurs in association with severe deformities leading to some level of bone defects, stiffness and instability. Working with such cases is usually difficult with only soft tissue release. There is usually a need for tibial stems to help balance the changes.

Another study has shown that knee with comminuted periarticular fractures associated with osteoporosis and preexisting arthritis makes an excellent indication to add a tibial stem to the prosthesis for replacing the joint [20].

2.2.8 Rheumatoid arthritis

McCalden also mentioned above also states in their study an important pathology altering the survivorship of the knee implant is rheumatoid arthritis. In the study, patients younger than 55 years of age had a prevalence of 6.7% compared 2.8% in the older groups [24].

2.2.9 Higher patient activity level

One example that the activity level of a patient anterior to the knee replacement surgery has an impact on the survivorship of the implant is a study by Ponzio et al [25], which retrospectively reviewed the cases operated between 2007 and 2012 and concluded that there is a higher risk of revision for active patients compared to inactive patients prior to the surgery. Moreover, using Lower Extremity Activity Scale (LEAS), Hospital for Special surgery Expectation Survey, and KOOS score, it was shown that inactive patients improved their physical activity levels postoperatively compared to active patients who did not increase their activity levels. It was not mentioned or recommended that extra fixation of the implant in the form of extension stems was needed.

2.2.10 Height

The majority of prior research has only considered obesity as a risk factor for a primary TKA aseptic early failure but an interesting finding of Cristensen et al [26] was that being a taller patient increased the risk of revision by cause of aseptic loosening compared to a shorter patient of equally high BMI.

3. Discussion: cemented or uncemented stems

The choice for either fully cemented or proximally cemented stems is a daisy one. Factors that determine this has remains controversial for a long time. It is known presently regarding uncemented stems is that a fluted or clothes-peg-type termination for the stem gives it a form of good press-fit purchase on the host bone. It is also essential to avoid using full-length stem cement fixation due to challenges encountered while removing it or with the residual defects during the preparation for revision total knee arthroplasty.

4. Limitations

The common limitation with the use of modular tibial extensions in primary TKA is increase of surgical time, increased difficulty of revision and cost. Some cases can require conversion from a standard primary tibial tray to a revision tibial tray, which usually influence and change the cost.

5. Conclusions

In our experience, we also used most of the presented indications and some other indications which relate to congenital, surgical or post-traumatic deformity of the tibia, presence of bone cysts, correction osteotomy prior to TKA, and inflammatory arthropathies whereby the use of the intramedullary stems may result in better outcomes. The choice of the optimal stem in terms of length and thickness is still under debate through literature and we are currently conducting different types of studies, including finite elements analysis in this regard.

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