

Cost Effectiveness Analysis of Knee Osteoarthritis Treatment

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Rezumat

Analiză cost eficacitate în tratamentul gonartrozei

Alocarea resurselor materiale pentru sistemul de sănătate reprezintă o provocare și nu se poate justifica doar pe baza indicațiilor clinice, ci trebuie să țină cont și de aspectul economic. O metodă de cercetare a rezultatelor unui tratament este reprezentată de estimarea QALY. Acest studiu va compara cost eficacitatea managementului conservativ în gonartroză cu cel chirurgical, reprezentat de artroplastia totală de genunchi, primară sau după o osteotomie înaltă tibială. Au fost studiate 3 loturi de pacienți alcătuite din câte 30 de subiecți pentru fiecare metodă de tratament. Un raport mediu cost eficacitate de 1800 € / QALY (450 – 2000 € /QALY) a fost găsit, pe baza scorului EuroQol, pentru lotul cu tratament conservativ; 1268 € / QALY (720 – 2160 € /QALY), pentru lotul cu artroplastia primară, și 1975 € / QALY (720 – 2160 € /QALY) pentru lotul cu artroplastia după osteotomie. Pe baza rezultatelor s-a observat cel mai bun raport cost eficacitate în lotul cu artroplastie primară. Este necesară o atentă selecție a metodelor de tratament pentru rezultate optime pe termen mediu și lung în tratamentul gonartrozei.

Cuvinte cheie: osteotomie tibială, artroplastie de genunchi, cost eficacitate.

Abstract

Introduction: Resource allocation is challenging in times of economic restraint and cannot be based only on clinical judgments, but must also take into account economic aspects. A method for assessing patient outcome is to estimate the quality-adjusted life years (QALYs). These will quantify the benefit gained by a certain treatment by measuring the change in health-related quality of life with time. This study will assess the cost effectiveness of conservative management, consisting in rehabilitation program, and compare the cost effectiveness of total knee arthroplasty when implanted to a non operated arthritic knee with cost effectiveness of the same procedure following high tibial osteotomy.

Materials and methods: This study reviewed 30 patients who were treated for knee osteoarthritis with rehabilitation care (group 1-G1), 30 patients who underwent unilateral TKA to an non-operated knee (group 2-G2) and 30 patients who underwent TKA following HTO for degenerative arthritis of the knee (group 3-G3). The economical endpoint were the total direct costs (Euro), based on DRG rates for procedures. The cost effectiveness analysis was assessed by the ratio between direct costs as assessed by the economical endpoint and the associated patient benefit as assessed by the clinical endpoint (€/QALY).

Results: No statistically significant differences was found between G2 and G3 regarding clinical or radiological outcomes of this study. Yet the patients who did not previously suffered a HTO procedure showed lower mean values of KSS, ROM and femurotibial angle. A significant benefit is observed for G2 and G3 towards G1 patients. Neither a clinically relevant nor a statistically significant association between groups is observed in G2 and G3 (median benefit estimates 2.5 versus 2.6 QALYs). Median benefit estimate for patients who did not previously

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suffered a HTO procedure was though smaller then benefit for those who did. A median cost effectiveness ratio of 1800 € / QALY (450 – 2000 € /QALY) was found based on the EuroQol scores for G1; 1268 € / QALY (720 – 2160 € /QALY), for G2, and 1975 € / QALY (720 – 2160 € /QALY) for G3.

Discussion: Regarding surgical treatment, the results showed a statistically significant better cost / benefit relation for patients from G2 ($p < 0,001$). Conservative management for knee OA is neither clinically effective for pain or disease progression nor cost effective, when applied for late stages of OA.

Conclusion: We report the lowest cost per QALY in the literature for TKA. If financial constraints is a cause for rationalizing the medical services, careful patient selection to optimise the clinical and economical aspects of procedures may help to improve further the cost-effectiveness of these interventions.

Key words: high tibial osteotomy; total knee arthroplasty, cost effectiveness

Introduction

Knee arthritis represents a leading health issue due to increasing incidence. Treatment of gonarthrosis is also a main economic concern, pain and disability being associated with high costs. Resource allocation is challenging in times of economic restraint and cannot be based only on clinical judgments, but must also take into account economic aspects. A method for assessing patient outcome is to estimate the quality-adjusted life years (QALYs). These will quantify the benefit gained by a certain treatment by measuring the change in health-related quality of life with time. When the financial cost of the intervention is factored in, a cost–utility ratio can be derived, giving a cost per QALY gained (1). Both the clinical effectiveness and the financial investment of a medical treatment must be considered simultaneously to derive a medical decision (2). Ignorance, lack of medical education and costs are reasons of delayed addressability for medical treatment. There are studies that have evaluated the influence of different types of treatment for gonarthrosis. Therapeutic sanction is nuanced depending on disease stage, patient age, its option and economic possibilities of the health system. Quite often, and especially in developing countries, treatment option is on economic considerations. Where a compromise is achieved, for economic reasons, the results can be good in the short term, but it is not known exactly evolution in terms of cost-effectiveness. There is a risk that, although short-term results are good, long-term effectiveness of procedures to be weak. Treatment for gonarthrosis consist in various methods like conservative management, high tibial osteotomy (HTO), unicompartmental arthroplasty (UKA) or total knee arthroplasty (TKA). The cost effectiveness analysis relates the costs of one of these treatments to its benefit from patients health state. This is estimated in terms of monetary units per gained quality adjusted life year

(QALY). Such analysis enables health care insurers to compare patients related benefit with other alternative procedures. HTO and UKA proved to be both cost-effective methods of treatment in gonarthrosis (3). Total knee arthroplasty appears to be cost-effective in the US Medicare-aged population, as currently practiced across all risk groups. Some authors claim that policy decisions should be made on the basis of available local options for TKA (4). The main objectives of all types of surgical interventions for knee arthritis are the same: axis realignment, loading redistribution, mobility recovering and pain relief, but in different stages of arthritis. The clinical results of HTO deteriorate with time despite the initial satisfactory results (5,6). Because of the loss of the correction angle and the pain caused by the progression of degenerative arthritis, most cases require conversion to TKA. The interval between HTO and TKA varies with indications of HTO. TKA after HTO is technically more difficult and lead to a greater rate of perioperatively complications such as prolonged surgery duration, greater blood loss, and greater risk of wound infection. HTO should be reserved to young, active patients, where indications are maintained, and it has a real benefit with good long term results (7). This study will assess the cost effectiveness of conservative management, consisting in rehabilitation program, and compare the cost effectiveness of total knee arthroplasty when implanted to a non operated arthritic knee with cost effectiveness of the same procedure following high tibial osteotomy. The analysis could provide objective and quantitative data about resource allocations in these situations and could help clinicians and health economists to choose the best treatment option for patients.

Materials and Methods

This study reviewed 30 patients who were treated for knee osteoarthritis with rehabilitation care (group 1-G1), 30 patients who underwent unilateral TKA to an non-operated knee (group 2-G2) and 30 patients who underwent TKA following HTO for degenerative arthritis of the knee (group 3-G3), at the Elias University Hospital and at the National Rehabilitation Institute. All patients were older than 60 years, with a varus deformity and an arthritis Ahlback score 3, 4 or 5. 70% of the patients were females. The median length of spitalization was 6 days. The mean age in G1 was 66, 7 years. The mean height and weight was 1,73 m and 74 kg, respectively. The mean age in the G2 was 64,3 years. The mean height and weight was 1,70 m and 71 kg, respectively. The mean age in the G3 was 65,3 years. The mean height and weight was 1,72 m and 73 kg, respectively. The patients were interviewed by means of EuroQol 5D questionnaire before and immediately after treatment in G1 and before and at least 6 weeks after treatment, in G2 and G3. The EuroQoL general health questionnaire evaluates five domains: mobility, self-care, usual activities, pain/ discomfort and anxiety/depression. The interviews were conducted by the main author of this work. Before and at least 6 weeks after surgery, the KSS (Knee Society Score) and Range of Motion (ROM) score for knee were assessed for G2 and G3. The radiological outcomes were

measured by anteroposterior simple radiographs to assess the femuro-tibial angle. The rehabilitation program was administered to individual participants. For about 30 minutes, participants performed simple exercises to improve functioning; these exercises were personalized according to each participant's ability. After that, patients participate to a physiotherapy session. The sessions were performed twice a day for 5 days before discharging the patient. For G2 and G3 the patients were routinely operated without tourniquet. The subvastus approach was used in all cases. Regarding the prosthetic implant, a postero-stabilized cemented total knee prosthesis was used for all patients. The same main surgeon performed all surgeries. The patella was prepared for resurfacing in both groups. First the femur was prepared, followed by tibial preparation with specific instruments. Intramedullary guides were used for all cases. After performing the bone cuts, next step was removing the osteophytes and balancing flexion and extension gaps. This can be achieved by soft tissues adjustment and adapting the thickness of the polyethylene liner. In 8 cases from post HTO group, removing the osteosynthesis material was performed in the same stage with TKA procedure, using the standard median skin incision for TKA. For the other 22 patients removing the material was performed previously, using the initial skin scar which is different than median skin incision used for TKA. For certain cases with severe varus knee deviation and important contracture of medial collateral ligament, medial epicondyle osteotomy was used for balancing the prosthetic knee. No reattachment technique was used for the resected epicondyle; moreover, patients started active motion of the prosthetic knee the day after the surgery. In fact, all patients started active motion of the prosthetic knee the day after the surgery and they were allowed for full weight bearing. Postoperatively all patients started antibiotherapy for 3 days in first group and for 5 days in second group. They also received anticoagulation treatment. Blood transfusion was used when was needed. The duration of surgeries, blood transfusions and perioperative complications were assessed.

The clinical endpoint of this investigation was the individual gain in quality of life (QALYs), when assessed by means of the EQ5 questionnaire. Before and after treatment patients answered the five EQ5 items. The patients clinical benefit achieved by treatment was assessed by individual difference of transformed EQ5 index. Following the intervention we used predicted life expectancy to estimate the QALYs gained until the end of the patient's life. According to European Health and Life Expectancy Information System – EHLEIS, life expectancy distribution in Romania 2011, was assumed with mean expectancy of 82,5 years for women and 79,3 years for men (8). The EQ5 based benefit was then assumed to persist over this patient's simulated rest life time. The overall benefit estimate was discounted at an annual discounting rate of 3%.

The economical endpoint were the total direct costs (Euro), based on DRG rates for procedures. The cost effectiveness analysis was assessed by the ratio between direct costs as assessed by the economical endpoint and the associated patient benefit as assessed by the clinical endpoint (€/QALY). It represents the marginal cost effectiveness ratio (MCER).

This ratio was calculated for every patient of this study.

Statistical tests were performed using SPSS software, and the results were compared by the Mann-Whitney and Kolmogorov-Smirnov tests. The 0.05 level was used to denote statistical significance throughout testing.

The study was approved by the local ethics committee and participants gave informed consent.

Results

Regarding personal characteristics of age, sex, height and weight, no statistically significant differences was found between groups. Fibrous union occurred in all knees with medial epicondyle osteotomy. In G2 (Fig. 1) the KSS improved from 29 $\pm$ 13 to 93 $\pm$ 7 points ($p < 0.001$), the range of motion increased from 75 $\pm$ 25 degrees to 110 $\pm$ 10 degrees ($p < 0.001$). In the G3 (Fig. 2), KSS improved from 20 $\pm$ 13 to 87 $\pm$ 8 points ($p < 0.001$), the range of motion increased from 70 $\pm$ 17 degrees to 105 $\pm$ 8 degrees ($p > 0.001$). The femurotibial angle was corrected from a 12.5° $\pm$ 4.61° varus to a 3.8° $\pm$ 1.33° valgus ($p < 0.001$), in G2, and from 13.7° $\pm$ 6.1° varus to a 2.9° $\pm$ 0.90° valgus ($p < 0.001$), in the G3. No statistically significant differences was found between G2 and G3 regarding clinical or radiological outcomes of this study. Yet the patients who did not previously suffered a HTO procedure showed lower mean values of KSS, ROM and femurotibial angle. The results are summarized in Table 1.

A statistically significant difference ($p < 0.001$) regarding the mean duration of surgery between groups: in G2 the TKA procedure lasted 80 $\pm$ 12 minutes, and 95 $\pm$ 14 minutes, in G3. A statistically significant ($p < 0.001$) number of patients from the G3 needed extension of ligamentary release to semi-membranosus insertion and superficial medial collateral ligament (20 to 5). A statistically significant number of patients from the G3 needed blood transfusion than in G2 (18 to 5). Perioperative complications like wound dehiscence or skin necrosis were found in 3 patients from the G3 and in none from G2.

The median EQ5 score rose insignificantly from 48% (39 –



Figure 1. Pre and 3 months postoperative X Ray in G2



Figure 2. Pre and 6 months postoperative X Ray in G3

56%) before rehab to 53% (40 – 60%) after rehab, in G1; significant from 42% (34 – 51%) before surgery to 75% (63 – 92%) after surgery ($p < 0,001$), in G2; and significant from 35% (31 – 53%) before surgery to 75% (42 – 93%) after surgery ($p < 0,001$), in the G3. The transformation of the EQ5 score increase into quality adjusted life years revealed a median benefit of 0,2 QALYs (0,09 – 0,5 QALYs) in G1; 2.5 QALYs (1.6 – 5.23 QALYs) in G2; and 2.6 QALYs (1.4 – 6.14 QALYs), in G3. A significant benefit is observed for G2 and G3 towards G1 patients. Neither a clinically relevant nor a statistically significant association between groups is observed in G2 and G3 (median benefit estimates 2.5 versus 2.6 QALYs). Median benefit estimate for patients who did not previously suffered a HTO procedure was though smaller then benefit for those who did. A median cost effectiveness ratio of 1800 € / QALY (450 – 2000 € / QALY) was found based on the EuroQuol scores for G1; 1268 € / QALY (720 – 2160 € / QALY), for G2, and 1975 € / QALY (720 – 2160 € / QALY) for G3. Regarding surgical treatment, the results showed a statistically significant better cost / benefit relation for patients from G2 ($p < 0,001$). The results are summarized in *Table 2*.

Discussion

Factors like age of the patients, level of activity or disease progression have been discussed when deciding to choose methods of treatment in knee osteoarthritis (OA). In developing countries financial is leading factor in decision making. Often conservative treatment in knee osteoarthritis result in failure to successfully correct the abnormal joint loading

Table 1. Clinical and radiological outcomes in G2 and G3

Outcomes	G2		G3	
	preop	postop	preop	postop
KSS	29	93	20	87
ROM	75	110	70	105
FT angle	12.5 (varus)	3.8 (valgus)	13.7 (varus)	2.9 (valgus)

resulting in continued disease progression. Knee osteoarthritis patients will eventually experience disease progression, and undergo TKA with the same frequency and at the same rate as if conservative measures were not employed. According to Crawford, OA patients spend \$173 per year on medications and average 3.3 office visits per year. Viscosupplementation treatments cost \$1700 to \$3700 annually. As OA progresses, the cost of treatments concomitantly rises. The 3.6 million patients in the United States with end-stage knee OA spend almost \$4000 per year on associated conservative treatments. Despite the considerable costs of conservative care, these therapies arguably result in mediocre pain amelioration with no demonstrable change in disease progression (9). As our study results showed, the median costs per QALY of the rehab programme is comparable with costs of TKA. This is probably cause of late addressability of patients to medical care (OA Ahlback score 3, 4 or 5), when conservative management of OA is no longer efficient. The main causes of late addressability are economical restrain and lack of education.

Total knee arthroplasty is an effective, but also cost-intensive health care procedure. Clinical results after TKA are not uniformly excellent. There are some risk factors associated with poorer TKA outcomes. Among these are older age, female sex, comorbidities and poverty (10,11). Number of TKA performed by the surgeon are inversely associated prosthesis failure rates and procedure costs (12, 13). There are little evidence about how patient risk factors for poor surgical outcomes affect the cost-effectiveness of TKA compared with other surgical procedures for treatment of gonarthrosis. The clinical results of high tibial osteotomy deteriorate with time despite the initial satisfactory results (5,6). Because of the loss of the correction angle and the pain caused by the progression of degenerative arthritis, most cases require conversion to total knee arthroplasty. It is said that clinical and radiological outcomes of TKA after HTO are similar to those of primary TKA, using a proper surgical technique (14-17). The interval between HTO and TKA varies with indications of HTO (5). All patients from the second group were older than 60 years, with a varus deformity greater than 10 degrees, an arthritis Ahlback

Table 2. Procedure evaluation results

Endpoints	G1		G2		G3	
	preop	postop	preop	postop	preop	postop
EQ5	48%	53%	42%	75%	35%	75%
QALYs	0.2		2.5		2.6	
MCER	1800		1268		1975	

score 3,4 or 5 at the time of HTO. This means that HTO indications were exceeded, and that is because of financial reasons. All these patients underwent conversion TKA at an average of 4.5 years. Surgical technique have been recognized to be crucial for the longevity of knee implant (18-20). Subperiosteal exposure of the proximal tibia and eversion of the patellar mechanism are more difficult in the post-osteotomy knee due to soft tissue scarring (21,22). Ligamentous imbalance may also reduce lifetime of the prosthesis. The results of this study showed that more extensive ligamentary releases was necessary for the post-osteotomy patients and consecutively a duration of surgery. This could increase the risk of infection and for blood transfusion. Wound dehiscence or skin necrosis were found in 3 patients from the second group and in none from the first group. A significant number of patients from the second group needed blood transfusion than in the first group (18 to 5). Exposure difficulties and alterations in knee anatomy may compromise precision and accuracy of the surgical technique. TKA after HTO is technically more difficult and lead to a greater rate of perioperatively complications such as prolonged surgery duration, greater blood loss, and greater risk of wound infection. Naudie showed that age older than 50 years was significantly associated with probability of early failure in tibial osteotomy (23). In his study, Farfalli (24) found that the prosthesis survival rate in case of TKA after a previous HTO was 82% at 5 years (95% CI, 69% to 95%) and 76% at 10 years (95% CI, 61% to 91%), with a mean KSS score of 79.9 points at final follow-up. According to other findings this indicate that the survival rate and overall functional outcome are inferior compared with the outcome of primary TKA without a previous high tibial osteotomy (25). According to Rodriguez the posterior stabilized prosthesis in TKA with an all polyethylene tibia had an average annual rate of failure of 0.38% and a 16-year success rate of 94.10% (26). The TKA patients in lowest-volume hospitals (1-25 procedures) had a higher risk of revision at 5 and 8 years compared with those operated on in highest-volume hospitals (27). According to National Register of Arthroplasty, orthopaedic department of Elias University Hospital performed 146 TKA's in 2014.

In his study Krummenauer (2) has found a median EuroQol score rose after TKA procedure from 40% (32 – 54%) before surgery to 70% (65 – 78%) after surgery and a age-related gradient in favour of the older patients. Transformation of this score increase into quality adjusted life years revealed a median benefit of 2.93 QALYs (1.75 – 5.59 QALYs). Total direct costs for the overall procedure were estimated 9549 € in median. Based on the EuroQol scores median marginal costs of 3064 € / QALY (1613 – 5291 € /QALY) were found, higher than in our study (1268 and 1975 €/QALY), but this costs included rehabilitation cost rates after surgery. This was deterministically modelled by assumption of a “flat rate” of 2100 € (referring to average daily costs of 100 € during a three weeks in patient rehabilitation).

It is widely accepted that TKA is a cost effective procedure and studies from USA, UK or Scandinavia showed that (28-30). According to Losina total knee arthroplasty appears to be cost-effective in the US Medicare-aged population and policy

decisions should be made on the basis of available local options for TKA. TKAs performed in a high-volume hospital confer even greater value per dollar spent than TKAs performed in low-volume centers (4). Dakin (31) showed that restricting TKA to patients with pre-operative OKS (Oxford Knee Score) <27 would inappropriately deny a highly cost-effective treatment to >10 000 patients annually. On opposite, TKA cost £5623/QALY gained. In his study Jenkins (1) found that the resulting cost per QALY was £2101 in the TKA group. When the health improvement was discounted (5% annual rate) for the length of the patient's predicted life expectancy, the cost per QALY rose to £4704 for TKA. Some authors studied possibilities for ameliorate the cost effectiveness of TKA by introducing the advantages of clinical pathway applications (32) in internal resource optimization, by making use of computer assisted surgery tools (33) or less invasive surgery (34), or using physiotherapeutic exercises before TKA. Gstoettner (35) et al detected no improvement in standing balance after TKA when no specific proprioceptive training had been performed. Also they found that preoperative proprioceptive training in patients undergoing total knee replacement proved to be effective in improving standing balance. Few authors provide outcome measures in terms of utility scores or quality adjusted life years, to compare TKA cost effectiveness with those of concurring treatment offers and to help health care insurers to apply the cost effectiveness information in local resource allocation discussions. As a consequence, only few published data allows for direct and quantitative comparison of its cost effectiveness characteristics with the MCER estimates (2).

This study has shown, like studies before, that TKA is a cost effective intervention. Accurate baseline data, as provided by this paper, will be vital to health-economic aspects as well as clinical function. Although the EQ-5D improved significantly in both groups, a greater improvement was seen after TKA in post HTO group, meaning that these patients have a worst condition before TKA than those from the first group. TKA procedure significantly ameliorate patients condition in both groups. One of the main determinants of cost-effectiveness for TKA was the degree of pre-operative dysfunction. Those patients with poorer pre-operative function derived greater benefit. TKA after HTO offered worst value per QALY than simple TKA (707 € more per QALY). The procedural cost of a TKA after HTO was higher, but owing to a greater gain in the EQ-5D score, the number of QALYs gained after this procedure was greater (2.6).

Conclusion

Conservative management for knee OA is neither clinically effective for pain or disease progression nor cost effective, when applied for late stages of OA. This treatment option does not address the fundamental causative factor of abnormal joint loading. TKA proved to be a cost effective procedure in treating knee osteoarthritis. We report the lowest cost per QALY in the literature for TKA. TKA after HTO is technically more difficult and lead to a greater rate of perioperatively complications

such as prolonged surgery duration, greater blood loss, and greater risk of wound infection. TKA is the method of choice in treating knee osteoarthritis Ahlback 3, 4 or 5 in older patients, with better long term results, despite the fact that it is more expensive than HTO. If financial constraints are a cause for rationalizing the medical services, careful patient selection to optimise the clinical and economical aspects of procedures may help to improve further the cost-effectiveness of these interventions.

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Conflict of interest

Nil.

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