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REVIEW

Comparison of pain perception between open and minimally invasive surgery in total knee arthroplasty

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Abstract: Total knee arthroplasty (TKA) was a well-established procedure that had shown excellent long-term results in terms of reduced pain and increased mobility. Pain was one of the most important outcome measures that contributed to patient dissatisfaction after TKA. After a computerized search of the Medline and Embase databases, we considered articles from January 1st, 1997 to October 31st, 2009 that underlined the impact on patient pain perception of either standard open total knee arthroplasty or minimally invasive total knee arthroplasty. We included articles that used the visual analog scale (VAS), Western Ontario and McMasters Universities Osteoarthritis Index (WOMAC), Knee Score, Hospital for Special Surgery Score (HSS), Oxford Knee Score (OKS) as postoperative pain indicators, and we included studies with a minimum follow-up period of two months. We excluded studies that monitored only functional postoperative knee activities. It was shown that TKA with the open technique was a better treatment for knees with a positive effect on pain and function than the minimally invasive technique.

Keywords: total knee arthroplasty, open technique, minimally invasive surgery total knee arthroplasty, pain perception, pain evaluation

Introduction

In recent years, the number of primary total knee arthroplasty (TKA) surgeries had increased significantly, almost tripling between 1990 and 2002.[1] Therefore, the numbers could be expected to increase in future years with aging of the increasing portion of the population who are obese.[2]

An uncommon complication following TKA or minimally invasive total knee arthroplasty (MIS-TKA) was pain associated with infections, loosening, reflex sympathetic dystrophy, and occasionally litigation.[3]

Pain following a TKA most frequently implicated infections, loosening or reflex sympathetic dystrophy. Rare incidences of pain had been associated with scarring, retained cement and osteophytes, and component fractures. Malalignment after surgery, although not desirable, had been implicated as a cause of only loosening, not pain, and then only when the knee was in varus.[4]

On the other hand, by using a mini mid vastus limited incision for primary TKA, as in the MIS-TKA, it was noted to decrease postoperative pain while speeding up the rate of recovery of motion and of return of function. By specific flexion and extension of the knee, the surgical window could be mobilized to visualize the articular surfaces at various stages during the surgery.[5] Radiographic evaluation revealed that component position and limb alignment were excellent despite the use of the more limited incision.[6]

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The main purpose of this review was to study the effective impact on patient pain perception of standard open TKA and MIS-TKA. Generally, patients expected that TKA would both decrease or eliminate their knee pain and improve their walking ability.[7]

To improve the outcomes of knee arthroplasty, MIS-TKA has been developed in recent years. Comparing MIS-TKA and traditional TKA highlighted a reduction of blood loss, shorter hospital stays, less narcotic requirements, and faster recovery of knee range of motion, all without compromise of accuracy or short-term outcome. In addition, one report comparing patients having traditional TKA and MIS-TKA suggested that the MIS-TKA patients experienced less extensive surgical dissection and resultant soft tissue trauma and had faster recovery of quadriceps muscle function, improved cosmesis, shorter incision and improved subjective satisfaction rates of wound complications, radiographic aligments, and short-term outcomes.[8] Indications for MIS-TKA were similar to indications for traditional TKA: failure of nonoperative management of knee pain, deformity, and limitation of function resulting from arthritis.

Contraindications to MIS-TKA included extremely large or obese patients and patients with extreme knee deformities or limitations of knee range of motion, risk factors for wound healing complications, advanced osteoporosis, previous high tibial osteotomy, and excessive patellar baja or patellar alta. In all these cases the traditional TKA was indicated.[9]

Materials and methods

Literature research

A computerized search of the Medline and Embase databases was conducted from January 1st, 1997 to October 31st, 2009. Both the inclusion and the exclusion criteria are shown in Table 1. The search was limited to literature published in English language, which better explain pain perception after TKA or MIS-TKA. Further, all reference lists were handsearched for other relevant articles. The selected articles were reviewed by the authors and judged on their relevance and contribution to the subject of this study. Finally, only six articles were found which well respected the inclusion criteria abovementioned. The second and the third tables summarize the material adopted by each study considered in this review. The fourth table shows the statistical methodology adopted for each study. There were many differences in the statistical technique, so it was inappropriate to attempt a quantitative meta-analysis on the effectiveness of open TKA and MIS-TKA.

Results

We found five articles effectively describing pain perception after TKA and MIS-TKA. Of these, five were published after 2000 and only one in 1997 were included. These studies included a total of 1097 patients that were assigned to TKA and 140 that were assigned to MIS-TKA surgery. By considering these studies and their results, specifically the treatment results, it was shown that the TKA with open technique was better than the MIS-TKA because the MIS-TKA results had methodological deficiencies, namely, small numbers and/or short follow-up periods.

Description of the studies

In 1997, Ritter studied pain (Table 2) as an uncommon complication following TKA associated with infections, loosening, reflex sympathetic dystrophy, and occasionally litigation.[10] In this randomized clinical trial study, 439 patients were followed between 1974 and 1983. The patients were followed at 2 months, 6 months, 1 year and then every 2 to 3 years thereafter, at which time radiographs were obtained and the Hospital for Special Surgery Scoring (HSS) was used, in which a quantifiable coding for pain was available. Slight or occasional pain, was not present daily, and required no medications; all other pain, moderate or worse, was considered significant. An observer collected the pain scores at each time interval and a visual analog scale (VAS) was not used. Patients with infections were excluded. All patients were evaluated, as stated, at each time interval to

Table 1 Inclusion and exclusion criteria in the study

Inclusion criteria
• All studies available in literature from January 1997 to October 2009, without limits of inclusion regarding their study designs;
• Revision of postoperative pain using: VAS, WOMAC, Knee Score, HSS, OKS;
• Postoperative follow-up which included a minimum period of two months.
Exclusion criteria
• Follow-up only monitoring functional knee activities

Abbreviations: HSS, Hospital for Special Surgery Score; OKS, Oxford Knee Score; VAS, visual analog scale; WOMAC, Western Ontario and McMasters Universities Osteoarthritis Index.

Table 2 Summary of studies on total knee arthroplasty with the open surgery procedure

Author	Ritter[10]	Bullens et al[11]	Muller et al[12]	Elson and Brenkel[13]
Study design	Randomized clinical trial	Survival analysis with the actuarial life-table method with 95% confidence intervals. Four endpoints were chosen: – revision, revision excluding deep infection – revision or VAS satisfaction <80 – revision, pain VAS >20, satisfaction VAS <80 – lost to follow-up (worst case scenario)	Comparison of both approaches for standard open and MIS-TKA	Non randomized, prospective study
Outcome measures	Moderate or worse pain was considered significant at each time intervals and a VAS was not used by an observer	Pearson' s correlation coefficient was determined to evaluate the relationship between the satisfaction VAS score and the other five systems: KSCRS (knee score) pain VAS, WOMAC pain, WOMAC stiffness, and WOMAC physical function. Correlation was determined between the satisfaction VAS and the combined WOMAC index and the individual questions of the WOMAC index. Significance was set at $P < 0,5$ to validate the correlation coefficient.	All patients were reassessed by two independent investigators using the HSS score	Demographic and operative variables were recorded in addition to serial assessments using the American Knee Society Score (AKSS). This was an outcome measure that had two main components: a knee score and a function score embodied in the knee score
Follow-up period in months	From 1974 to 1983 At 2 months, 6 months, 1 year and then every 2 to 3 years	5 years	From November 1998 to February 2001	From January 1995 to August 1998
Number of patients	439	108	38	512 patients (622 knees)
Pain perception after surgery	203 patients (46.2%) with no pain, 205 patients (46.7%) with occasional pain and 31 (7.1%) with moderate or more pain	The correlation coefficient in the comparison of the satisfaction VAS with the other systems varied between 0.48 and 0.62. The *P* value was significant for all correlation coefficients. The correlation of the satisfaction VAS with the individual questions of the WOMAC index varied from 0.43 to 0.68.	Mean value 78 (24–99); Excellent (85–100 points): 15 (50%); Good (70–84): 13 (34%); Fair (60–69 points): 5 (13%); Poor (<60 points): 5 (13%)	There were 380 knees with a pain score of one (no pain). Six knees were excluded because one had deep knee infection and five had undergone revision during the 5-year period.
Significant differences in advantage of TKA–open surgery technique	9 of 31 patients were revised for a loose prothesis, 6 had a diagnosis of reflex sympathetic dystrophy, and the other 16 were just coded as moderate pain, but the prothesis was stable and the patient did not decline any specific treatment	It appeared that 73% of the patients had a satisfactory outcome 5 years after TKA		Predictors of poor outcome were: younger age, category of patient, cruciate-sacrificing femoral components, performing a lateral release, preoperative pain scores, as well as mobility on stairs
Conclusion	Pain was only a subjective complaint with which we tried to associate an objective finding. All modalities, such as various scans, aspirations, injections, radiographs and laboratory examinations should be used to ascertain the cause of the pain because we were unable to show that radiographic abnormalities such as aligment, position and size of the prothesis had any association with pain.	The average satisfaction score after TKA was 80 points on a 0 to 100 VAS scale. We found poor correlations between the objective and subjective outcome systems, indicating that patients and surgeons had different criteria for a satisfactory outcome after TKA. It appeared that surgeons were more satisfied than patients after TKA		Younger patients undergoing a staged approach to bilateral disease were more likely to complain of unexplained postoperative knee pain

determine if pain could be correlated with the above anatomic variables. At two months of their follow-up there were 203 (46.2%) with no pain, 205 (46.7%) with occasional pain and 31 (7.1%) with moderate or more pain. Nine of the 31 were revised for a loose prosthesis, 6 had a diagnosis of reflex sympathetic dystrophy, and the other 16 were just coded as moderate pain, but the prosthesis was stable and the patient did not desire any specific treatment. This study concluded that pain was only a subjective complaint, which was not associated with an objective finding. In fact, all modalities, such as various scans, aspirations, injections, radiographs, and laboratory examinations should be used only to ascertain the cause of the pain.

In 2001, Bullens et al[11] (Table 2) evaluated pain after TKA by using different scoring systems in a group of 108 patients with short- to medium-term follow-up. The scoring systems used were: VAS, Knee Society Scoring System, and the Western Ontario and McMasters Universities Osteoarthritis Index (WOMAC). In particular, this study assessed pain by using both subjective and objective criteria and then by analyzing existing correlations. These correlations were determined by the Pearson's correlation coefficient but poor correlations were found between subjective and objective outcome systems mentioned above.

In 2004, Muller et al[12] (Table 2) described postoperative pain perception in 38 cases after TKA compared with 30 cases following MIS-TKA. Patients with the minimally invasive approach had significantly better functional results, with an average HSS score of 92 (range 81–98) compared with 78 (range 24–99). Range of motion 1 year postoperatively was better in the minimally invasive group, but the results were not significantly higher after the open approach, because the sample, in the minimally invasive approach, was smaller than the sample used in the open technique. The minimally invasive approach had no negative effect on positioning of the prosthesis.

Although the data were obtained retrospectively and the groups were not matched, their data and the results from the literature showed that minimally invasive implantation of knee prostheses resulted in better postoperative results in terms of early recovery and functional outcome without impairing the accuracy of implantation when compared with other TKA. Therefore, in their opinion, minimally invasive implantation should be the method of choice for the treatment of TKA.

In a non randomized prospective study in 2006 by Elson and Brenkel[13] (Table 2), a group of 512 patients undergoing primary TKA, with no pain, and one with severe pain at 5 years, were statistically compared. The paper showed that 17% of patients younger than 60 years were in the poor outcome group in comparison with 7% of patients aged 60 to 64 years with even less poor outcome knees represented in older age groups. If these figures were extrapolated, then patients younger than 60 years at TKA were more than twice as likely to report poor pain score at 5-year follow up than those older than 60 years. This study also demonstrated that poor outcome knees were represented by 13% of those patients undergoing the first TKA, compared with 6% of those patients undergoing the second TKA in a staged unilateral approach and 5% of patients with multiple arthritis. These proportions were significantly ($P < 0.01$) higher than 2% of those receiving simultaneous bilateral knee arthroplasty.

In addition, 17% of the group with a sacrificed cruciate ligament reported poor pain scores compared with only 6% from the group with a retained cruciate ligament. This difference was seen to be statistically significant ($P < 0.01$) despite the relatively small numbers in the cruciate sacrificed group. Furthermore, 13% of patients who had a lateral release reported poor pain. In conclusion, this study was based upon 622 knee arthroplasties with prospective data and midterm follow-up at 5 years. It compared good and poor pain outcome groups and had shown four variables to be significant predictors of poor outcome by multivariate analysis. Younger patients and those undergoing a staged approach to bilateral disease were more likely to complain of unexplained postoperative knee pain. However, the authors could not exclude the possibility of selection bias in this finding.

In 2005, Berger et al[14] (Table 3) wrote about 50 patients who were enrolled in a prospective study. Patients aged between 50 and 80 years undergoing primary TKA without a history of prior open knee surgery qualified for enrollment. Patients were followed prospectively for 3 months to assess postoperative complications by utilizing a comprehensive perioperative management pathway that was developed and implemented, which combined regional anesthesia with a minimally invasive TKA technique. After specific discharge criteria were met, 48 patients (96%) chose to go home the day of surgery. No intraoperative complications occurred. There were three readmissions, none related to early discharge. This study was designed to only evaluate if TKA outpatient could be performed on a selected group of patients without significant complications due to early discharge. Although the study did demonstrate that TKA outpatient could be performed on a selected group of patients, there were limitations of this study, which should be addressed. First, this study was not a

Table 3 Summary of studies on minimally invasive surgery in total knee arthroplasty

Author	Muller et al[12]	Berger et al[14]	Luscombe et al[22]
Study design	Comparison of both approaches for standard open and MIS-TKA	Prospective study	Prospective study
Outcome measures	All patients were reassessed by two independent investigators using the HSS score	A comprehensive perioperative management pathway and a rehabilitation protocol were developed and were implemented	The primary study endpoint was the postoperative OKS. Secondary endpoints included the American Knee Society Score (AKSS), pains scores and range of motion.
Follow-up period in months	From November 1998 to February 2001	3 months	2 years
Number of patients	30	50	60
Pain perception after surgery	Mean value: 92 (81–98 points): 92 (81–98) Excellent (85–100 points): 24 (80%) Good (70–84 points): 6 (20%) Fair (60–69 points): 0 (0%) Poor (<60 points): 0 (0%)	Of the 50 patients enrolled in this study, 96% were discharged the day of surgery, demonstrating that, for the properly selected patient, outpatient TKA was feasible	Postoperative OKS: 38.3–7.8 AKSS: 91.8–10.5 AKSS (function): 84.0–19.0
Significant differences in advantage of MIS-TKA	All patients in the MIS-TKA group were classified as either excellent or good	With no readmissions, reoperations, or significant complications related to early discharge in this patient group, outpatient TKA was safe in these patients. This study was designed to only evaluated if outpatient TKA could be performed on a select group of patients without significant complications due to early discharge	Four knee replacements required revision for unexplained pain, deep infection, aseptic loosening, and bearing dislocation.
Conclusion	The MIS-TKA resulted in better postoperative results in terms of early recovery and functional outcome without impairing the accuracy of implantation	Outpatient TKA could be done safely in selected patients, there are many unanswered questions. Should this be done, and if so, should this only be done only at specialized, high-volume centers or could this be done in a community practice setting? Lastly, could this be done in outpatient centers where surgeon–owners had more control over the entire process?	Minimally invasive joint replacement was attractive to both patients and surgeons, but was technically demanding with complications inherent to limited access.

randomized control study nor did the authors compare this group with a control group. Although the average length of stay at hospital for patients with traditional approach was about 3 days, they were unable to separately evaluate the variables of surgical techniques, anesthetic technique, and rapid rehabilitation protocols because they related to recovery and early discharge. Future prospective randomized studies should address how each one of these variables affects the patient's recovery.

Other authors[15,16] had also shown that a decreased length of stay did not increase complications after total joint arthroplasty and found that it increased patient satisfaction. Many studies[17,18] cited the implementation of specialized clinical pathways with decreasing the length of stay in total joint arthroplasty. Kim et al[20] in a review article, found that on average implementation of a clinical pathway decreased the length of stay for TKA by 2 days without an increased rate of complications. The authors[20,21] believed that the combination of this comprehensive pathway and the minimally invasive surgical technique was critical to achieving outpatient TKA; addressing and alleviating the patient's apprehension about outpatient TKA was what their comprehensive pathway facilitated. Based on feedback from the patients, there seemed to be four main patient fears to early discharge. These included having uncontrollable pain, developing a complication, having a slower recovery, and being dependent on someone else. Once these fears were dispelled, most patients would rather be discharged to recover at home rather than stay in the hospital.

In addition, these patients were usually independent preoperatively, even with the pain and disability of their

Table 4 Statistical analysis description of the six studies considered

Article	Number of knees considered and surgical procedure adopted	Material and method	Results
Ritter[10]	439 with open standard approach	The Hospital for Special Surgery clinical scoring was collected by an observer	46.2%: no pain 46.7%: occasional pain 7.1%: more pain
Bullens et al[11]	128 with open standard approach	Pearson's correlation coefficient was determined to evaluate the relationship between the satisfaction VAS score and the five other systems: KSCRS, pain VAS, WOMAC pain, WOMAC stiffness and WOMAC physical function	The correlation coefficient in the comparison of the satisfaction VAS with other systems varied between 0.48 and 0.62. The *P* value was significant for all correlation coefficients
Muller et al[12]	38 knees with standard open approach versus 30 cases with a minimally invasive approach	Standard open approach: average for Special Surgery Score of 78 (range 24–99). Minimally invasive approach: average for Special Surgery Score of 92	Standard open approach: Mean value: 78 Excellent: 50% Good: 34% Fair: 13% Poor: 13% Minimally invasive approach: Mean value: 92 Excellent: 80% Good: 20% Fair: 0% Poor: 0%
Elson and Brenkel[13]	622 with open standard approach	A group with no pain and one with severe pain were statistically compared by using the American Knee Society Score	Two groups of knees with a good and poor outcome were selected. There were data available on 462 knees for 385 patients. There were: 380 knees with a pain scoring of 1; 6 knees were excluded from the group; 1 had a deep infection; 5 underwent revision. This left 81% that comprised good outcome group. 50 knees (11%) were not studied. 32 knees had severe pain.
Berger et al[14]	50 with minimally invasive approach	A comprehensive perioperative management pathway and a rehabilitation protocol were developed and implemented	In selected patients outpatient TKA was safe with no short term readmission or complications related to early discharge
Luscombe et al[22]	78 with minimally invasive approach	Firstly, patients were evaluated by Oxford Knee Score (OKS); secondly by American Knee Society Score (AKSS)	Perioperative OKS: 20.6 ± 8.6 Postoperative OKS: 38.3 ± 7.8 AKSS: 91.8 ± 10.5 AKSS function: 84 ± 19 Range of motion: 119.5 Degrees range: 95–140

arthritic knee. Therefore, when the TKA resulted in minimal postoperative pain and anesthesia side effects, they were independent enough to be discharged to home immediately. This study demonstrated that, with a minimally invasive TKA approach and a preemptive pain control strategy, the patient's postoperative pain was manageable in an outpatient setting with only oral analgesia. This was evident from no patient having to stay overnight because of pain and the fact that no patient was delayed in the pathway because of pain.

In 2007, Luscombe et al[22] (Table 3) presented the peak outcome results of the Oxford medial unicompartmental arthroplasty through a minimally invasive surgical incision. This prospective study included 78 Oxford medial unicompartmental knee replacements in 68 patients. At the 2-year review the patients achieved a mean OKS of 38.3. This was not significantly different to the 2-year results of the Phase II Oxford Knee carried out using a standard parapatellar approach when patients achieved a mean OKS of 36.0.

Four unicompartmetal knee replacements required revision for unexplained pain, deep infection, aseptic loosening, and bearing dislocation. MIS-TKA was attractive to both patients and surgeons, but was technically demanding with complications inherent to limited access. This study had also shown that early discharge did not result in short-term readmissions or other postdischarge complications related to early discharge.

Other authors[23,24] had shown that minimally invasive total joint arthroplasty was safe and associated with accelerated recovery. Romanowski and Repicci[25] demonstrated shorter length of stay, less pain, and quicker recovery without increased complications with MIS-TKA. This had been found in other orthopedic knee procedures that have moved to outpatient procedures, such as arthroscopic meniscectomy and anterior cruciate ligament reconstruction.

Although they had shown that outpatient TKA, using a minimally invasive approach, could be done safely in selected patients, there were many unanswered questions. Should this be done, and if so, should this only be done only at specialized, high volume centers or could this be done in a community practice setting? Lastly, could this be done in outpatient centers where surgeon–owners had more control over the entire process? All of these questions were outside the scope of this study; however, the authors continued to perform outpatient total joint arthroplasty daily.

Discussion

All six studies included in this review concluded that both TKA and MIS-TKA were safe procedures that could be performed to relieve pain and offer patients improved function and quality of life (Table 4).[26] It was important to be aware of the patient's past medical history so that it could predict areas that were predisposed to complications and so recognize, prevent, and treat early and effectively.[27]

Since there were many differences in the techniques used for the studies considered, it would be inappropriate to attempt a quantitative meta-analysis on the effectiveness of TKA and MIS-TKA, because the results should be interpreted with caution, since the quality of the studies were variable.

In fact, for TKA with open technique, one study was a randomized clinical trial; one was a survival analysis with the actuarial life-table method with 95% confidence intervals; one was a comparison of both approaches, such as the open and the minimally invasive technique; and one other was a non randomized prospective study. On the other hand, for the MIS-TKA technique, one study was a prospective study and the other was a comparison of both approaches for open and minimally invasive technique. Moreover, it was very difficult to compare patient pain perception after both TKA and MIS-TKA; in fact it was shown that there were poor correlations between subjective and objective complaint regarding pain. Therefore an objective complaint that helped in the comparison between TKA and MIS-TKA postoperative pain perception didn't exist.

Lastly, it was underlined that MIS-TKA was appropriate for most, but not all knees.[28] Because the group of patients that underwent MIS-TKA was small and the available evidence in the literature was less than for the open technique, it was impossible to recommended MIS-TKA specifically for all patients without risks. In fact, the concept of MIS-TKA was definitely exciting but required more long-term studies to support its role. Furthermore, there was definitely a renewed interest in MIS-TKA because of its more physiologic nature, good results, decreased cost, and faster recovery. The success of the procedure depends on strict patient selection, meticulous surgical technique, and proper implant selection.[29] Regardless of the encouraging results with MIS-TKA approach, MIS-TKA was a technically demanding procedure and required adequate surgical experience to prevent complications and implant malpositioning.[30]

Disclosure

The authors report no conflict of interest in this work.

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