Complications of total knee arthroplasty

Alan Cheung*, Seo Kiat Goh, Andrew Tang, Tay Boon Keng

Department of Orthopaedic Surgery, Singapore General Hospital, Outram Road, Singapore 169608, Singapore

KEYWORDS
Total knee arthroplasty; complication; computer navigated surgery; mobile bearing; minimally invasive surgery

Summary
Total knee arthroplasty (TKA) is a safe, cost-effective treatment for alleviating pain and restoring function in patients with knee arthritis who do not respond to conservative treatment. It is a commonly performed procedure worldwide with a high rate of patient satisfaction. Despite this, complications may occur and can cause significant morbidity. This paper describes complications occurring in the early and late postoperative period following primary total knee arthroplasty. We highlight potential complications from newer technologies that may become commonplace in the future, such as computer navigation and minimally invasive surgery.

Introduction
Total knee arthroplasty (TKA) is a safe, cost-effective treatment for alleviating pain and restoring function in patients with knee arthritis who do not respond to conservative treatment. It is a commonly performed procedure worldwide with a high rate of patient satisfaction. Currently, the survival rate of cemented TKA implants using a medial parapatellar approach has been reported to be as high as 98% at 20 years. Mortality rates have also decreased since TKA was first introduced, due to improved anaesthetic agents, surgical techniques and perioperative management. As with all surgical procedures, complications do occur. It is the duty of the surgeon to be aware of such risks in order to counsel the patient preoperatively and anticipate complications during surgery and the postoperative period.

Risk factors for morbidity following total knee arthroplasty
Several studies have attempted to predict factors which may increase complication rates in TKA. Data were analysed from 222,684 patients who had undergone primary total knee arthroplasty in California between 1991 and 2001, for the specific complications of mortality and readmission due to infection and pulmonary embolism. Overall, the mortality rate was 0.53%, infection rate was 0.71% and pulmonary embolism rate was 0.41% in the first 90 days following discharge. Assessment of co-morbidity was made using the Charlson co-morbidity index (Table 1), which is based on assessments of a number of parameters. The most consistent associations with complications were increased age (>65), greater number and severity of perioperative patient co-morbidities (e.g. diabetes mellitus, ischaemic heart disease) and low hospital volume of primary TKA. In one study, a low volume institution was defined as a hospital in which less than 25 TKAs were performed per year,
whereas in a high volume institution, 200 or more TKAs were performed annually. The mortality rate for TKA was reported to be greater in low volume institutions than in high volume institutions (0.73% vs 0.43%).

Another study assessed the effect of hypertension, diabetes, obesity and their combinations on postoperative complications and discharge on 959,839 patients across the United States who had undergone not only knee, but also hip and shoulder arthroplasty, between 1998 to 2000. Patients with any of the three co-morbidities were more likely to have a postoperative complication.

With regard to when fatal or near-fatal complications occur, 1,636 patients who had undergone primary total arthroplasties of the knee (n = 670) and hip between July 2004 to July 2005 were evaluated. The mortality rate was 0.06% and 104 life-threatening complications occurred. 90% of these complications occurred within the first four days following surgery. Increasing age, obesity and co-morbidities were important predictors of a complication occurring, although 58% of patients had no identifiable predisposing factors.

Immediate and early complications

Infection

Infection in a prosthetic total knee joint is a serious complication, which can be difficult to treat (Fig. 1). Reports of infection rates vary from 0.5 to 12%. Hinged prostheses, rheumatoid arthritis and previous knee surgery are all associated with an increased risk of infection. Laminar flow theatres, effective antibiotic prophylaxis, occlusive clothing, chlorhexidine lavage, and ‘ring fencing’ of orthopaedic beds are all factors that may decrease infection rates. The treatment options for infected total knee replacement are beyond the scope of this paper.

Deep vein thrombosis and pulmonary embolism

Thromboembolic disease is a potentially serious complication of TKA. The incidence of isolated calf thrombi has been reported to be 23.8 to 60%, and of proximal thrombi of the lower limb, between 3 to 20%. It is generally held that those patients with proximal thrombi are at greater risk of suffering a pulmonary embolism, but the significance and treatment of calf thrombi is controversial. Potential disadvantages of routine DVT prophylaxis following TKA include bleeding and wound problems as well as cost, drug side-effects and inconvenience for the patient.

The natural history of deep vein thrombosis (DVT) in 227 patients undergoing primary TKA was prospectively evaluated using ultrasonography and venograms. The findings were that the DVT rate was around 41% in both unilateral and simultaneous bilateral TKAs without DVT prophylaxis. There was no difference in DVT occurrence between cemented and uncemented TKAs. However all thrombi regardless of size or location resolved without causing pulmonary embolism at six months.

In another study, 675 patients undergoing TKA were evaluated over a 13-year period. The incidence of symptomatic DVT and PE was 1.6% and 0.6% respectively, and the median time to presentation of DVT and PE in this cohort was twenty and twelve days respectively. Around half of these cases presented following discharge. However, the benefit of thromboprophylaxis after discharge for TKA patients has not been demonstrated.

A Canadian study evaluating 310 patients undergoing major orthopaedic surgery over a nine-month period identified those patients at higher risk of DVT despite thromboprophylaxis. Overall, patients undergoing TKA were at greater risk of DVT than those undergoing total hip replacement (THA) and hip fracture surgery (incidence of DVT 26%, 10% and 9% respectively).
Type and duration of thromboprophylaxis used following TKA remains controversial and there appears to be no universal consensus. Thromboprophylaxis may include aspirin, heparin, low molecular weight heparins (LMWH’s), warfarin and intermittent pneumatic calf compression devices. In a meta-analysis of 23 studies involving 6001 patients assessing efficacy of the above, intermittent pneumatic compression devices with low molecular weight heparin were significantly better than warfarin or aspirin in preventing DVT. A multimodal thromboprophylactic regimen based on risk may be useful to prevent DVT/PE while limiting complications from prophylaxis.

Neurovascular injury

A survey conducted upon the members of the American Association of Hip and Knee Surgeons showed that 78% of responding surgeons had been named as a defendant in at least one lawsuit alleging medical malpractice. Nerve injury was the most commonly cited source of litigation, followed by limb length discrepancy, infection, vascular injury, hip dislocation, compartment syndrome, deep vein thrombosis, chronic pain, and periprosthetic fracture.

The total incidence of nerve palsy after TKA has been reported between 0.9% and 1.3%. In a retrospective review of 1476 primary TKAs performed between 1970 and December 1998, nineteen patients with a documented neurologic complication were identified, with an overall incidence of 1.3%. In this series the common peroneal nerve was the commonest nerve to be injured (79%). Isolated cases of brachial plexus neurapraxia, sacral plexopathy, and sciatic neuropathy have also been reported. Conditions associated with peroneal nerve injury after TKA include flexion contracture, valgus deformity, postoperative epidural analgesia, external leg compression, increased tourniquet time, postoperative haematoma, and history of nerve root compression.

Vascular injury following TKA, although rare, may have disastrous sequelae. The popliteal artery is the commonest major vessel at risk. Use of a tourniquet is contraindicated in TKA in the presence of peripheral vascular disease. A retrospective analysis of acute arterial injuries following TKA was performed involving 23,199 TKAs (13,618 total, 11,953 primary, 1665 revision) between 1989 and 2002 at a single centre in the USA. Acute arterial complications were associated with 24 TKA procedures (0.17%). Of these patients with arterial complications, seventeen underwent first-time unilateral (n = 11) or simultaneous bilateral (n = 6) knee replacement procedures and seven underwent repeat unilateral knee operations. Patients undergoing revision TKA procedures were twice as likely to require arterial surgery compared with patients undergoing primary TKA (0.36% vs 0.15%). Data regarding tourniquet use was unavailable in this series. Arterial complications included acute lower-limb ischaemia alone in eighteen patients, involving primarily the popliteal artery and common femoral artery, although one case of distal emboli to the anterior tibial artery branches was reported. Bleeding alone occurred in four patients, and arterial transection (three popliteal, two common femoral) occurred in five patients resulting in both ischaemia and bleeding, and popliteal artery pseudoaneurysm was identified in five patients. No deaths were reported, and limb salvage was achieved in all patients.

Wound complications

Superficial wound complications following TKA are common and include erythema, superficial surgical site infection, postoperative drainage and skin necrosis (Fig. 2). Differentiating superficial from deep infection is vital. As previously discussed, infection risk increases with the number of patient co-morbidities and other factors. Old scars may be problematic and reopening a recently healed medial incision or conversely, a long healed lateral scar may be the best choice to preserve skin vascularity in TKA. A plastic surgical opinion may be helpful following burns or multiple previous surgeries. Careful handling of soft tissues and skin edges during TKA is important. The use of drains is controversial. Drains may increase blood loss and transfusion rates postoperatively but reduce the need for a reinforced wound dressing. Postoperative thromboprophylaxis has been discussed previously and may increase wound complications. Intermittent pneumatic foot pumps may be preferable to avoid side effects of haemorrhage, haemarthrosis and persistent wound discharge.

Periprosthetic fracture

Periprosthetic patellar fractures may be the commonest fractures complicating total knee arthroplasty (Table 2). Up to 80% may be asymptomatic and detected only upon radiographic follow-up. The reported prevalence ranges from as low as 0.11% to as high as 21.4%. The Mayo Clinic Joint Registry reports a rate of periprosthetic patellar fracture of 0.68%, based upon 12,000 primary total knee arthroplasties over a thirteen-year period. Type 1 fractures are frequently asymptomatic and can often be treated successfully by non-operative methods. In Type 2 fractures the extensor function must be restored by operative treatment, as non-operative management would likely result in poor extension. Complications are common in the treatment of these fractures. Type 3 fractures with

Figure 2  Superficial wound infection
Adequate bone stock (type 3A) have been treated with revision or resection and patelloplasty. Inadequate bone stock (type 3B) requires partial or complete patellectomy with advancement and repair of the extensor mechanism.28 The risk of a patellar fracture in association with a total knee arthroplasty is lower intra-operatively than it is in the postoperative period. Predisposing intra-operative factors include aggressive clamping of the patella during the resurfacing, over-reaming of the patella, slippage of the reamer, aggressive bone resection with <10 to 15 mm of patellar bone stock left remaining, thermal injury and bone necrosis due to polymethylmethacrylate cement, particularly in a patient with poor bone stock. Postoperatively, periprosthetic patellar fractures can result from direct trauma, or indirectly by eccentric quadriceps muscle contraction. Implant design risk factors include a large central peg requiring increased bone resection acting as a stress riser. Cementless metal-backed or press-fit implants and posterior-stabilized total knee prostheses lead to higher contact stresses across the patellofemoral joint and are also risk factors for fracture. When the remaining patella is <10 mm thick, a new patellar component should not be implanted. Treatment options include non-operative management; open reduction and internal fixation, occasionally in combination with partial or total patellectomy; revision total knee arthroplasty with replacement of all three components; or isolated revision of the patellar component.29

The incidence of supracondylar femoral fractures above TKAs has been reported to be between 0.3% and 2.5% (Fig. 3). Risk factors include osteopenia, femoral notching, rheumatoid arthritis and poor flexion. Depending on the type and severity of fracture, patient condition and surgeon’s preference, treatment options include conservative management, retrograde intramedullary (IM) nailing, flexible IM nailing, revision arthroplasty using a long IM stem, conventional plate-and-screw fixation and the Less Invasive Stabilization System (LISS).30

Periprosthetic tibial fractures are less common than patellar or supracondylar fractures. In general, well-fixed, undisplaced fractures (Type 1–4A) may be treated non-operatively with protected weight-bearing and brace or cast immobilization. Unstable, displaced fractures (Type 1–3B) usually require revision arthroplasty with a long stemmed prosthesis. Type 4B fractures require open reduction and internal fixation.31

Stress fractures of the pelvis and femoral neck following TKA are uncommon. They may result from intra-operative technique or a postoperative fall. They are associated with profound osteopaenia, and are treated according to the type of fracture.32 Periprosthetic fractures following computer navigated surgery are discussed in a later section.

The successful treatment of periprosthetic fractures about a TKA has been described as the absence of knee pain, fracture union in less than 6 months, range of motion from 0° to 90°, and a return to normal ambulatory status.33

Pain

TKA is an effective method of relieving pain in a degenerative joint, with high satisfaction rates. Inevitably there will be some degree of pain during the initial postoperative period. There are numerous methods to counter this, for example regional anaesthesia including spinal anaesthesia;
epidural anaesthesia with or without indwelling catheters for 24 or 48 hours; combined spinal/epidurals; intrathecal morphine; extended-release epidural morphine; nerve blocks; local periarticular injections; continuous post-operative infusion of a local anaesthetic, also oral/intramuscular/intravenous/rectal and patient controlled analgesia, as well as patient education, motivation and an appropriate, effective rehabilitation programme. The advantages, disadvantages and side-effects of these methods are beyond the scope of this review.

Stiffness

The incidence of stiffness after TKA has been reported at between 1.3% and 12%. Stiffness may be the result of improper implant position or size, inadequate bone resection, improper soft-tissue balancing, anterior tibial slope, instability, infection, reflex sympathetic dystrophy, heterotopic ossification, poor patient compliance, poor pain management or subacute infection.

A study evaluating patient factors contributing to pain and stiffness after TKA identified 71 patients at 1-year follow-up as having a poor result because of either stiffness or pain. Radiographs demonstrated well-fixed and aligned implants. These patients were compared to a matched control group of 148 patients with non-painful or stiff TKAs. Factors that were significantly associated with a stiff or painful outcome included female sex, higher body-mass index, previous knee surgery, patients on disability, diabetes mellitus, pulmonary disease, and depression.

Management of a stiff, painful TKA may vary according to the cause, and patient/surgeon preference. In one study, 33 patients presented with persistent pain, inadequate knee motion, or both after TKA. 26 of these patients had inadequate motion treated by closed manipulation, arthroscopic manipulation, or a modified open release manipulation. In 23 patients, these procedures were successful. Of the 26 patients, 85% had a history of previous knee surgery or diabetes mellitus. Performing manipulation early or late (before or after 12 weeks) did not affect outcome. Four patients had failure of bonding between the polymethylmethacrylate cement and the implants, three patients had painful fibrous intra-articular bands. These patients were treated successfully either by re-cementing the components or by arthroscopic release.

Another study compared 112 TKAs with stiffness (arc of motion of <90° at one year) with 224 matched control TKA’s with >90 arc° of motion at one year. Factors predisposing women to stiffness included young age, lower body-mass index, a high femoral flexion angle, and the presence of patella baja. Only patella baja was a significant predictor in males.

Complications contributing to prosthetic failure

Osteolysis and wear

Debris displaced from the articular and backside surfaces of the polyethylene inserts of modular tibial components may be a primary cause of osteolysis and subsequent failure of TKAs. Many factors contribute to the generation of wear particles including surface abrasion and subsurface oxidation (Fig. 4). Sterilisation of TKA inserts in inert gases rather than gamma radiation in air is thought to result in improved crosslinking of ultra-high-molecular-weight polyethylene (UHMWPE), resulting in decreased wear and subsequent osteolysis. Controversy exists as to the exact mechanism by which this occurs. Sterilization by gamma irradiation in air has been shown to have the potential to accelerate the oxidation of polyethylene components resulting in reduced mechanical properties. Analysis of 1635 retrieved polyethylene knee bearings showed that retrieved polyethylene knee components that were gamma-irradiated in air had a high incidence of delamination and cracking, leading at times to complete wear-through of the bearing. Knee components sterilized with ethylene oxide showed minimal evidence of fatigue damage even after in vivo durations in excess of 15 years. Several investigators have attempted to eliminate osteolysis by polishing the baseplate surface and sterilizing the insert with means other than gamma irradiation in air. A radiographic follow-up study was performed upon 365 posterior cruciate ligament (PCL) retaining Anatomic Modular Knee primary TKA’s performed in 300 patients from 1987 to 1998. Osteolysis was identified in 34% (n = 82) of 242 knees treated with an insert that had been gamma-irradiated in air and affixed to a rough baseplate surface, and identified in only 9% (n = 9) of ninety-eight knees treated with an insert that had been gamma-irradiated in an inert gas, or had not been irradiated, and joined to a polished surface. Osteolysis...
was associated with six factors, including one related to the patient (male gender), one related to the tibial baseplate (the proximal surface finish), three related to the polyethylene insert (the material from which it was machined, the sterilization method, and the shelf age), and one related to the technique (hyperextension of the femoral component relative to the tibial component).41

A similar study compared the incidence of wear-related failures in 1183 second-generation press-fit condylar prostheses having inserts packaged and sterilized in an oxygen-free environment at a minimum 5-year follow-up (mean, 7.0 years) with 1287 first-generation press-fit condylar modular knees having inserts sterilized by gamma irradiation in air at 5-year minimum follow-up (mean, 7.8 years).42 The wear-related failure rate for the second-generation design was 1.1% and 10-year survivorship was 97.0% compared with 8.3% failure and 87.7% 10-year survival for the first-generation design. For second-generation components, patient age was the only variable correlated with wear-related failure. For first-generation components sterilized in air, shelf age of the polyethylene insert was the most important factor, as well as male gender, a young age, the type of polyethylene from which the insert had been machined (the sheet supplier and the type of resin) and the insert tumbling method (a process used to remove rough edges from the bearing) for increased rates of osteolysis.43

The average volumetric wear rate of a cemented modular tibial insert (Anatomic Modular Knee; DePuy) has been calculated at $138 \pm 95 \text{mm}^3/\text{yr}$ based upon retrieval analysis studies upon 15 polyethylene tibial inserts retrieved on average, 91 months after implantation.44 Insert design also has a bearing upon backside wear. 124 polyethylene tibial inserts were retrieved after an average of 50.7 months after implantation. Moderate-to-severe wear of the non-articulating surface of the tibial insert was frequently observed in all designs of knee prostheses. The term burnishing was used to describe highly polished areas in which any machining marks present on the original surface had been removed by creep or polishing. Pitting described shallow, irregular voids in the polyethylene surface. In components with screw-holes in the tibial baseplate, protrusion of the polyethylene insert was measured. Across all implant designs, pitting was observed in 90% of the retrieved specimens; burnishing, in 77%; and protrusion, in 61%. Overall, implants of the IB-II (Install-Burstein-II) design (Zimmer) exhibited the most severe burnishing, whereas those of the Duracon design (Howmedica) had the most severe pitting. Severe protrusions were noted with inserts of one design (AMK [Anatomic Modular Knee]; DePuy). A longer time in situ was associated with larger polyethylene protrusions, but the severity of pitting and burnishing did not increase with increasing duration of implantation.45

To counter the effects of backside wear, implant designs involving an all polyethylene and also mobile-bearing platform have been developed.

**Tibial mobile-bearing platforms**

The purported advantages of a mobile bearing are to reduce both wear and loosening. So far mobile-bearing TKAs have shown acceptable survival rates in the mid-term, for example the Rotaglide prosthesis (Corin Ltd, Cirencester, UK) having an estimated survival probability of 93.5% at 9 years.46 Several studies have shown no significant difference in functional outcome between fixed and mobile-bearing knees in the early and mid-term following TKR, although concerns regarding instability and bearing dislocation have been raised.

In one randomised controlled trial (RCT) involving single stage bilateral TKR, the 3-year outcome of a mobile-bearing prosthesis (Total Meniscal Knee, Biomet, Europe) in one knee and a fixed-bearing TKA in the other (Anatomic Graduated Condylar, Biomet, Europe) in 40 patients was described. No significant differences were found in outcome (American Knee Society Score and Oxford Knee Score) between the two prostheses. A greater incidence of ‘clicking’ was found in the mobile-bearing knee. A separate multi-centre cohort of 172 patients who had undergone unilateral arthroplasty with the mobile-bearing implant showed an ‘acceptable’ complication rate although some patients complained of subjective instability.47

In a similar study over a longer term period, 146 patients received an anatomic modular knee fixed-bearing TKA in one knee and a low contact stress rotating platform mobile-bearing TKA in the other. The mean follow-up was 13.2 years. No significant difference was found between the two types of implants using the Hospital for Special Surgery and the Knee Society scores pre-operatively and at the final review. In the anatomic modular knee group, one knee was revised because of aseptic loosening of the tibial component and one because of infection. In addition, three knees were revised because of wear of the polyethylene tibial bearing. In the low contact stress group, two knees were revised because of instability requiring exchange of the polyethylene insert and one because of infection.48

An international multi-centre study investigated primary TKA with a mobile-bearing design involving 4743 TKAs between 1981 and 1997. 324 implants retained both cruciate ligaments, 2165 retained the posterior cruciate, and 2254 sacrificed both cruciates. The patella was resurfaced in 2838 and left un-resurfaced in 1905. The overall survivorship was 79% at 16 years follow-up. Revision occurred in 259 (5.4%) knees out of the entire cohort. The risk adjusted rates of failure were higher in females, younger patients, osteoarthritis, post-traumatic arthritis, and in patients who had a meniscal bearing prosthesis or patellar resurfacing. The most common cause of revision was bearing-related issues including chronic instability, bearing subluxation, bearing dislocation, or bearing wear in 2.3%.49

**Cementless total knee arthroplasty**

Cementless TKA implants were designed to reduce wear and subsequent osteolysis from cement debris, and preserve bone stock in younger patients. Some types of cementless implants have achieved excellent survivorship in the long term of between 96.1% to 98.3% at 18 years.50,51 However, cementless TKAs may be associated with a specific set of complications such as poor fixation, aseptic
Several MIS techniques have been described which above reasons to use MIS in TKA, particularly in the long have been raised regarding lack of evidence to support the ions has yet to be defined for patients following knee contact dermatitis remains unproven, but rarely a rapid, ultimately lead to implant failure. Skin patch testing for T cell-mediated, allergic response may occur which may being four times greater in patients who had symptoms of TKA. In a study of 94 patients, TKA failure was reported as metal hypersensitivity may be a predictor for failure of Metallosis, metal allergy and metal ions

Metallosis is a rare cause of implant loosening, demineralization of bone and subsequent fracture following TKA. Perhaps of greater concern is the effect of metal ion debris (eg. cobalt, chromium), which have shown raised serum level concentrations following TKR. A safe level for metal ions has yet to be defined for patients following knee arthroplasty. Longitudinal studies of large numbers of patients will ultimately be required to answer specific clinical concerns.

Sensitisation to metals following TKA is an uncommon phenomenon, and the majority of patients show no immune system reaction to metals following TKA. A causal link to contact dermatitis remains unproven, but rarely a rapid, T cell-mediated, allergic response may occur which may ultimately lead to implant failure. Skin patch testing for metal hypersensitivity may be a predictor for failure of TKA. In a study of 94 patients, TKA failure was reported as being four times greater in patients who had symptoms of metal hypersensitivity before surgery.

Special considerations

Minimally invasive surgery

The advantages of Minimally Invasive Surgery (MIS) in TKA are purported to be improved wound cosmesis, faster patient recovery time and subsequent decreased length of hospital stay and improved function compared to a standard TKA approach. TKA using MIS has even been described as a day case outpatient procedure. Concerns have been raised regarding lack of evidence to support the above reasons to use MIS in TKA, particularly in the long term. Several MIS techniques have been described which minimize quadriceps damage, and avoid patellar eversion and tibial dislocation: mini-arthrotomy, mini-midvastus, medial quad-sparing, mini-subvastus and direct lateral. The mini-arthrotomy technique uses a smaller medial parapatellar arthroscopy than a traditional medial parapatellar arthroscopy does. The mini-midvastus technique has an arthroscopy that extends 2 cm or more into the vastus medialis muscle. The medial quad-sparing approach uses a more medial incision and avoids a quadriceps arthroscopy. The mini-subvastus approach, uses an anterior approach and a quad-sparing arthroscopy. The direct lateral approach utilizes an 8 to 10 cm incision from below Gerdy’s tubercle to the lateral epicondyle lateral to the patella.

Several studies have shown MIS to be as effective as a standard approach when performing TKA, but have not demonstrated superiority in the long term. A single surgeon performed 200 consecutive primary total knee arthroplasties using identical implants. Half were performed using a traditional medial parapatellar arthrotomy. The other half were performed using a medial parapatellar approach combined with minimally invasive surgical techniques. Patients in the minimal incision group had shorter incision length, shorter length of stay, and less pain as well as less flexion contracture and better flexion in the first 12 weeks. Manipulation was necessary in 14% of the traditional group compared with 2% in the minimal incision group. There was no significant difference in range of motion or functional outcome at 1 year after surgery, or in component position and complication rates.

A prospective, randomized, multi-centre study was performed comparing the midvastus approach to a standard medial parapatellar approach for TKA in 80 knees. There were no differences in blood loss, operative time, infection rate, and ultimate wound healing. Early clinical and radiographic results were similar. At 12 weeks follow-up, there was no difference in mean Knee Society objective and functional scores.

A substantial learning curve may exist with MIS techniques, which may be unacceptably long for surgeons performing low volumes of TKA. The first 100 minimally invasive total knee arthroplasties done by a single surgeon were compared with his previous fifty procedures performed through a medial parapatellar approach. The minimally invasive approach took significantly longer to perform than a medial parapatellar approach (86.3 and 78.9 minutes, respectively) and the operative times in the first twenty-five patients in the MIS group were particularly long (mean = 102.5 minutes). The first twenty-five minimally invasive procedures had significantly less patellar resection accuracy and significantly more patellar tilt than the last twenty-five. The patients who had the minimally invasive approach demonstrated significantly better clinical outcomes with respect to the length of hospital stay, need for inpatient rehabilitation after discharge, analgesia at two and six weeks postoperatively and the need for walking aids at two weeks.

A randomized controlled trial compared the radiologic outcomes of total knee arthroplasty using the conventional technique with minimally invasive surgery (MIS) techniques. Ninety patients were randomized to undergo conventional (control), mini-incision midvastus, or side cut (direct lateral) techniques for their total knee arthroplasty. Long-leg radiographs were assessed postoperatively. The mean overall limb varus alignments were 1.0° (SD, 2.58°) for the control group, 0.87° (SD, 2.96°) for the mini group, and 0.37° (SD 4.27°) for the side cut group. The mean overall limb alignments within ±3.0° varus/valgus were 83.3%, 83.3%, and 56.7%, respectively. Femoral implant placement and overall limb alignment in the side cut group were significantly poorer as compared with those in the control group. The side cut group also had more outliers in the coronal plane. Results were
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comparable between the mini and control groups. The side cut technique appeared to affect the accuracy of implant placement adversely.\textsuperscript{67}

In summary, although MIS techniques have shown early promise, they have not yet been proven to be superior to standard TKA approaches.

Computer navigation in TKA

Computer navigation for TKA allows accurate positioning of the components relative to the mechanical axis of the limb. It may enhance soft-tissue balancing, resulting in improved functional outcome, and theoretically the improvement in alignment should also reduce the rate of wear giving an increase in the longevity of the prosthesis. A rare complication of computer navigation is stress fracture at the pinhole site for the navigation trackers, which may be tibial or femoral.\textsuperscript{68} Pin placement has been cited as a factor, but exact location of pin placement remains controversial. Bicortical or even unicortical fixation may be superior to transcortical pin placement. Any reported pain in the thigh or tibia after the initial healing period of three to four weeks following computer-assisted TKA should be considered a potential stress fracture.\textsuperscript{69}

It is acknowledged that using computer navigation to perform TKA, one may obtain a significant improvement in alignment compared to non-navigated TKA.\textsuperscript{70} Short-term studies comparing computer navigated to standard TKA, however, have shown no difference in functional outcome despite the better alignment achieved with computer navigated surgery.\textsuperscript{71} Longer term studies may be required.

One particular area in which computer navigation may prove particularly useful is in combination with MIS to perform TKA. A prospective randomized study determined the rate of functional recovery and radiographic accuracy of 108 consecutive patients who underwent computer navigated (DePuy/Brainlab, Munich, Germany) minimally invasive (mini medial parapatellar approach) TKA (DePuy International) or conventional total knee TKA. Patients who underwent computer navigated minimally invasive TKA had a significantly longer operative time (by a mean of twenty-four minutes) and a significantly shorter inpatient stay (3.3 compared with 4.5 days) in comparison with those who underwent conventional arthroplasty. Significantly more patients in the computer-assisted minimally invasive total knee arthroplasty group were able to walk independently for more than thirty minutes at one month. The percentage of patients with a coronal tibio-femoral angle within $\pm 3^\circ$ of the ideal was 92% for the computer-assisted minimally invasive total knee arthroplasty group, compared with 68% for the conventional total knee arthroplasty group. The authors concluded that although the computer navigated minimally invasive TKAs had improved functional recovery in the first month compared with the conventional TKAs, the main advantage of this technique was improved post-operative radiographic alignment without increased short-term complications.\textsuperscript{72}

Conclusion

This paper has described complications occurring in the immediate or early postoperative period, and medium to long term following primary total knee arthroplasty. We have also highlighted potential complications from newer technologies that may become commonplace in the future such as computer navigation and minimally invasive surgery.

Large longitudinal studies indicate that patients with comorbidities are at greater risk of complications. Proper preoperative workup of patients to optimize their pre-existing conditions is required. Knowledge of potential complications is necessary to obtain informed consent from the patient. Intra-operatively, use of antibiotics, meticulous surgical technique and careful handling of soft tissues, in a laminar flow theatre using the proper sterile precautions can reduce the incidence of infection, which is a potential disaster following TKA. Methods of thromboprophylaxis vary between surgeons, but at least the potential benefits and risks of each method should be understood. How the prosthesis is implanted will affect the long term survival rates secondary to wear and osteolysis. Enthusiasm for the introduction of newer technologies should be tempered by the lack of long-term evidence to support their use. The cemented total knee arthroplasty using a conventional medial parapatellar approach without computer navigation remains the gold standard.

References

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