

Systematic review of periprosthetic tibia fracture after total knee arthroplasties

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Abstract

AIM: To investigate the known incidences, treatment options, and related outcomes of periprosthetic tibia fractures after total knee arthroplasty (TKA).

METHODS: A literature search was done to identify studies that fit the inclusion criteria. The database search yielded 185 results, which were further reduced by the exclusion criteria to 13 papers, totaling 157 patients that met these criteria. Incidence rates of the different types of periprosthetic tibia fractures were determined and their treatments were subsequently analyzed based on the fracture's subclass, with patient outcomes being overall favorable.

RESULTS: Of the 144 documented patients, 54 (37.5%) had a subclass C fracture, which are frequently seen in revision arthroplasties or when using cement intraoperatively. The fractures of subclasses A and B occur postoperatively. There were 90 subclass A and B fractures with incidences of 18.75% and 43.75% respectively. When broken down by type, 62 (55.36%) were type 1, 24 (21.4%) were type 2, 24 (21.4%) were type 3, and 2 (1.8%) were type 4. Furthermore, from the studies that included origin of injury, the types were further classified as having non-traumatic or traumatic origins. Type 1 had 78% (40/51) non-traumatic origin and 22% (11/51) traumatic origin. Fifteen fractures were type 2, but 5 were falls and 1 through a motor vehicle accident, giving a trauma causation of 40% (6/15). Of the 24 type 3 fractures, 12 were falls and 2 vehicular accidents, leading to a trauma causation of 58% (14/24).

CONCLUSION: Type 1 fractures were the most common. Subclass A was treated with locking plates, B required a revision TKA, and C was treated intraoperatively or nonoperatively.

Key words: Periprosthetic fractures; Literature review; Tibia fractures

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Core tip: A literature search of the PubMed and Web of Science databases was done to compile the known incidences and treatments of periprosthetic tibia fractures after total knee arthroplasties (TKA). Among the relatively uncommon periprosthetic tibia fracture, type 1 fractures were the most common among documented types. Subclass A fractures were treated with locking plates, subclass B fractures first required a revision TKA, and subclass C fractures were either treated intraoperatively when they occurred or were treated nonoperatively.

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INTRODUCTION

As of 2010, there were approximately 500000 total knee arthroplasties (TKAs) being performed annually in the United States, with that number increasing each year^[1]. After such a procedure, subsequent complications can no longer be treated with the same initial methodology that would be used for non-TKA patients, and so surgeons must approach each case with new treatments. One such complication is the occurrence of periprosthetic tibial fractures.

The incidence rate of periprosthetic tibial fractures after TKA is less than 1%^[2], but with the increasing quantity of TKAs being performed each year, the absolute number of periprosthetic tibial fractures is also increasing^[3]. However, due to its relatively scarce occurrence, very little research has been done on the subject. A meta-analysis of periprosthetic tibia fractures has not yet been done and so the purpose of this review is to compile the studies done on periprosthetic tibial fractures after TKA and analyze the procedures used for treatment. The focus will be on treatment method for the particular classification of fracture and the anatomical and functional outcome.

MATERIALS AND METHODS

To locate the publications used in this review, PubMed and Web of Science databases were searched for the key term "periprosthetic tibia fracture". From the given results, studies were individually either included or excluded. Criteria for inclusion were the following: (1) Patient must have a fracture of the tibia; and (2) Patient must have undergone a TKA.

Multiple fractures and intraoperative fractures were included. Results that appeared in multiple searches,

were not from a human, or were simply a documentation of treatment methods were excluded.

Preliminary data from these studies was organized into an excel spreadsheet for analysis. Important information included study dates, fracture classifications, number of patients, treatment methods, anatomical outcomes, functional outcomes, and any complications encountered during the process. This data was qualitatively and quantitatively analyzed for successful and unsuccessful patterns as well as novel techniques that require further attention.

RESULTS

The database searches yielded 185 results, which were then further reduced based on the inclusion and exclusion criteria from Section 2.65 of the results. Those studies that were eliminated included redundant studies, 8 results that focused on a unicompartamental arthroplasty, 1 result that was of a canine tibia, 59 results that did not actually have a tibia fracture, and 39 results that did not have any patient data. After the exclusion of these papers, only 13 papers were left that fit the inclusion criteria. This breakdown is graphically shown in Figure 1. The papers are shown in Table 1.

Classification

The majority of the papers used the Felix classification system to identify the fracture type associated with the periprosthetic tibia fracture. Simply, there are 4 fracture categories: type 1 are those that extend partially across the tibial plateau, type 2 fully cross the tibial plateau, type 3 are across the tibial shaft past the tibial stem of the prosthesis, and type 4 involve the tibial tuberosity. Each of these types can be further categorized into subclasses: (1) having a stable prosthesis; (2) having an unstable prosthesis; or (3) occurring intraoperatively^[10]. This breakdown can be seen in Table 2.

Causes of fractures

Many of the studies did not provide a direct cause for the fractures, instead focusing on the fracture itself and the treatment used. However, a limited number of studies did include this information and, therefore, will be the only studies included here.

Of the 144 documented patients, 54 had a subclass C fracture. These fractures, by definition, occur intraoperatively. A variety of sources can cause subclass C fractures, but they are frequently seen in revision arthroplasties or when using cement.

The fractures of subclasses A and B occur postoperatively. There were 90 subclass A and B fractures. Fifty-one were type 1 and mainly occurred non-traumatically: 8 were through a fall and only 3 were caused by a more major traumatic event. This means only 22% (11/51) of type 1 fractures were caused through trauma. Fifteen fractures were type 2, but only 5 were through falls and 1 through a motor vehicle accident, giving a trauma causation of 40% (6/15). Of the 24 type 3 fractures, 12

Table 1 Studies included in this review

Ref.	Number of patients	Fracture type	Treatment method
Agarwal <i>et al</i> ^[2]	2	Type 2	Revision TKA and locking plate
Cipriano <i>et al</i> ^[4]	16	Subclass C	13 were nonoperative and 3 were braced
Alden <i>et al</i> ^[5]	18	Subclass C	Observation
Thompson <i>et al</i> ^[6]	7	Not stated	Not stated
Jeong <i>et al</i> ^[7]	1	3A	Reduction and revision of tibial stem component
Beharrie <i>et al</i> ^[8]	1	3B	Revision TKA with long stemmed tibial component and bone grafting
Ruchholtz <i>et al</i> ^[9]	NA	NA	No patients, only offered treatment methods for various fracture classifications
Felix <i>et al</i> ^[10]	102	All types	Many different methods were used depending on the fracture type
Watanabe <i>et al</i> ^[11]	1	Not stated	Revision TKA with long stemmed tibial component
Cordeiro <i>et al</i> ^[12]	1	Not Stated	Revision TKA
Fonseca <i>et al</i> ^[13]	1	1B	Revision TKA
Tabutin <i>et al</i> ^[14]	6	3A	Intramedullary nailing
Banim <i>et al</i> ^[15]	1	3C	Cables and plate, with reduction

TKA: Total knee arthroplasty; NA: Not available.

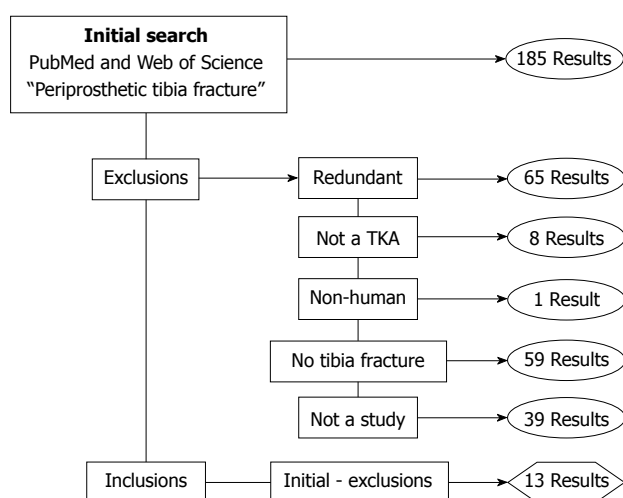
Table 2 Breakdown of the types and subclass for diagnosing periprosthetic tibia fractures, as described by Felix *et al*^[10] in her 1997 study

Type	Description	Subclass	Description
1	Partial tibial plateau	A	Stable prosthesis
2	Full tibial plateau	B	Unstable prosthesis
3	Distal tibial shaft	C	Intraoperatively
4	Tibial tuberosity		

Table 3 Breakdown of the incidents of types and subclasses of fractures

Type	Incidents	Subclass	Incidents
1	62	A	27
2	24	B	63
3	24	C	54
4	2		
Total	112	Total	144

The total number of patients in the review was 154, but not every patient was classified fully.

**Figure 1** Flowchart of article exclusion from the PubMed and Web of Science database searches. TKA: Total knee arthroplasty.

occurred through falls and 2 through vehicular accidents, leading to a trauma causation of 58% (14/24).

Diagnosis

As stated before, the incidence rate of periprosthetic tibia fractures is very low, and so diagnostic methods have yet to be standardized. Frequently, a periprosthetic tibia fracture can be clinically diagnosed using the same methods that would be utilized to diagnose a typical tibia fracture. In order to classify the fracture according to the Felix system, however, a radiological evaluation is

required. This is important as treatment methods, to be described in section 4D, differ based upon the fracture classification.

From the studies, not every patient's fracture was fully classified according to the Felix system - several only stated the type or the subclass. Taking this into account, the sum of the breakdown of the types will not add up to the total number of patients in the study. This data is shown in Table 3.

As for incidence rate, of the 144 categorized by subclass, 18.75% (27/144) were subclass A, 43.75% (63/144) were subclass B, and 37.5% (54/144) were subclass C. The large portion of subclass C fractures is misleading due to the fact that many of them did not require any treatment. The subclass B fractures, however, are important as these fractures typically require additional surgery and because they are the most prominent. When broken down by type, of the 112 classified, 55.36% (62/112) were type 1, 21.4% (24/112) were type 2, 21.4% (24/112) were type 3, and 1.8% (2/112) were type 4. A vast majority of the cases were type 1, which is the smallest of the possible fractures as it does not span the width of the bone. Type 2 and 3 fractures were equally prominent. Type 4 fractures, however, appear very rare and an analysis of them is hard to obtain with such a small sample size.

Treatment

Treatment of the various fractures seemed to follow a

pattern based on the subclass for the fracture. Patients with a subclass A fracture typically were treated as normal, that is, as one would be treated without a periprosthetic tibial fracture. This could encompass anything from weight bearing restrictions to nails, depending on the severity of the fracture. Of the 27 cases of subclass A fractures: 6 were treated with intramedullary nailing, all of which were type 3; 2 were treated with extension immobilization and screw fixation, both were type 4; and the rest were treated with either a cast or weight bearing restrictions. Furthermore, these fractures tended to heal as typical fractures and showed little complications.

Patients with subclass B fractures were initially treated in either one of two ways: either they had a revision TKA or they did not. Besides the revision TKA, the fracture itself was treated as normal. There were 63 subclass B fractures, of which only 28 did not immediately undergo revision TKA. For the 40 that underwent revision TKAs, the fractures healed without complications. For those that were simply treated without a revision TKA; however, complications arose in 23 and a revision TKA needed to be done later in order to resolve those issues. Another article did not provide numbers of patients diagnosed with subclass B fractures, but all of them were said to have undergone revision TKA^[9]. From the data gathered, it seems that an unstable prosthesis requires a revision TKA before one can address the periprosthetic tibia fracture.

Subclass C fractures tended to be the least severe. Of the 54 type C fractures, none required additional surgery. Those that are noticed intraoperatively can be treated immediately, if necessary. Twelve of the fractures required additional attention during the surgery, while the others were treated nonoperatively. Of these 12, 9 were type 1C and were either fixed with screws or wires, 2 were type 2C and were fixed with bone grafting, lastly, 1 was type 3C, which required cables and a plate after reduction. There were 42 nonoperatively treated subclass C fractures that only required weight-bearing restrictions and, occasionally, casting. Of the 54 patients, only 1 had pain after treatment and 1 passed away before fully healing. The other 52 patients saw full recovery of their subclass C fracture. Overall, subclass C fractures required the least amount of attention.

DISCUSSION

TKAs alone have a low rate of failure, only 20% after 20 years^[1], and so the incidence rate of periprosthetic tibia fractures seems to follow that same trend. Data was not gathered on the number of TKAs performed each year, but the small quantity of studies and case reports found on periprosthetic tibia fractures supports the notion that they are very uncommon. Furthermore, many of the more serious fractures, types 2 and 3, are much more common after a traumatic event. It seems as if the design of the prosthesis itself, as well as the procedure used to implant it, is not a major factor in

the incidence of periprosthetic tibia fractures. The one obvious exception are subclass C fractures, which have basically no other causation factors.

Nonetheless, periprosthetic tibia fractures do occur and thus are a pertinent issue that needs addressing. Of the different types of periprosthetic tibial fractures, type 1 appeared the most often making up over half of the cases. Type 1 fractures also tended to be the least severe since these fractures do not span the width of the bone. Though not explicitly documented, these fractures can frequently be described as a collapse of the tibial head, where one side of the tibia caves under pressure. These collapses are infrequent in persons with a normal knee, and so their incidence in TKAs begs the question as to what causes these fractures to arise. Firstly, when undergoing a TKA, the removal of the original knee requires cutting of the bone. If too much of the bone is cut, the remaining bone is weaker and more susceptible to fractures. These most prominently result in type 1 fractures as they are closer to the tibial head and less severe. Furthermore, altering the surface of the tibia through cutting can affect the biomechanics of the knee where the tibia contacts the prosthesis. This change in the biomechanics of the joint can redirect the forces of the knee onto different parts of the tibia, which can result in fractures of those respective parts if they cannot support the new load.

In addition to the bone loss from a TKA, muscles are also cut or moved during the procedure. Since the knee initially does not have much muscle support, altering these muscles will have a larger impact on the performance of the knee. With less muscle support, there is more force being exerted from the knee onto the surrounding bone, which can cause the collapse fractures seen in type 1 periprosthetic tibia fractures. These pressure induced fractures are much more likely to cause type 1 fractures than type 2 or 3.

As noted before, type 2 and 3 fractures are seen less frequently than type 1 fractures, but are much more likely to be the result of a traumatic incident. This lends more support to the idea that the procedure or prosthesis has less of an effect on these fractures than they do in type 1. What makes these fractures notable is that they typically require more serious treatment than their non-TKA counterparts. By already having a TKA, the tibia is weaker, and so more cautious care must be given to the healing of these fractures. This is why reduction and internal fixation, using mainly locking plates and screws, was the most common form of treatment for these fractures.

Due to the variety of treatment methods for the different fracture types, it often becomes a difficult decision for the surgeon to decide on a treatment method. It has been shown that, in cases with a subclass B fracture, a revision TKA is required for full recovery over an extended period of time. However, in subclass A cases, the surgeon must decide whether to treat operatively or not. On one hand, nonoperative treatments are often preferred by the patient and

are at less risk for other complications. However, operative treatments are often more direct and can reduce the complications that arise from the prolonged immobilization of nonoperative treatment^[16]. In the end, there is not a standardized method to date and the decision is still a judgment call between the patient and surgeon.

Even 17 years after the study by Felix that established the classification system for periprosthetic tibia fractures, very little research has been done on the subject. Of the 13 studies used in this review, there were only 157 patients. Furthermore, of these 157, 102 were from the Felix study done at the Mayo clinic in Rochester, Minnesota. This limits the scope of this review to mostly that specific clinic. Of the remaining 52 patients, 34 came from 2 studies specifically on intraoperative fractures. This leaves only 18 patients from novel studies, many of which were case reports. While the data gathered in this review is still relevant, it is limited in scope by the scarcity of studies on the injury.

This systematic review showed, most importantly, that there is very little data on periprosthetic tibia fractures, but with the rise in occurrence of TKA, periprosthetic tibia fracture incidence will also rise. To this end, more studying needs to be done on the topic to standardize treatment methods so the patient can be given the best treatment.

In conclusion, periprosthetic tibia fractures are relatively uncommon. Type 1 fractures were the most common among documented types. Subclass A fractures were treated with locking plates, subclass B fractures first required a revision TKA, and subclass C fractures were either treated intraoperatively when they occurred or were treated nonoperatively.

COMMENTS

Background

Periprosthetic tibia fractures are relatively uncommon and there are no systemic reviews on this topic thus far. Since total knee arthroplasties are increasing, the incidence of periprosthetic tibia fractures will likely also be following the same trend.

Research frontiers

Periprosthetic tibia fractures are not very common, however, total knee arthroplasties are. Since the incidence of these fractures is low after a total knee arthroplasty (TKA), the design and material used in the implants is being reflected as good. Additionally, there has yet to be an establishment of a standardized protocol for the periprosthetic tibia fracture after TKA.

Innovations and breakthroughs

The authors have summarized the available data on periprosthetic tibia fractures and have found that periprosthetic tibia fractures are relatively uncommon. Type 1 fractures were the most common among documented types. Subclass A fractures were treated with locking plates, subclass B fractures first required a revision TKA, and subclass C fractures were either treated intraoperatively when they occurred or were treated nonoperatively.

Applications

This study can hopefully guide physicians on the periprosthetic tibia fracture

and allow them to provide information to their patients. However, further investigation is still necessary.

Terminology

Periprosthetic fractures are fractures that occur around implants associated with arthroplasty, particularly after TKA in the proximal tibia in this study.

Peer-review

This systematic review showed, most importantly, that there is very little data on periprosthetic fractures. This summarization of literature with regards to incidence and treatment can help physicians treat this situation and will improve patient outcomes.

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