



## Total knee arthroplasty for acute tibial plateau fractures: a survey amongst 68 Dutch orthopaedic surgeons

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In older patients with highly comminuted intra-articular tibial plateau fractures (TPFs), primary total knee arthroplasty (TKA) may be a treatment option. Our aim was to report and rank decisional factors considered by Dutch orthopaedic trauma and knee surgeons that may lead to the decision for TKA as treatment for TPFs.

A survey was distributed among 141 experts on traumatology and arthroplasty of the knee. The survey assessed the likelihood of TKA surgery after TPF in various patient and radiological characteristics. The level of experience with this of each responder was also noted. Descriptive statistics were calculated for all items.

141 participants were approached and 68 responded (48.2%). Responders were not more likely to proceed with TKA based on fracture types, impaired mobility, multiple incisions for ORIF, body mass index and ASA classification. However, in patients with pre-existing osteoarthritis (OA) and age  $\geq 80$  a majority would be more likely to proceed with TKA, with respectively 69.1% and 50.0%.

The most strongly considered factors were the presence of pre-existing OA, the age of the patient and the type of fracture, with respectively 55.9%, 51.4% and 42.6% of responders ranking it in their top three most important factors.

The study showed that the presence of pre-existing symptomatic OA and age of the patient were valued highest and increased the probability of a TKA in acute TPFs.

**Keywords:** Tibial plateau; fracture care; total knee arthroplasty; post-traumatic osteoarthritis; expert survey.

### INTRODUCTION

Tibial Plateau Fractures (TPFs) are fractures of the proximal tibia that are relatively common and pose various challenges. The management of these fractures ranges from conservative treatment to surgical intervention. For displaced TPFs, Open Reduction and Internal Fixation (ORIF) is considered to be the 'gold standard' (9). In elderly, orthogeriatric patients ORIF is prone to failure and a Total Knee Arthroplasty (TKA) may be an alternative.

Recently there has been an increased interest in the use of TKA as primary treatment for intra-

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articular TPFs. It is thought that in orthogeriatric patients TKA may help to avoid the great technical challenges that are posed by primary fracture repair and that TKA will facilitate full-weight bearing in the early postoperative period. The functional outcome of TKA as primary treatment for TPFs appears to be similar to ORIF with advantages of early immobilization and fewer revision surgeries. However, a higher complication rate must be taken into consideration (14).

The patient selection for a TKA after a TPF remains unclear. Several factors, such as age >65 years, radiographic evidence of local osteopaenia, pre-existing osteoarthritis (OA) and complex peri-articular fractures advocate for TKA (9,20).

The aim of the study was to assess whether Dutch orthopaedic surgeons would consider TKA as primary treatment for TPFs and rank the factors which would influence their decision.

## MATERIALS AND METHODS

Using a cross-sectional study design, a survey was distributed amongst 141 orthopaedic surgeons nationwide that were both members of the Dutch Knee Society (Dutch: 'Werkgroep Knie') and the Dutch Society for Orthopaedic Traumatology (NVOT). We believe that these were the most appropriate responders as they are experienced in both arthroplasty and traumatology of the knee. This would minimize treatment selection based on surgical experience.

For a translated version of the questionnaire, please refer to Appendix 1. The questionnaire gathered information on the experience of the responder by assessing the level-of-trauma hospital in which they practiced, the amount of TPFs treated per year, the amount of TKA surgeries per year, the amount of TKA revisions per year and their years of overall experience as orthopaedic surgeon. Fourteen characteristics that could potentially influence the decision were proposed and responders were asked to select if a certain characteristic would make the decision to proceed with a TKA more likely, less likely or if it would have no influence on the decision. These characteristics were based on existing literature, personal experience of the

authors and existing guidelines for regular TKA. Surveyed characteristics included various fracture types according to the AO/OTA classification (5), the presence of pre-existing OA, different age brackets (65-75 and  $\geq 80$ ), an ORIF that would require multiple incisions, BMI, American Society of Anesthesiology (ASA) Physical Status Classification score (19) and patient walking ability. Finally, responders were asked to rank their top three most influential factors for TKA surgery in acute TPF. The questionnaire was conducted using SurveyMonkey online software (SurveyMonkey Inc., San Mateo, CA).

Results have been analyzed using descriptive statistics. Statistics have been performed using R software (Version 4.0.2, R Core Team, Vienna, Austria, 2020). Subgroup analyses based on the trauma level of the hospital, amount of TPFs treated yearly, amount of TKA surgeries performed yearly and overall years of experience as orthopaedic surgeon were performed using chi-square tests.

An alpha value of 0.05 was considered statistically significant. If significance was found, a manual post-hoc Bonferroni correction was performed using an adjusted alpha value according to the Bonferroni correction ( $\alpha / K$ , with K being the number of hypotheses tested in the unadjusted analysis).

Approval by the regional Medical Ethical Board was not required for our study. IRB approval has been obtained. The study received no funding from external parties. The authors declare that there is no conflict of interest regarding the publication of this study.

## RESULTS

The survey was sent to 141 responders (130 orthopedic consultants and 11 residents) of which 68 (48.2%) responded. All questions were completed by all responders, with the exception of ranking factors. This was left blank by 3 responders (4.4%). Notably, only 1 (1.5%) responder treated over 15 TPFs yearly, 33.8% responders treated 5-15 TPFs yearly, and the majority (64.7%) treated less than 5 TPFs yearly. Detailed responder characteristics are shown in Table I. The most highly valued factors are

Table I. — Responder level of care, surgical volume and professional experience (n = 68)

	Responders, n (%)
1. In what type of hospital do you work?	
Academic	9 (13.2)
Level I Trauma center	14 (20.5)
Level II Trauma center	33 (48.5)
Level III Trauma center	12 (17.6)
2. How many tibial plateau fractures do you treat yearly?	
< 5	44 (64.7)
5-15	23 (33.8)
> 15	1 (1.5)
3. How many total knee arthroplasty procedures do you perform yearly?	
< 25	7 (10.3)
25-50	19 (27.9)
> 50	42 (61.8)
4. How many revision total knee arthroplasty procedures do you perform yearly?	
< 5	32 (47.1)
5-15	12 (17.6)
> 15	24 (35.3)
5. For how many years have you been working as an orthopaedic surgeon?	
Resident in training	7 (10.3)
< 5	21 (30.9)
5-15	24 (35.3)
> 15	16 (23.5)

displayed in descending order in Table II. In Table III the individual factors are displayed: surgeons are more likely to select TKA as primary treatment of a TPF in patients with symptomatic pre-existing OA or in patients that are over the age of 80. These are also the two most frequently considered factors. Subgroup analysis found that surgeons that performed over 50 TKAs / year were more likely to select TKA in patients with an ASA  $\geq$  3 compared to lower volume surgeons ( $p=0.0026$ ; chi-square with Bonferroni correction).

## DISCUSSION

The aim of this online survey was to report and rank the factors that influence the decision of proceeding with TKA following TPF amongst Dutch orthopaedic surgeons. The results revealed symptomatic OA and age as the most important factors for surgeons to proceed with TKA as primary treatment for TPFs. Furthermore, the survey showed that the concept of an 'expert opinion' is still in place, as there is still a large amount of disagreement

Table II. — Factors that are considered during the decision of TKA as primary treatment for TPF, where different fracture types have been combined into one. ‘No TKA’ indicates responders that would never proceed with TKA as primary treatment for TPF. Results are displayed as percentage of responders that named it in the top three most important characteristics. (n = 65)

	Responders, n (%)
Symptomatic OA	38 (58.5%)
Age	35 (53.8%)
Type of fracture	29 (44.6%)
Mobility	11 (16.9%)
Asymptomatic OA	8 (12.3%)
Multiple incisions	7 (10.8%)
Level of comminution	7 (10.8%)
BMI	4 (6.2%)
ASA	4 (6.2%)
Osteoporosis	3 (4.6%)
Comorbidity	3 (4.6%)
Other	8 (12.3%)
No TKA	7 (10.8%)

in most of the studied factors. This is most likely due to a lack of guidelines and scientific evidence on this topic. Although studies have been published on the subject of primary TKA for TPF, this study is the first to focus on the decision-making process that leads to the indication of primary TKA.

In our study the most highly valued factor for proceeding with a TKA, was the presence of pre-existing symptomatic OA. 38 (58.5%) responders ranked it in their top three, of which 20 (30.7%) named it as the most important factor. This can be logically explained by the usual indication of TKA for primary OA. It can also be supported by the knowledge of the incidence of post-traumatic OA (PTOA), which is reported to be approximately 23% to 44% in TPF patients (4,15,18) and can contribute to a worsening of existing symptoms. 47 responders (69.1%) were also more likely to proceed with TKA if the patient had pre-existing symptomatic OA. However, we see a large decline of TKA selection if the OA is asymptomatic. In contrast to symptomatic OA, the majority (40 responders, 58.8%) is less likely to proceed with TKA if the patients had not yet experienced symptoms. Some controversy remains, 8 responders (12.3%) rated asymptomatic OA as the

Table III. — Effect of investigated factors on the likelihood of TKA as primary treatment for TPF. (n = 68)

	More likely, n (%)	Less likely, n (%)	Indifferent, n (%)
Type B1 fracture	1 (1.5%)	63 (92.6%)	4 (5.9%)
Type B2 fracture	16 (23.5%)	49 (72.1%)	3 (4.4%)
Type B3 fracture	3 (4.4%)	61 (89.7%)	4 (5.9%)
Type C1 fracture	2 (2.9%)	63 (92.6%)	3 (4.4%)
Type C2 fracture	8 (11.8%)	55 (80.9%)	5 (7.4%)
Type C3 fracture	20 (29.4%)	42 (61.8%)	6 (8.8%)
Symptomatic OA	47 (69.1%)	18 (26.5%)	3 (4.4%)
Asymptomatic OA	13 (19.1%)	40 (58.8%)	15 (22.1%)
Age 65 – 75	15 (22.1%)	42 (61.8%)	11 (16.2%)
Age ≥ 80	34 (50.0%)	24 (35.3%)	10 (14.7%)
Multiple incisions	15 (22.1%)	39 (57.4%)	14 (20.6%)
Mobility impaired	14 (20.6%)	41 (60.3%)	12 (17.6%)
BMI ≥ 35	4 (5.9%)	48 (70.6%)	16 (23.5%)
ASA ≥ 3	16 (23.5%)	36 (52.9%)	16 (23.5%)

most important factor, and we found it to be the 5<sup>th</sup> highest ranked factor overall. An important note to these factors is that symptomatic is subjective to the patient and does not necessarily reflect the severity of the OA.

The age of patients was second most frequently selected as an important factor, 35 (53.8%) ranked it in their top three. Half of the responders were also more likely to proceed with TKA if a patient would be over the age of 80 years. Existing literature agrees that TKA should be considered in older patients. In a large population-matched study, Wasserstein et al. (17) had found a hazard ratio for TKA conversion from ORIF that increases with age. Although initial consolidation with ORIF may yield an easier conversion to TKA, but it also reduces the robustness of the surrounding soft tissue envelope of the knee and subsequently exposes patients to an increased risk of complications (12). Standard procedure following ORIF is a prolonged period of partial weightbearing, which exposes patients to complications that may especially have an impact on geriatric patients (16). The survey shows that less responders (15 responders, 22.1%) would be more likely to proceed with TKA for patients that are aged 65 to 75 years. This difference is most likely caused by a more conservative and cautious approach for TKA in this age bracket for the Dutch surgeons. Furthermore, TPFs in this age bracket are often associated with osteoporosis (8). This may increase the risk of periprosthetic fractures following TKA (11). Thus, surgeons may prefer initial consolidation using ORIF instead of primary TKA.

We found that the type of fracture was ranked 3<sup>rd</sup> overall for considered factors for a TKA with 29 responders (44.6%). A vast majority (63 responders, 92.6%) is less likely to proceed with TKA in case of a type B1 fracture. These fractures can be treated fairly simple using an anterolateral or medial approach (9). Only one responder would be more likely to perform TKA in case of a B1 fracture. For type B2 fractures, a much larger group (16 responders, 23.5%) would be more likely to select TKA. As there is no fragmentation of the proximal tibia in B2 fractures, the bone is still very suitable to perform a regular TKA. This may show that not only the complexity of the ORIF plays a role,

but also the technicality of a TKA. Furthermore, failure to maintain a congruent articular surface after depression fractures has a big influence on accelerated degeneration of the knee (12,13,18). B3 fractures are a combination of both depression and a split of the tibial plateau. This type of fracture, similar to B1 fractures, can be treated without extremely challenging procedures. We found similar results for B3 and B1 fractures. For B3 fractures, 61 responders (89.7%) were less likely to proceed with acute TKA.

Type C fractures are complete intra-articular fractures and management is usually more challenging than type B fractures. Type C1 fractures are simple articular and metaphyseal fractures. Like type B1 fractures, 63 responders (92.6%) were less likely to treat with TKA. These fractures can be treated with single plate fixation (7) and generally do not pose a big challenge for fracture management. For type C2 fractures a larger group of responders was more likely to treat with TKA. Still, 55 responders (80.8%) were less likely to proceed with TKA. Although the metaphyseal fracture is multifragmentary, the articular surface is still relatively intact, with only a simple fracture. Restoring articular congruence may not be the biggest challenge in the management of these fractures. Finally, type C3 fractures that are multifragmentary for both the joint surface and the metaphysis pose perhaps the biggest challenge for surgical management. 20 responders (29.4%) were more likely to proceed with TKA, this is the highest percentage amongst the different fractures. It can be explained by the extensiveness with which these fractures often present. Fracture reduction may be very challenging and TKA may be a viable alternative, as fragmentation of the articular surface also strongly increases the chance of PTOA (12,17,18).

Type C2 or C3 fractures may require double plate fixation in order to establish proper reduction of the fracture (7). Especially type C3 benefits from this type of fixation. Subsequently, multiple incisions are necessary during this type of surgery. We surveyed if this need for multiple incisions would influence the decision of proceeding with TKA. Amongst the responders, 15 (22.1%) reported that they would be more likely to proceed with TKA in this case. The

theoretical benefit of this decision may be that the soft tissue envelope takes less damage by requiring only one incision for TKA, thus it may be a valuable alternative. 7 responders (10.8%) stated that this was amongst their most considered characteristics.

We found that the presence of a limited walking ability in a patient would make TKA less likely for 41 responders (61.8%), compared to 12 responders (20.5%) that would be more likely to select TKA. In existing literature, presence of a pre-operative limited walking ability is described as a predictor for a worse outcome following TKA (10), this supports the majority of our responders. It was named as one of the most important factors by 11 responders (16.9%), which ranks it as 4<sup>th</sup> overall.

Only a small group would be more likely to select TKA if the patient has a high BMI. Whereas we see an approximate twenty percent of more likely responders in most patient-related characteristics, it is much lower for BMI with 4 responders (5.8%). Literature shows that obesity can lead to more complications and reoperation, this increased risk often had a relationship with the height of the BMI (1,2).

A similar relationship is seen in patients with higher ASA Physical Status Classification score. No significant relationship between ASA score and reoperation after primary total joint arthroplasty was found. However, there was an increased risk at complications, readmissions and mortality (3). Our survey showed that in spite of this, 16 responders (23.5%) would be more likely to choose TKA for patients with an ASA score of 3 or higher. We found that high-volume (> 50/year) TKA surgeons would more often select this option. It is important to note that this result may be skewed due to the distribution of surgeons amongst the three categories of TKA volume (less than 25/year: 7, 10.3%; 25-0/year: 19, 27.9%; over 50/year: 42, 61.8%).

Although it was not an item in our survey, 3 responders (4.6%) named presence of osteoporosis as an important factor. This characteristic has also been described in existing literature (9). We had not included it in the survey as a separate item due to its relationship with high age (6) and ASA score. Nevertheless, it is a notable result. Similarly, 3 responders (4.6%) reported that comorbidity plays

an important role. Comorbidity is a broad term that includes a large number of illnesses. The reason to not include this in the survey, was to keep the survey within reasonable length. Instead of using multiple items for various problems, we have used a single item with the score of ASA 3 or higher. The authors do however fully agree that comorbidity is an important factor to consider in every patient on an individual level.

Our survey also found that 8 responders (12.3%) would come up with other characteristics to consider. These included the amount of articular congruence, displacement of the fracture, previous level of activities of daily living, the expertise of the treating physician, the practical possibility within the hospital and if there had been radiological progression of pre-existing OA.

Lastly, we found that 7 responders (10.8%) would never proceed with TKA following TPF. Although it may be an interesting development to consider TKA in rare cases, a lack of scientific evidence may prevent some surgeons to proceed with this decision and a careful approach is advised. Furthermore, most TPFs in the Netherlands are not treated by orthopaedic surgeons, but by so called trauma surgeons. Only a very small amount of TPFs is treated by orthopaedic surgeons.

A limitation to our study is, as previously mentioned, posed by the Dutch differentiation between orthopaedic and trauma surgeons, as both are separate specialties and thus few surgeons have experience with both arthroplasty and traumatology of the knee. Our decision to send our survey to members of both the Dutch Knee Society and Dutch Society for Orthopaedic Traumatology was made with the aim to target exactly those specialists that have knowledge and expertise on both topics. Due to this, a selection bias may have occurred. After gathering information on the amount of TPFs treated per year, we saw that there was only one high-volume surgeon and most responders treated up to only 5 TPFs per year. Furthermore, most responders were high volume TKA surgeons and thus may have been biased towards TKA in some cases due to their experience and daily practice. Another possible result of the expert group that we approached is that we missed experts on revision

TKA. These surgeons are more experienced with technically demanding procedures, this may yield different results. We made the decision not to include any trauma surgeons as they never perform TKA in the Netherlands. Nonetheless, we do believe that our responder group was the most representative group available, as we aimed to assess the opinion of orthopaedic surgeons in the Netherlands that may treat these kinds of fractures and would be heavily involved in the decision of using TKA. This limitation is therefore subsequently coherent to the aim of our study.

### CONCLUSION

It is necessary to proceed with caution while drawing conclusions following our survey and to emphasize that the decision of TKA as treatment of acute TPF is never one-sided, but always depends on multiple variables and that every patient should be assessed individually. The survey reports that surgeons are more likely to select TKA as primary treatment of a TPF in patients with symptomatic pre-existing OA or in patients that are over the age of 80 and that these are also the two most frequently considered factors.

All authors contributed to the design of the work and the questionnaire. MKH performed the analysis of the data. All authors contributed to drafting the work or revising the content critically and all authors have approved the final version.

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**Appendix 1: Translated version of survey****Factors involved in treatment selection for Tibial Plateau Factors Expert Survey (Translated version)**

1. In what type of hospital do you work?
  - Academic Hospital
  - Level I trauma center
  - Level II trauma center
  - Level III trauma center
2. How many tibial plateau fractures do you treat yearly?
  - < 5
  - 5 - 15
  - > 15
3. How many total knee arthroplasty procedures do you perform yearly?
  - < 25
  - 25 - 50
  - > 50
4. How many revision total knee arthroplasty procedures do you perform yearly?
  - < 5
  - 5 - 15
  - > 15
5. For how many years have you been working as an orthopaedic surgeon?
  - Resident in training
  - < 5
  - 5 - 15
  - > 15
6. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if there is an AO type B1 fracture?
  - More likely
  - Less likely
  - Indifferent
7. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if there is an AO type B2 fracture?
  - More likely
  - Less likely
  - Indifferent
8. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if there is an AO type B3 fracture?
  - More likely
  - Less likely
  - Indifferent
9. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if there is an AO type C1 fracture?
  - More likely
  - Less likely
  - Indifferent
10. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if there is an AO type C2 fracture?
  - More likely
  - Less likely
  - Indifferent
11. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if there is an AO type C3 fracture?
  - More likely
  - Less likely
  - Indifferent

12. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient had pre-existing symptomatic osteoarthritis?
  - More likely
  - Less likely
  - Indifferent
13. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient had pre-existing osteoarthritis without symptoms?
  - More likely
  - Less likely
  - Indifferent
14. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient was aged 65-75?
  - More likely
  - Less likely
  - Indifferent
15. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient was aged  $\geq 80$ ?
  - More likely
  - Less likely
  - Indifferent
16. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient has a type AO C2 or C3 that would require multiple incisions for ORIF?
  - More likely
  - Less likely
  - Indifferent
17. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient had limited walking ability?
  - More likely
  - Less likely
  - Indifferent
18. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient has a BMI  $\geq 35$ ?
  - More likely
  - Less likely
  - Indifferent
19. Are you more likely, less likely or indifferent to select TKA as treatment for TPF if the patient has an ASA classification  $\geq 3$ ?
  - More likely
  - Less likely
  - Indifferent
20. Please rank the top 3 characteristics from question 6 through 19 that are most important to you.
  1. \_\_\_\_\_
  2. \_\_\_\_\_
  3. \_\_\_\_\_