


# Prioritised challenges in the management of acute knee dislocations are stiffness, obesity, treatment delays and associated limb-threatening injuries: a global consensus study

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## ABSTRACT

**Objectives** Heterogeneous patient factors and injury mechanisms result in a great variety of injury patterns encountered in knee dislocations (KD). Attempts to improve outcome can focus on a wide range of challenges. The aim of this study was to establish and prioritise a list of challenges encountered when treating patients with acute KD.

**Methods** A modified Delphi consensus study was conducted with international knee specialists who generated a prioritised list of challenges. Selected priorities were limited to half of the possible items. Agreement of more than 70% was defined as consensus on each of these items a priori.

**Results** Ninety-one international surgeons participated in the first round. The majority worked in public hospitals and treated patients from low-income and middle-income households. Their propositions were prioritised by 27 knee surgeons from Europe, Africa, Asia, as well as North and South America, with a mean of 15.3 years of experience in knee surgery (SD 17.8). Consensus was reached for postoperative stiffness, obesity, delay to presentation and associated common peroneal nerve injuries. Challenges such as vascular injuries, ipsilateral fractures, open injuries as well as residual laxity were also rated high. Most of these topics with high priority are key during the initial management of a patient with KD, at presentation. Topics with lower priority were postsurgical challenges, such as patient insight, expectations and compliance, rehabilitation programme, and pain management.

**Conclusion** This consensus study has a wide geographical footprint of experts around the world practising in various settings. These participants prioritised stiffness, obesity, treatment delays and associated limb-threatening injuries as the most important challenges when managing a patient with acute KD. This list calls for applicable and feasible solutions for these challenges in a global setting. It should be used to prioritise research efforts and discuss treatment guidelines.

**Level of evidence** V.

## INTRODUCTION

Knee dislocation (KD) is often defined as complete tibiofemoral articular displacement, although spontaneous reduction or cruciate-intact KDs<sup>1</sup> can add

## What are the new findings

- ▶ A prioritised list of the most important challenges in the management of acute knee dislocations was established through a modified Delphi consensus study.
- ▶ A global perspective of international knee surgeons was generated, who mostly worked in public sector hospitals treating patients from middle-income and low-income households.
- ▶ Consensus was reached for postoperative stiffness, obesity, delay to presentation and associated common peroneal nerve injuries.

complexity to this definition. Schenck's classification<sup>2</sup> is based on the number of ruptured ligaments and provides more anatomical detail. Most agree that a true KD commonly leads to disruption of three or more of the main stabilising ligaments.<sup>3</sup> Great variety in injury mechanisms, pattern of associated injuries as well as unique patient characteristics make KD complex injuries to treat and study.<sup>2</sup> Additionally, most reports are low-level case series with limited power.<sup>4</sup> For these reasons, surgeons are faced with unique challenges when treating KD, which vary significantly according to specific hospital settings and availability of resources. Areas with a high trauma burden are often under-resourced with funding and lack of operating time, staff and skills. As a result the management of KD differs when comparing high-volume centres in developed countries with other centres with resource limitations.<sup>5 6</sup> Understanding these challenges is the first step to establish research priorities and clinical guidelines with global impact. Recent work of leading centres in the USA and Europe has provided solutions to some of these challenges, but these might not be transferrable to various socio-economic settings and hospital set-ups in other countries. The key to improve the management of KD in these deprived areas is to understand the main challenges presented by KD which need attention regardless of where in the world the patient is being treated.

The aim of this study was therefore to establish and prioritise the most important challenges surgeons from around the world face when managing acute

KDs. The emphasis was put on a wide geographical and sectorial footprint of participating surgeons to allow insights into various hospital settings and socioeconomic circumstances.

## METHODS

A modified Delphi consensus study in the form of interactive iterative rounds of communication was conducted<sup>7-9</sup> to prioritise items by international knee experts between December 2019 and February 2020. First a list of items was established, which were then prioritised in subsequent rounds by experts who could choose a maximum of 50% of the items that were listed. Consensus was defined as a percentage agreement of 70% of all participants.

### Participants

An invitation to possible participants was sent out via email. For the first round the directory of the International Society of Orthopaedic Surgery and Traumatology was used and orthopaedic surgeons with a special interest in KD were targeted. The experts of the second and third rounds were selected based on their experience or the volume of KDs in their practice. They reported to treat at least 10 KDs per year and/or had at least 10 years of experience in knee surgery. These experts were from Brazil, India, China, South Africa, the USA and the UK. This provided insight into clinical settings of various countries, cultures and socioeconomic circumstances.

### Iterations and timing

During the first round participants provided specific challenges they faced in the management of acute KD, which were submitted as free text answers. Responses were synthesised into categories by the main investigators (all specialist knee surgeons) without access to specific names or affiliation of participants. The established list of challenges was then sent out to the group of experienced knee surgeons for prioritisation. This strategy ensured that surgeons with various levels of skills and experience could inform the list of challenges, which could then be prioritised by experienced, high-volume knee surgeons. For the first and second rounds, participants were blinded to each other's responses. For the third round, the items were prioritised according to their percentage agreement and this information was then shared with the experts prior to their reprioritisation of each challenge item. The entire consensus process was carried out anonymously over a period of 3 months, with weekly reminders and a 4-week period between rounds.<sup>10</sup> The data collection was done electronically using REDCap (Research Electronic Data Capture) electronic data capture tool hosted at the main study institution. This is a secure, web-based application designed to support data capture for research studies, with previously documented ease of use and applicability.<sup>11</sup>

### Data analysis

Descriptive statistics were used to analyse the consensus agreement. To describe the study population, normally distributed continuous data were summarised by mean, SD and 95% CI. Continuous data not distributed normally were summarised by median and IQR. Categorical data were summarised as proportions with 95% CI. According to the Delphi process, agreement was defined as percentage agreement of  $\geq 70\%$ .

### Sample size

Sample size calculations are not routinely performed for Delphi studies. A number from 10 to 15 experts is acceptable,<sup>10 12</sup>

although most consensus studies use 15–20 participants<sup>13</sup> and usually have a maximum of 50.<sup>14</sup> For our study 20–30 participants were targeted for each round. Informed consent was obtained prior to participation.

## RESULTS

### Participants

Ninety-one surgeons (86 male, 94.5%) with a mean age of 47.3 years (SD 12.5) participated in the first round to establish a list of the most important challenges in the management of KD. They reported an average of 15 years (SD 11.1) of experience. Of the surgeons 35 (38%) were from Asia, 21 (23%) from Africa, 23 (25%) from Europe and 5 each from North and South America. Of the surgeons 53 (58%) worked in public hospitals and 82 (90%) treated patients from low-income and middle-income households (figure 1). These surgeons performed a median of 50 anterior cruciate ligament (ACL) reconstructions (IQR 80) and 6 surgeries for KDs per year (IQR 14).

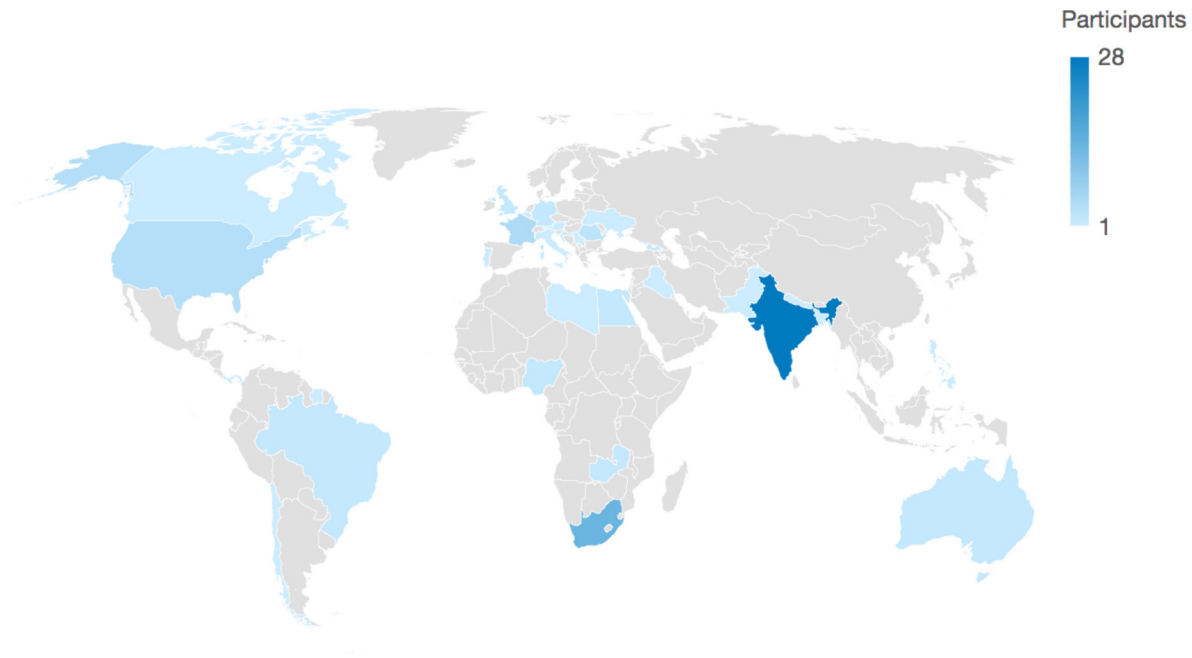
The answers to the open questions of this first round were then prioritised by 27 (100% male) experienced, high-volume surgeons in the second and third rounds. These surgeons had a mean age of 46 years (SD 8.4) and a mean of 15.3 years of experience in knee surgery (SD 17.8). All had access to arthroscopic equipment and 24 (89%) had access to MRI. In this group, 9 (33.3%) were from Brazil, 6 (22.2%) from the USA, 4 (14.8%) from South Africa and India, respectively, and 2 (7.4%) each from China and the UK (figure 2). These surgeons reported to perform a median of 80 (IQR 60) ACL reconstructions and a median of 15 (IQR 17.5) surgeries for KD per year. Eighteen surgeons (67%) worked in public sector hospitals and 24 (89%) treated patients from low-income or middle-income households (figure 2).

### List of challenges in the management of KD

The group of experts reached consensus for most important challenges such as postoperative stiffness, obesity, delay to presentation and associated common peroneal nerve injuries (table 1). Challenges such as vascular injuries, ipsilateral fractures and open injuries also reached a high percentage agreement, although not enough for consensus as per our definition. Less than 20% of participants prioritised challenges in areas like pain management, access to MRI, surgical skills training, sequence of graft tensioning, lack of operating time and the decision making surrounding single-stage bicruciate reconstruction. Many of the listed challenges are interrelated, which should be taken into account especially for items with lower percentage agreement. Notably, some of these challenges need to be addressed outside of the operating room, such as patient insight, compliance and expectations, access to high-quality physiotherapy, and pain management. Most of these topics with high priority are key during the initial management of a patient with KD, at presentation. Topics with lower priority were postsurgical challenges, such as patient insight, expectations and compliance, rehabilitation programme, and pain management.

## DISCUSSION

This consensus study spans various healthcare sectors and has a geographical footprint including most major continents, with strong participation from Africa, Asia and South America. These surgeons established a list of challenges they encounter in the management of acute KD and reached consensus of 70% agreement on postoperative stiffness, obesity, delay to presentation and associated common peroneal nerve injuries.



**Figure 1** Geographical distribution of participants for the first round shows strong participation from Asia, Africa and South America.

### Participants

Of the final round participants, 89% treated patients from either middle-income (63%) or low-income (25.9%) households and 67% worked in public hospitals. This provided a global perspective of challenges seen specifically in these settings. Although all participants of the final rounds were subspecialists, 41.8% of the initial round were general orthopaedic surgeons. Specialists are rare in areas with limited resources,<sup>15</sup> and the treatment of complex injuries has to be undertaken by generalists.<sup>16</sup> This also influences the challenges posed in patients in these areas of the world with KDs. The inclusion of such surgeons is crucial to identify the specific problems they face and develop appropriate solutions for these areas. Furthermore, most of these participating surgeons worked in low-income to middle-income nations such as South Africa, India and Brazil, which are among the countries with the highest trauma burden worldwide.<sup>17</sup> This study is therefore informed by surgeons who have insight into

the challenges of high-volume trauma in low-resource settings. This can hopefully be translated to other countries with similar circumstances which were not part of this study and for which studies from developed countries may well not be as relevant.

### Priority of challenges

From the list of challenges generated, consensus was reached for postoperative stiffness, obesity, delay to treatment and associated common peroneal nerve injuries. The following section discusses these four challenges in the light of a global setting with resource limitations.

*Postoperative stiffness* is a common sequela after KD which has been associated with early surgery.<sup>18</sup> Therefore, delaying, or staging, surgery can potentially reduce stiffness, but patient selection for delayed or non-operative management can be challenging, which was also a point established in our study. One of



**Figure 2** Geographical distribution of the 27 participants of the final round per country.

**Table 1** Challenges in the management of acute knee dislocations as prioritised by the 27 participants of the final round

Challenges in the management of acute knee dislocations	n	%
Postoperative stiffness	22	81
Obesity	22	81
Delay to presentation	20	74
Associated common peroneal nerve injury	19	70
Associated vascular injuries	18	67
Associated ipsilateral fractures (extra-articular)	17	63
Open injuries (periarticular wounds)	17	63
Postoperative residual instability	17	63
Patient compliance to postoperative management	16	59
Managing patient expectations regarding outcome	16	59
Convergence of tunnels during surgery	15	56
Allograft limitations (availability and quality)	14	52
Patient insight into treatment, rehabilitation and expected outcome	13	48
Decision making: two-stage vs single-stage surgery	13	48
Osteotomies in multiligament knee injuries	11	41
Bilateral knee dislocations	11	41
Objective diagnosis of posterolateral corner injuries	10	37
Decision making: repair vs reconstruction	10	37
Decision making: timing of surgery	7	26
Rehabilitation programme (access/adequacy)	7	26
External fixation (deciding on indications)	7	26
Associated meniscal injuries	7	26
Decision making: prioritisation of ligaments in staged reconstruction	7	26
Patient selection for conservative management	6	22
Pain management (preoperative and postoperative)	5	19
Lack of MRI	4	15
Surgical skills training	4	15
Decision making: sequence of graft tensioning	4	15
Lack of operating time	2	7
Decision making: single-stage bicruciate reconstruction	1	4

n, number of participants; %, percentage agreement.

\*The horizontal line indicates the limit of agreement set at 70%.

the most important factors to avoid stiffness is early functional rehabilitation, even though in 10% of patients further surgery for arthrofibrosis is still required.<sup>19</sup> Stiffness has also been associated with the extent of the ligamentous injury.<sup>20</sup> Ongoing research is therefore targeting some questions around postoperative rehabilitation.<sup>21</sup> However, adequate access to physiotherapy is a further challenge in low-resource settings, which was listed in our study. In addition, poor patient compliance and insight can further hamper postoperative recovery. The approach to avoid stiffness for many surgeons in similar circumstances might involve patient education and improving access to physiotherapy, along with a lower threshold for delayed or staged surgery or even conservative management.

*Obesity* in KD is another universal challenge as it is associated with significant morbidity. In these patients, surgery can be complicated by iatrogenic neurovascular damage, surgical site infection or overall poor patient-reported outcomes.<sup>22</sup> Difficult postoperative patient mobilisation and inability to immobilise the often cone-shaped limb add to the complexity. Consequently, patient expectation must be managed before surgery, explaining risks and benefits.

*Delay to treatment* is especially common in areas with limited access to healthcare and long distances to travel to hospitals. In

the acute setting with associated vascular injuries, delay to treatment of more than 6 hours increases the risk of limb loss and can be fatal due to muscle necrosis and reperfusion injury.<sup>23–26</sup> However, even without vascular damage, delay to treatment can limit the success of early repair of ligamentous and meniscal injuries, necessitating more complex and costly reconstruction procedures. In severe cases, neglected KD with a permanently fixed dislocated joint often requires salvage procedures such as arthroplasty or arthrodesis to achieve acceptable function.<sup>6</sup> Education and training of front-line healthcare workers, such as nurses, interns and medical officers, is a first step to achieve early referral and reduce delays.

*Common peroneal nerve injuries* are present in up to 40% of KDs, especially in posterolateral corner injuries<sup>26–28</sup> and especially so with biceps tendon avulsions, with or without fibular head fractures.<sup>29</sup> With a recovery rate of 25%,<sup>27</sup> nerve repair, grafting or nerve transfer has been proposed in acute injuries with nerve discontinuity, or later for intact nerves without recovery,<sup>30</sup> but tendon transfers are still the most reliable and feasible surgical treatment,<sup>31 32</sup> especially in the low-resource setting and in delayed cases.

Although consensus was not reached for some items, these remain high in the rating of the participants. *Vascular injuries* (percentage agreement: 67%) were selected as an important challenge as they are reported to occur in on average 18% of cases<sup>33</sup> and are the most time-sensitive associated injuries in KDs.<sup>24 25 34 35</sup> Selective angiography triggered by an abnormal ankle-brachial index is often promoted to exclude vascular injuries,<sup>35</sup> but a limited number of healthcare workers or inadequate training of ward staff can make serial neurovascular checks an unsafe strategy.<sup>36</sup> CT angiography, although highly sensitive and specific, might not always be available. Furthermore, in case of arterial damage, vascular surgery and immobilisation via an external fixation device add to morbidity of patients especially due to stiffness and pin site complications. Subsequent ligament surgery after recovery can compromise important collateral perfusion and potentially has a higher risk of surgical site infection and stiffness due to the previous surgery.

Another important challenge rated high was *ipsilateral fractures* (percentage agreement: 63%), which occur in 16.6% of KDs.<sup>37</sup> Furthermore, 30% of patients with long bone fractures are reported to present with ipsilateral knee ligament injuries.<sup>38</sup> These ligament injuries have increased morbidity,<sup>39</sup> yet are often overlooked in the presence of fractures. This warrants a thorough clinical examination, especially in the presence of knee haemarthrosis, and should ideally be confirmed with a preoperative MRI scan. The coordination of ligamentous surgery at the time of fracture fixation is a major challenge, especially in low-resource settings, and procedures are therefore often staged to allow healing of surgical wounds, increase of range of motion, fracture union and acceptable mobilisation. Further challenges arise with intramedullary or extramedullary fracture fixation devices, which can reduce image quality of later MRI scans and might need to be removed to achieve appropriate bone tunnels for reconstruction. In such cases, fracture union is a prerequisite for removal of fixation devices, which may delay ligament surgery for several months.

Similarly, *open dislocations* can be devastating injuries and many surgeons rated this challenge highly (percentage agreement: 63%). Skin and soft tissue integument injuries are found in 13% of KDs<sup>40</sup> and are associated with an infection in up to 40%.<sup>41 42</sup> Adequate irrigation and debridement are paramount, and in most cases stabilisation with a knee spanning external fixator is needed. Ligamentous structures should be addressed

once soft tissues allow and wounds are healed to reduce infection risk. This often leads to long delays as pin sites need to heal and range of motion needs to be regained after removal of external fixation.

### Limitations

This study has some limitations. Most participants were subspecialist knee surgeons from high-volume centres, which might have overshadowed the perspective of generalists, thereby creating bias away from the view of those surgeons from less developed parts of the world. However, a large proportion of generalist orthopaedic surgeons were included in the first round to reduce this.

Also, although a wide range of countries participated, many nations were not represented. Yet the study findings are still applicable to countries in similar socioeconomic and political circumstances. Furthermore, consensus was reached only for a few challenges in the management of KD, although increasing the limit for possible answers to more than 50% most likely would have increased the percentage agreement. Some details from the propositions of the initial round were also lost after categorisation into broader topics. Furthermore, consensus was only reached for four items. This would reduce to only two items if the limit of agreement was set to 75% as is often the case for consensus studies. However, increasing the limit of possible answers to more than the set value of 50% would have likely increased the consensus per item. Also, aside from consensus, the main value of this list is its prioritisation of challenges. Furthermore, 94.5% of participants in the first round and all participants in the second round were male. This is a reflection of the gender imbalance in orthopaedic surgery and must lead to mentoring female orthopaedic surgeons to treat these injuries.

### CONCLUSION

This study provides a prioritised list of challenges in KD which were based on insights of an international group of knee surgeons from Europe, Africa, Asia, and North and South America. Consensus was reached for four challenges: postoperative stiffness, obesity, delay to presentation and common peroneal nerve injuries. Associated injuries to ipsilateral vessels, long bones and skin were also prioritised with high agreement but did not reach the consensus threshold of 70%. This study can therefore be used to establish and prioritise focused research questions within each of the top challenges, which are applicable to a global setting. It can also serve as basis to discuss treatment guidelines keeping in mind regional variations in healthcare provision. Overall the study highlights the need for global solutions to address acute KD.

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