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Original Research

Inclusion of open injuries in an updated Schenck classification of knee dislocations based on a global Delphi consensus study

Michael Held[a,2,*], Waldo Scheepers[a,2], Richard von Bormann[b], Daniel C. Wascher[c], Dustin L. Richter[d], Robert C. Schenck Jr.[c], Christopher D. Harner[e], Knee surgery in LRS[f,1]

[a] University of Cape Town, Department of Orthopaedic Surgery, Cape Town, Western Cape, South Africa
[b] University of Cape Town, Department of Orthopaedic Surgery, Cape Town Sports & Orthopaedics Clinic, Cape Town, Western Cape, South Africa
[c] University of New Mexico School of Medicine, Department of Orthopaedics, Albuquerque, New Mexico, USA
[d] University of New Mexico Health Sciences Center, Department of Orthopaedics & Rehabilitation, Albuquerque, New Mexico, USA
[e] University of Texas Health Sciences Center Houston, Department of Orthopaedics, Houston, Texas, USA
[f] University of Cape Town, Department of Orthopaedic Surgery, Cape Town, Western Cape, South Africa

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ABSTRACT

Objectives: Knee dislocations (KDs) are complex injuries defined as incongruity of the tibiofemoral joint, which leads to tears of two or more of the main stabilising knee ligaments, and they are often associated with damage to surrounding soft tissue or neurovascular structures. A classification system for these injuries should be simple and reproducible and allow communication among surgeons for surgical planning and outcome prediction. The aim of this study was to formulate a list of factors, prioritised by high-volume knee surgeons, that should be included in a KD classification system.

Methods: A global panel of orthopaedic knee surgery specialists participated in a Delphi process. The first survey employed 91 orthopaedic surgeons to generate a list of patient- and system-specific factors that should be included in a KD classification system that may affect surgical planning and outcomes. This list was subsequently prioritised by 27 identified experts (mean 15.3 years of experience) from Brazil (n = 9), USA (n = 6), South Africa (n = 4), India (n = 4), China (n = 2), and the United Kingdom (n = 2). The items were analysed to find factors that had at least 70% consensus for inclusion in a classification system.

Results: Of the 12 factors identified, four (33%) achieved at least 70% consensus for inclusion in a classification system. The factors deemed critical for inclusion in a classification system included vascular injuries (89%), common peroneal nerve injuries (78%), number of torn ligaments (78%), and open injuries (70%).

Conclusion: Consensus for inclusion of various factors in a KD classification system was not easily achieved. The wide geographic distribution of participants provides diverse insight and makes the results of the study globally applicable. The most important factors to include in a classification system as determined by the Delphi technique were vascular injuries, common peroneal nerve injuries, number of torn ligaments, and open injuries. To date, the Schenck anatomic classification system most accurately identifies these patient variables with the addition of open injury classification. The authors propose to update the Schenck classification system with the inclusion of open injuries as an additional modifier, although this is only a small step in updating the classification, and further studies should evaluate the inclusion of more advanced imaging modalities. Future research should focus on integrating these factors into useful existing classification systems that are predictive of surgical treatment and patient outcomes.

* Corresponding author. University of Cape Town, Department of Orthopaedic Surgery, Cape Town, Western Cape, South Africa
E-mail addresses: Michael.held@uct.ac.za (M. Held), waldoscheepers@gmail.com (W. Scheepers), drrichard@ctorth.com (R. von Bormann), dwascher@unm.edu (D.C. Wascher), dlrichter@salud.unm.edu (D.L. Richter), rcschenckjr@gmail.com (R.C. Schenck), harnercd1981@gmail.com (C.D. Harner).

[1] Members of of the collaboration group listed in Appendix section.
[2] Michael Held and Waldo Scheepers are co-first authors.

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What are the new findings?

- The aim of the study was to formulate a list of factors to be included in a classification system for knee dislocations.
- A global panel of orthopaedic surgeons participated in a Delphi process, and a refined list of items was established, but consensus was not easily reached.
- The most important factors to include in a classification system for knee dislocations were vascular injuries, common peroneal nerve injuries, number of torn ligaments, and open injuries.
- We therefore propose an update to the Schenck classification to include open injuries.

Introduction

Knee dislocations (KDs) are complex and potentially devastating injuries that pose significant challenges to both the patient and treating surgeon. They have been defined as incongruity of the tibiofemoral joint, which leads to tears of two or more of the main stabilising knee ligaments [1,2]. The nature of the injury involves damage of multiple knee ligaments, surrounding soft tissue, and neurovascular structures [3]. Spontaneous reduction has been reported [3,4], and without radiographic evidence of a true dislocation, the definition based on incongruity is challenging to translate into clinical practice. Therefore, more recently, KDs have been defined as bicruciate ligament injuries [5]. However, KDs without bicruciate ligament tears are possible [6,7]. The terminology is critical, as a KD is a multiligament knee injury (MLKI), but the majority of MLKIs are not KDs. This is an important distinction because the incidence of neurovascular injury is significant in KDs but extremely rare in other single cruciate ligament injuries. A recent study has demonstrated that MLKIs with documented KDs have a significantly higher rate of vascular injuries in comparison to nondocumented KDs with similar ligament injury patterns [8]. Most of the available literature on KDs constitutes a low level of evidence based on small cohort studies or underpowered prospective studies [9].

Furthermore, many classification systems still lack specificity and consistency to guide clinical decision-making amongst surgeons [9]. Conventionally, the modified Schenck Anatomic Classification System for KDs (Table 1) is based on complete injuries of the main knee ligaments assessed during a clinical examination, with specifiers for neurovascular injuries. Further classification systems have attempted to add greater detail to injury description, which may aid with surgical planning [10] and prognostic value for clinical outcome [11]. The positional Kennedy classification and energy-based classification systems have been found inadequate to accurately classify KDs [11].

An ideal classification system should therefore include all possible types of an injury, be consistent and reproducible, enable clear communication between clinicians, guide management, be predictive of outcomes, and should facilitate research [11]. To create such a system, existing classifications must be reviewed and amended. A prioritised list of factors when classifying KDs from world experts in knee surgery could form the basis for further modification of established systems. The aim of this Delphi consensus study was to formulate a list of factors, prioritised by high-volume knee surgeons, that should be included in a KD classification.

Methods

The Delphi process is a method of obtaining consensus in larger groups. It is characterised by anonymity and multiple rounds of surveys until consensus is reached. In general, the first round of questions solicit general information on areas of focus about the topic of controversy in an open-ended question format, whereas subsequent rounds are designed to assess the importance of these items [12–14]. The research question “Which are the most important factors you would include in a classification for knee dislocations?” was posed to an international panel of general and specialist knee orthopaedic surgeons in the format of a Delphi consensus study. Consensus was defined as at least 70% agreement among participants. The study was approved by a local review board (HREC 591/2018), and informed consent was obtained prior to participation.

Participants

An initial list of factors was formed by the first round of communication to a large group of international orthopaedic surgeons (Table 2). This ensures a representative pooling of free-text answers and avoids expert blind spots. This list was then subsequently prioritised in two further iterative rounds by selected smaller group of high-volume experts who could choose half of the factors initially listed. Using a smaller number of experts in these subsequent rounds avoids low response rates and increases the chance of consensus. These experts were selected based on their experience or the volume of KDs in their practice. They reported treating at least ten KDs per year and/or had at least 10 years of experience in knee surgery.

Orthopaedic surgeons with an interest in knee surgery or trauma surgery who were members of the International Society of Orthopaedic Surgery and Traumatology (SICOT) were approached to participate in the first round via email. In further rounds, an international selection of experienced subspecialist knee surgeons who were also members of SICOT and had a special interest in KDs were consulted to prioritise the factors via email. These experts were from Brazil, China, India, South Africa, the United Kingdom, and the USA.

Iterations

Participants were asked to name the most important factors to include in a classification for KDs in the first round in the form of an open-ended question. Their data were anonymised and blinded for the subsequent rounds. The generated answers were then distilled down to a group of factors by the core research team and sent to the subgroup of specialist knee surgeons to prioritise. The consensus rounds were performed over 3 months between December 2019 and February 2020, with the rounds occurring monthly. Weekly reminders were sent via email. Consensus was defined as $\geq$70% agreement among experts.

Data capture and analysis

The data were captured with Research Electronic Data Capture, an electronic database, and hosted at the main study centre. The study population was described by summarising normally distributed continuous data by mean, standard deviations, and 95% confidence intervals

Table 1
Modified Schenck anatomic classification system.

Category	Injury Patterns
KD-I	ACL or PCL + collateral
KD-II	ACL + PCL
KD-III-M	ACL + PCL + medial collateral/posteromedial corner
KD-III-L	ACL + PCL + lateral collateral/posterolateral corner
KD-IV	ACL + PCL + medial collateral + lateral collateral
KD-V	Any KD with periarticular fracture
Modifiers	
N	Nerve injury
V	Vessel injury
O	Open injury (proposed new modifier)

Abbreviations: KD, knee dislocation; M, medial; L, lateral; ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.
The proposed new modifier ‘o’ for open injuries is included.

Table 2
Important factors to be included in a classification for knee dislocations, prioritised by the expert panel. Consensus was identified as >70% agreement. N, number; %, percentage.

Factors for Classification System	N	%
Vascular injuries	24	89%
Common peroneal nerve injury	21	78%
Number of torn knee ligaments	21	78%
Open injuries	19	70%
Obesity	16	59%
Extra-articular ipsilateral fractures	12	44%
Axial deviations in chronic injuries	9	33%
Stiffness in chronic injuries	7	26%
Delay to presentation	7	26%
Bilateral knee dislocations	6	22%
Meniscal injuries	5	19%
Resource limitations	2	7%

(CIs), whereas non-normally distributed continuous data were summarised by median and interquartile range (IQR). 95% CIs with proportions were used to summarise categorical data.

Sample size

Approximately 100 participants were targeted for the first round to provide a list of factors, with a sample size of 20–30 experts chosen for subsequent prioritisation rounds. A total of 15–20 participants are frequently used in consensus studies [15], with numbers as low as 10–15 [16–18] and as high as 50–70 [19,20] considered acceptable.

Results

Participants

Participants of the first round consisted of 91 orthopaedic surgeons (86 male, 94.5%) from Africa (21), Asia (35), Europe (23), North America (5), and South America (5). They had a median age of 45 years (IQR 21), with an average of 15 years (IQR 18) of experience, performing a median of 50 anterior cruciate ligament (ACL) reconstructions (IQR 80) and six surgeries for KDs (IQR 14) per year. Of these, 41.8% were general orthopaedic surgeons, 37.4% were subspecialist knee surgeons, and 20.9% were sport-orthopaedic specialists. The majority worked either in public services with or without limited private practice (28.6% and 29.7%, respectively). The remainder of participants (38, 41.8%) worked exclusively in private practice. Most participants treated patients from the middle-income bracket of socioeconomic status (65.9%), followed by low income (24.2%) and high income (9.9%).

Twenty-seven experienced high-volume surgeons with a mean age of 45 years (IQR 12) and median of 15 years (IQR 11) of clinical practice participated in the second and third rounds. They performed a median of 80 (IQR 60) ACL reconstructions and 15 (IQR 17.5) surgeries for KDs annually. This group constituted surgeons from Brazil (9), the USA (6), India (4), South Africa (4), China (2), and the United Kingdom (2). Overall, 51.9% were sports-orthopaedic specialists, 44.4% were subspecialist knee surgeons, and 3.7% were general orthopaedic surgeons. A total of 51.9% of the experts worked in public service with limited private practice, 33% worked exclusively in private practice, and 14.8% worked in purely public service. The majority (63.0%) of their patients fell into the middle-income bracket, just more than one-fourth (26.9%) fell into the low-income bracket, with the remainder (11.1%) in the high-income bracket.

Consensus on most important factors for a classification of KDs

The expert panel reached consensus, defined as at least 70% agreement, on four factors to be included in a classification for KDs (Table 2): vascular injuries (89%, n = 24), common peroneal nerve (CPN) injuries (78%, n = 21), number of knee ligaments torn (78%, n = 21), and open injuries (70%, n = 19). These factors are consistent with the existing Schenck classification with the addition of open injuries and would be most effectively used as a suffix in the existing classification system. Associated obesity and extra-articular ipsilateral fractures also reached a high prioritisation rating with 59% and 44%, respectively, but agreement was not high enough to reach consensus.

Discussion

According to the consensus of the participating surgeons, associated vascular injuries, CPN injuries, and number of torn ligaments should be used to classify KDs as is done in the existing Schenck classification. As a new finding, the consensus also included open KDs as an important factor, which supports its use as a modifier in the Schenck classification. Obesity and extra-articular ipsilateral fractures were also rated high but missed consensus agreement. These factors are still important to be considered in KDs, as they can dictate timing and management of these complex injuries. Obesity was the only patient factor not related to pathoanatomy, which received high ratings. Azar et al. reviewed a case series of 17 patients with KDs and an average body mass index (BMI) of 48 kg/m^2. They showed that neurovascular injuries were frequent with these ultra-low-velocity KDs, the likelihood of combined neurovascular injury tends to increase as BMI increases, and surgical ligament reconstruction appears to improve outcomes [21].

Participants

The geographic diversity of the expert panel leads to insights of factors for KD classifications with global relevance. Most participants in the initial round were generalists, which provided important input, as classifications must be useful to clinicians with various levels of experience and specialisation. Especially in low- to middle-income countries, subspecialist care is not readily available, and it is important to have a user-informed practical classification for these settings. The expert group in the second and third rounds were also members of SICOT like the generalists but were selected based on a higher reported volume of KD surgery per year and/or years of experience in knee surgery in comparison to the generalists.

Vascular injuries (89% consensus)

Vascular injuries are a devastating complication of KDs with poor clinical outcomes and a 12% amputation rate [3,22]. Prompt recognition and re-establishing adequate blood flow is critical to prevent amputation, which can be as high as 80% in cases of prolonged ischaemia exceeding 8 hr [23]. More than half of KDs requiring amputations are associated with vascular injuries (55.3%) [23]. A systematic review that analysed 23 studies, including 907 patients, found an 18% incidence of vascular injury in KDs. KDIIIL injuries of the Schenck classification and posterior KDs of the Kennedy classification have been shown to have the highest rate of vascular injuries at 32% [9] and 25% [22,24], respectively. The popliteal artery is affected most frequently (83.6%), followed by the tibial artery (7.54%) [23]. The risk factors for vascular injury include high-velocity injuries, open injuries (7% increased risk), and obesity (300% increased risk) [4]. There is a greater chance of vascular injury if peroneal nerve injury is present (16.2% vs 4.8%) [25]. These injuries often require multiple surgeries and provisional stabilisation with a transarticular external fixation, which spans the tibiofemoral joint. This should be used with a clear purpose as prolonged immobilisation can lead to arthrofibrosis and prolongs definitive management [26].

CPN injuries (78% consensus)

CPN injuries add to the morbidity of patients with KDs because of the loss of dorsiflexion strength and the resultant drop foot gait abnormality [27]. The incidence of neurological injury in KDs varies greatly (5–59%), with a systematic review calculating it at an average of 25% [22]. A retrospective review of the American College of Surgeons National Trauma Data Bank analysed 6,454 patients with KDs between 2010 and 2014 and found neurological injury documented in 6.2% of cases, with the peroneal nerve affected most commonly (53.3%) [23]. CPN injuries are often associated with posterior-lateral corner injuries (21.6%) because of anatomic proximity, and up to 93% are found with posterior cruciate ligament injuries [25]. They are most commonly found in Schenck Classification KDI (with lateral collateral ligament involvement), KDIIIL, and KDIV injuries [3,27]. These injuries can be partial or complete [27], with higher grade injuries correlating with worse outcomes [28]. While partial CPN injuries often obtain functional antigravity dorsiflexion, the long-term prognosis for complete CPN injuries is poor. Patients often require the use of an ankle-foot-orthosis or a posterior tibial tendon transfer to improve ambulation. However, in a retrospective study of 357 patients with MLKI who underwent knee reconstruction, patients with CPN injuries had no statistically significant difference in return to work or postoperative activity level, pain, or patient-reported outcome scores, when compared with patients with an intact CPN [25].

Number of torn ligaments (78% consensus)

Schenck's KD classification system is most frequently used in clinical practice, as it describes both the number and type of ligaments injured. In the KD classification, only complete ligament injuries diagnosed by physical examination and imaging studies confirmed at the time of surgery are included. It is useful for surgical planning and stratifying the risk of poor postoperative outcomes [29], especially in KD IV and V patterns [11,30].

More recent systems have expanded on the pathoanatomy using Müeller maps, with individual structures and grades of injury identified within a class [9,10]. Adding skin integrity (open vs closed) or extensor mechanism involvement as additional information to the KD system will be useful, as these injuries will usually affect the treatment algorithm and can easily be included.

Open injuries (70% consensus)

Open KDs are complex injuries and often present in the setting of high-velocity polytrauma, significantly complicating their management [31]. They account for 13.6% of KDs [23], and in open joint injuries of the lower extremities, the knee joint is most frequently involved (53–91%) [32]. Noteworthy problems of open joint injuries include soft tissue loss, open intra-articular fractures, and bone and cartilage loss [32], which leads to a greater infection risk of up to 43% [31]. Approximately half of open KDs are associated with a fracture [23]. An open injury is a risk factor for vascular injuries [31,33] and carries a risk of amputation of 14.3–15.6% [23]. Management of open KDs requires emergent surgery for irrigation and debridement along with antibiotic use [32]. These issues contribute to poor functional outcomes in this injury type [24,34]. However, the great variation in the extent of soft tissue compromise and contamination makes the classification of open injuries challenging. Despite this, the presence of any open injury should serve as a warning for complications. A classification of open joint injuries was proposed by Collins and Temple in 1989 to address immediate complications and variations in wound management [32] but is not widely referenced in current literature. The four main classes include injuries with single capsular perforation or laceration without extensive soft-tissue injury, single or multiple capsular perforations or lacerations with extensive soft-tissue injury, open periarticular fracture with extension through the adjacent intra-articular surface, and open dislocation with an associated nerve or vascular injury requiring repair [32]. To date, the criteria of an open injury have not been included as a factor in any KD classification.

Limitations

The study is limited by the fact that only subspecialist knee surgeons prioritised factors in the second and third rounds. Although this neglected the opinion of generalist orthopaedic surgeons in final consensus rounds, their input was still used in the first round. Furthermore, these experts were selected purely based on their volume of surgery for KDs and years of experience as a presumptive surrogate for expertise, which could introduce selection bias. The group of generalist and subspecialist surgeons were members of the International Society of Orthopaedic Surgery and Traumatology (SICOT), and they were contacted via a generic email. This is a potential limitation as the expert group could have been subjected to a more rigorous review process for their selection. The panel consisted of experts from a selected number of countries, with most surgeons treating low- to middle-income patients who may have particular demographic features and injury patterns. However, the data are still applicable to a large proportion of the world's population. The definition of consensus was set at 70%, and participants were restricted to choosing only half of the possible factors from the list provided. In order of consensus achieved, the 12 possible factors included vascular injuries, CPN injury, number of torn ligaments, open injuries, obesity, extra-articular ipsilateral fractures, axial deviations in chronic injuries, stiffness in chronic injuries, delay to presentation, bilateral KDs, meniscal injuries, and resource limitations. This restriction might have resulted in certain factors, such as obesity, narrowly missing the definition of agreement although they are still extremely pertinent. Also, details of initial open-ended responses in the first round might have been lost with refining and consolidating the list of factors to pose a concise selection to the experts, i.e., peri-articular fractures were not included as a separate item, nor injuries to nerves other than the CPN. These are important factors that should be included in an assessment and classification of KDs.

Conclusion

Consensus for the inclusion of various factors in a KD classification system was not easily achieved. The wide geographic distribution of participants provides diverse insight and makes the results of the study globally applicable. The most important factors to include in a classification system as determined by the Delphi technique were vascular injuries, CPN injuries, number of torn ligaments, and open injuries. To date, the Schenck anatomic classification system most accurately identifies these patient variables with the addition of open injuries. We therefore propose to update the Schenck classification system with the inclusion of open injuries as an additional modifier, although this is only a small step in updating the classification, and further studies should evaluate the inclusion of more advanced imaging modalities. Future research should focus on integrating these factors into useful existing classification systems that are predictive of surgical treatment and patient outcomes.

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Informed consent

This study was approved by the local review board. Informed consent was obtained before participation.

Authors' contributions

All authors listed have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work. They also participated in drafting the work or revising it critically and provided final approval. Contributors in the authorship group 'Knee surgery in LRS' were participating investigators.

Declaration of competing interest

D.CW. is a member of the ISAKOS Board of Directors. The other authors have no competing interest to declare.

Appendix

Authorship group: Knee Surgery in LRS

Hasan Alizayagam, Carlos Mourao, Diogo Mesquita, Soliudeen Arojuraye, Ednei Freitas, Rtesh Patel, S Deepak, Fernanda Nahas, Paulo Fontes, Gabriel M Miura, Gian Du Preez, Guilherme F Simoes, Leandro Marinho, Roberto Cunha Luciano, Yogesh Gowda, Bernardo Ribeiro, David North, Constantino Calapodopulos Jr, Dustin Richter, Ennio Coutinho, Weili Fu, Frederico Ferreira, Clauco Passos, Hannes Jonker, Hayden Hobbs, John Grant, Sebastian Magobotha, Marcos Alves, Marcelo Amorim, Marcelo Denaro, Marc Safran, Marcelo Moraes, Dinshaw Pardiwala, Rodrigo Lazzarini, Seth Sherman, Saseendar Shanmugasundaram, Sundararajan Silvampatti, Richard von Bormann, Wagner Lemos, Jose M Juliano Eustaquio, Peter Venter.

References

[1] Seroyer ST, Musahl V, Harner CD. Management of the acute knee dislocation: the Pittsburgh experience. Injury 2008;39:710–8. https://doi.org/10.1016/j.injury.2007.11.022. 2008/05/13.

[2] Walker D, Hardison R, Schenck R. A baker's dozen of knee dislocations. Am J Knee Surg 1994;7:117–24.

[3] Neri T, Myat D, Beach A, et al. Multiligament knee injury: injury patterns, outcomes, and gait analysis. Clin Sports Med 2019;38:235–46. https://doi.org/10.1016/j.csm.2018.11.010. 2019/03/18.

[4] Matthewson G, Kwapisz A, Sasyniuk T, et al. Vascular injury in the multiligament injured knee. Clin Sports Med 2019;38:199–213. https://doi.org/10.1016/j.csm.2018.11.001. 2019/03/18.

[5] Harner CD, Waltrip RL, Bennett CH, et al. Surgical management of knee dislocations. J Bone Joint Surg Am 2004;86:262–73. https://doi.org/10.2106/00004623-200402000-00008. 2004/02/13.

[6] Bratt HD, Newman AP. Complete dislocation of the knee without disruption of both cruciate ligaments. J Trauma 1993;34:383–9. https://doi.org/10.1097/00005373-199303000-00013. 1993/03/01.

[7] Cooper DE, Speer KP, Wickiewicz TL, Warren RF. Complete knee dislocation without posterior cruciate ligament disruption. A report of four cases and review of the literature. Clin Orthop Relat Res 1992;284:228–33. pmid: 1395298/.

[8] Kahan JB, Schneble CA, Li D, et al. Increased neurovascular morbidity is seen in documented knee dislocation versus multiligamentous knee injury. J Bone Joint Surg Am 2021;103:921–30. https://doi.org/10.2106/jbjs.20.01151. 2021/02/16.

[9] Dosher WB, Maxwell GT, Warth RJ, et al. Multiple ligament knee injuries: current state and proposed classification. Clin Sports Med 2019;38:183–92. https://doi.org/10.1016/j.csm.2018.11.006. 2019/03/18.

[10] Maxwell GT, Warth RJ, Amin A, et al. Multiple ligament knee injuries: does the knee dislocation classification predict the type of surgical management? J Knee Surg 2021;34:273–9. https://doi.org/10.1055/s-0039-1695739. 2020/03/19.

[11] Goebel CP, Domes C. Classifications in brief: the Schenck classification of knee dislocations. Clin Orthop Relat Res 2020;478:1368–72. https://doi.org/10.1097/corr.0000000000001186. 2020/02/28.

[12] Brown BB. Delphi process: a methodology used for the elicitation of opinions of experts. RAND Corp; 1968.

[13] Dakley N, Helmer O. An experimental application of the DELPHI method to the use of experts. Manag Sci 1963;9:458–67. https://doi.org/10.1287/mnsc.9.3.458.

[14] Sackman H. Delphi assessment: expert opinion, forecasting, and group process. RAND Corp; 1974.

[15] Ludwig B. Predicting the future: have you considered using the Delphi methodology. J Ext 1997;35:1–4.

[16] Delbecq AL, Van de Ven AH, Gustafson DH. Group techniques for program planning: a guide to nominal group and Delphi processes. Soc Work 1976;21. https://doi.org/10.1093/sw/21.4.338. 338-338.

[17] Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42:377–81. https://doi.org/10.1016/j.jbi.2008.08.010. 2008/10/22.

[18] Adler M, Ziglio E. Gazing into the oracle : the Delphi method and its application to social policy and public health. London: Jessica Kingsley Publishers; 1996.

[19] Witkin BR, Altschuld JW, Altschuld J. Planning and conducting needs assessments: a practical guide. Thousand Oaks, CA, London, New Delhi: Sage Publications, 302 pp. ISBN 0-8039-5809-9. Int Soc Work 1995;39. https://doi.org/10.1177/002087289603900316. 350-350.

[20] Tokish JM, Kuhn JE, Ayers GD, et al. Decision making in treatment after a first-time anterior glenohumeral dislocation: a Delphi approach by the Neer Circle of the American Shoulder and Elbow Surgeons. J Shoulder Elbow Surg 2020;29:2429–45. https://doi.org/10.1016/j.jse.2020.08.011. 2020/08/29.

[21] Azar FM, Brandt JC, Miller 3rd RH, et al. Ultra-low-velocity knee dislocations. Am J Sports Med 2011;39:2170–4. https://doi.org/10.1177/0363546511414855. 2011/07/16.

[22] Medina O, Arom GA, Yeranosian MG, et al. Vascular and nerve injury after knee dislocation: a systematic review. Clin Orthop Relat Res 2014;472:2621–9. https://doi.org/10.1007/s11999-014-3511-3. 2014/02/21.

[23] Chowdhry M, Burchette D, Whelan D, et al. Knee dislocation and associated injuries: an analysis of the American College of surgeons national trauma Data Bank. Knee Surg Sports Traumatol Arthrosc 2020;28:568–75. https://doi.org/10.1007/s00167-019-05712-y. 2019/09/29.

[24] Arom GA, Yeranosian MG, Petrigliano FA, et al. The changing demographics of knee dislocation: a retrospective database review. Clin Orthop Relat Res 2014;472: 2609–14. https://doi.org/10.1007/s11999-013-3373-0. 2013/11/12.

[25] Worley JR, Brimmo O, Nuelle CW, et al. Incidence of concurrent peroneal nerve injury in multiligament knee injuries and outcomes after knee reconstruction. J Knee Surg 2019;32:560–4. https://doi.org/10.1055/s-0038-1660512. 2018/06/14.

[26] Ramírez-Bermejo E, Gelber PE, Pujol N. Management of acute knee dislocation with vascular injury: the use of the external fixator. A systematic review. Arch Orthop Trauma Surg 2020. https://doi.org/10.1007/s00402-020-03684-0. 2020/11/23.

[27] Krych AJ, Giuseffi SA, Kuzma SA, et al. Is peroneal nerve injury associated with worse function after knee dislocation? Clin Orthop Relat Res 2014;472:2630–6. https://doi.org/10.1007/s11999-014-3542-9. 2014/02/28.

[28] Samson D, Ng CY, Power D. An evidence-based algorithm for the management of common peroneal nerve injury associated with traumatic knee dislocation. EFORT Open Rev 2016;1:362–7. https://doi.org/10.1302/2058-5241.160012. 2017/05/04.

[29] Everhart JS, Du A, Chalasani R, et al. Return to work or sport after multiligament knee injury: a systematic review of 21 studies and 524 patients. Arthroscopy 2018; 34:1708–16. https://doi.org/10.1016/j.arthro.2017.12.025. 2018/02/13.

[30] Cook S, Ridley TJ, McCarthy MA, et al. Surgical treatment of multiligament knee injuries. Knee Surg Sports Traumatol Arthrosc 2015;23:2983–91. https://doi.org/10.1007/s00167-014-3451-1. 2014/11/28.

[31] King 3rd JJ, Cerynik DL, Blair JA, et al. Surgical outcomes after traumatic open knee dislocation. Knee Surg Sports Traumatol Arthrosc 2009;17:1027–32. https://doi.org/10.1007/s00167-009-0721-4. 2009/02/12.

[32] Collins DN, Temple SD. Open joint injuries. Classification and treatment. Clin Orthop Relat Res 1989;243:48–56. pmid: 2721074.

[33] Weinberg DS, Scarcella NR, Napora JK, et al. Can vascular injury be appropriately assessed with physical examination after knee dislocation? Clin Orthop Relat Res 2016;474:1453–8. https://doi.org/10.1007/s11999-016-4730-6. 2016/02/04.

[34] Wright DG, Covey DC, Born CT, et al. Open dislocation of the knee. J Orthop Trauma 1995;9:135–40. https://doi.org/10.1097/00005131-199504000-00008.