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Development of the Revision Hip Complexity Classification using a modified Delphi technique

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Aims

The aim of this modified Delphi process was to create a structured Revision Hip Complexity Classification (RHCC) which can be used as a tool to help direct multidisciplinary team (MDT) discussions of complex cases in local or regional revision networks.

Methods

The RHCC was developed with the help of a steering group and an invitation through the British Hip Society (BHS) to members to apply, forming an expert panel of 35. We ran a mixed-method modified Delphi process (three rounds of questionnaires and one virtual meeting). Round 1 consisted of identifying the factors that govern the decision-making and complexities, with weighting given to factors considered most important by experts. Participants were asked to identify classification systems where relevant. Rounds 2 and 3 focused on grouping each factor into H1, H2, or H3, creating a hierarchy of complexity. This was followed by a virtual meeting in an attempt to achieve consensus on the factors which had not achieved consensus in preceding rounds.

Results

The expert group achieved strong consensus in 32 out of 36 factors following the Delphi process. The RHCC used the existing Paprosky (acetabulum and femur), Unified Classification System, and American Society of Anesthesiologists (ASA) classification systems. Patients with ASA grade III/IV are recognized with a qualifier of an asterisk added to the final classification. The classification has good intraobserver and interobserver reliability with Kappa values of 0.88 to 0.92 and 0.77 to 0.85, respectively.

Conclusion

The RHCC has been developed through a modified Delphi technique. RHCC will provide a framework to allow discussion of complex cases as part of a local or regional hip revision MDT. We believe that adoption of the RHCC will provide a comprehensive and reproducible method to describe each patient's case with regard to surgical complexity, in addition to medical comorbidities that may influence their management.

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Introduction

There is considerable variation of practice across the NHS in the UK with regard to provision of revision total hip arthroplasty (RTHA). Approximately 60% of surgeons undertaking the procedure perform fewer than ten procedures a year.[1] There is evidence that better outcomes can be achieved by hospitals undertaking high volumes of particular specialist procedures.[2,3] In the latest Getting It Right First Time (GIRFT) report, published in 2020, the recommendation was to create hub-and-spoke networks for complex surgery such as revision, with centralization of the most complex revision work.[1] As part of this drive for improvement in outcomes, NHS England and NHS Improvement established formal revision knee networks across

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Table I. Criteria of expert panel for Delphi process.

BHS member
Five years or more of experience as a consultant
Five or more peer-reviewed publications in the last five years on hip arthroplasty
Performs more than 15 revision hip arthroplasty per year

BHS, British Hip Society.

Table II. Level of consensus at second international consensus meeting at Philadelphia in 2018.

Majority	Agreement (%)	Level of consensus
Simple majority	50.1 to 59.9	No consensus
Majority	60.0 to 65.9	Weak consensus
Super majority	66.0 to 99.9	Strong consensus
Unanimous	100	100% agreement

Table III. Goals of the Revision Hip Complexity Classification.

Goals
Be simple to use
Have a graded level of complexity
Identify factors that carry greater weighting
Use established classification systems whenever appropriate, for example acetabular/femoral defect, host factors (local or systemic), periprosthetic fracture etc.
Have good inter- and intraobserver reliability

England to support implementation of the GIRFT recommendation.

The process adopted by the British Hip Society (BHS) for the formation of revision hip networks is intended to foster collaboration and encourage the natural and organic development of revision hip networks. Units which are not already part of such networks will be encouraged to join, and the process will be supported by the creation of guidance produced by the BHS in the form of standards documents. These will cover multidisciplinary team (MDT) working, perioperative and intraoperative care of revision patients, and in particular a Revision Hip Complexity Classification (RHCC), to allow efficient and accurate description of case complexity to support where and by whom the case should be managed. The RHCC should help facilitate MDT discussion, provide an objective and consistent method to report cases, allow useful data collection, and support future audit and research.

There are currently no comprehensive complexity classifications published for revision hip surgery as the current classification systems tend to be specific to either a particular preoperative diagnosis (e.g. periprosthetic fracture), a specific intraoperative issue (e.g. degree of bone loss), or patient physical status (e.g. American Society of Anesthesiologists (ASA) grade).[4]

We sought to develop the comprehensive RHCC in a scientific manner by using the modified Delphi technique of consensus-building among a group of expert hip surgeons in the UK. The Delphi process was originally developed by Norman Dalkey from RAND Corperation in 1967.[5] The process was designed to reduce the effects of group interaction and bias, and has three distinctive characteristics: anonymity, controlled feedback, and statistical "group response". The experts respond to online questionnaires, receive aggregated results feedback, and resubmit their opinion. The entire process is repeated for multiple iterations.[5]

The aim of the modified Delphi process was to create a simple, structured RHCC which can be used to classify all cases requiring revision hip surgery, based solely on preoperative information.

Methods

A steering group (SG) was formed from members of the BHS executive and research committee. The purpose of the SG was to drive the process and to avoid individual and facilitator bias during the Delphi process. The SG met online to agree on the methodology. There were subsequent online SG meetings following each round of the Delphi process to discuss findings and plan for subsequent rounds.

An invitation seeking volunteers to form an expert panel was sent out to the BHS membership during a network webinar and included in the presidential newsletter. The criteria for expert panel membership were defined as per Table I. In our study, the expert panel consisted of 35 specialist hip surgeons who met the inclusion criteria. We adopted the consensus criteria that was used during the second International Consensus Meeting on PJI at Philadelphia in 2018 (Table II).[6] All expert panel responses were blinded prior to analysis by the SG.

Round 1. Our first round of questions aimed to identify: factors that are relevant to decision-making including geographical, surgical, implant factors, or host factors (local and systemic); factors that should be given greater weighting and immediately lead to an increase in severity/complexity; preoperative classification systems that are used frequently in surgical planning; expert familiarity with using Revision Knee Complexity Classification (RKCC);[7] and whether RHCC should mirror RKCC.

During the process, we outlined the goal of the classification to the expert panel as shown in Table III. The questionnaire (Supplementary Material) was generated using Survey Monkey (www.surveymonkey.co.uk), and was sent electronically to the expert panel. All responses were recorded anonymously in line with Delphi standards.

Round 2. Following round 1, the SG grouped responses to identify the major factors that were deemed important to the expert panel, including bone loss, infection, periprosthetic fracture, soft-tissue deficiencies, previous revisions and patient factors, and which existing classification systems were preferred for each of these by the panel

Fig. 1

Top ten factors that experts considered important in governing complexity of revision hip arthroplasty.

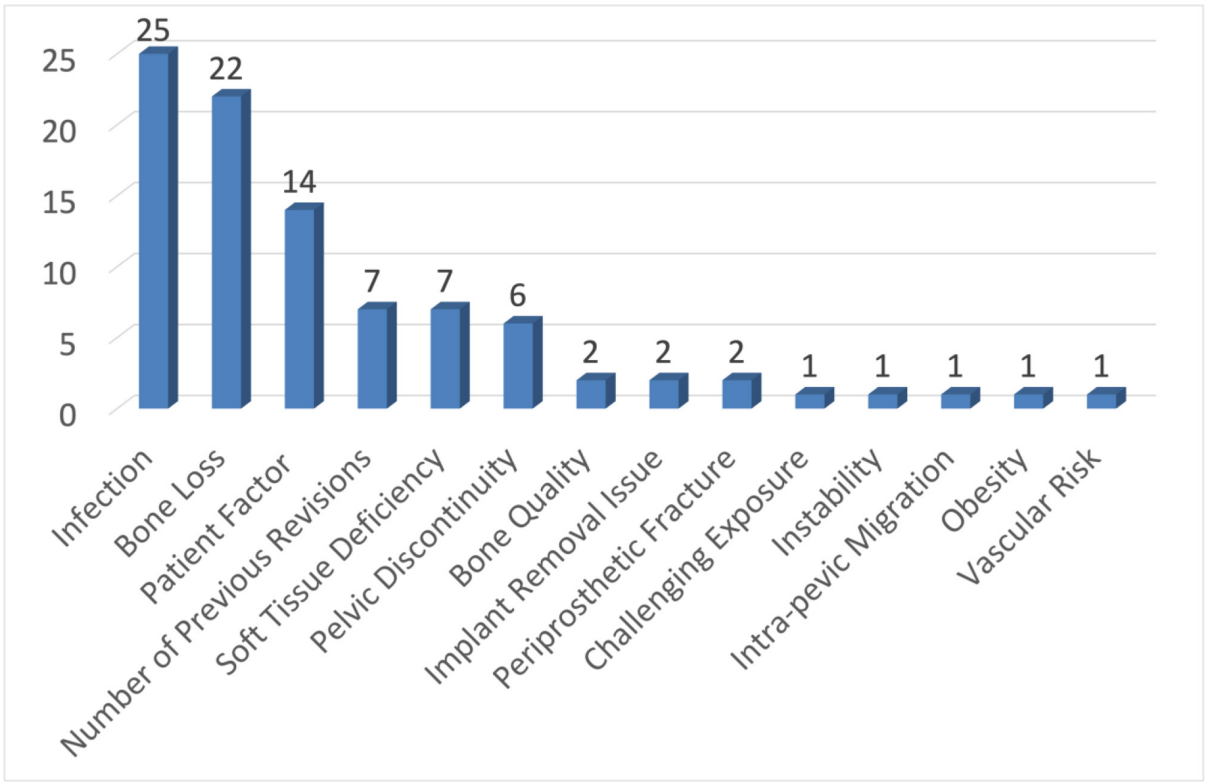

Fig. 2

Top three factors deemed important for complexity.

(Supplementary Material). These included Paprosky classification for acetabular[8] and femoral bone loss,[9] Unified Classification System[10] (UCS) for periprosthetic fractures, and ASA grade[4] for patient factors. The results of the first round were presented to the panel during the round 2 survey for feedback.

During round 2, the SG and expert panel delved deeper into deciding how much each factor would affect

Table IV. Factors discussed in final consensus meeting.

Well-fixed uncemented socket with lysis >10mm into ischium, pubic ramus, or ilium
Removal of well-fixed uncemented metaphyseal filling uncemented implants
UCS classification B1, C, D
Debridement, antibiotics and implant retention for infection

UCS, Unified Classification System.

Table V. Consensus regarding classification systems.

Factors	Classification system	Consensus level (%)
Bone loss	Paprosky	Strong (75)
Patient factor	ASA	Strong (67)
Periprosthetic fracture	UCS/Vancouver	Unanimous (100)

ASA, American Society of Anesthesiologists; UCS, Unified Classification System.

the complexity of a particular case by asking the panel to categorize each classification into one of three levels of complexity: H1 (simplest cases), H2 (cases of moderate complexity), or H3 (most complex cases). We chose H1, H2, and H3 as our categories to mirror the RKCC to provide uniformity across revision networks.

Round 3. We achieved strong consensus in some factors in previous rounds. The results of round 2 were reviewed by the panel. We also performed a literature review and provided a summary of available evidence for each factor where consensus remained in question. Anonymous comments from panellists recorded during round 2 Delphi process were also summarized and presented to the expert panel.

Following some comments made by experts during round 2, a number of new factors were included for consideration. Concerns were raised about the complexity of removal of a well-fixed uncemented metaphyseal filling femoral stem and removal of a well-fixed uncemented cup with severe lysis into the ischium or ilium. Neither of these issues are considered in the Paprosky classification, but were noted to be important by a number of experts. We also added UCS D, E, and F for consideration. There were also comments with regards to potentially classifying a patient to the highest complexity category due to high ASA grade despite the patient undergoing relatively straightforward surgery. We therefore posed the question as to whether ASA should be considered as independent factor or as an escalator of complexity (Supplementary Material).

Final virtual consensus meeting. As there were still six remaining factors out of 36 that had not achieved consensus, the SG agreed that we should hold an online meeting in an attempt to achieve consensus for these remaining factors and to vote on the final classification.

The results of consensus achieved thus far were summarized and presented during the online consensus meeting on 19 April 2021. This was attended by 27 out of the original 35 experts (77%). The aim of the RHCC was reiterated. The remaining six factors yet to achieve consensus were posted for discussion. The process started with presentation of the previous round results, comments made by experts in round 3, and a short presentation of current scientific evidence with discussion regarding published outcomes. The panellists were then asked to vote anonymously in real time. The process was repeated for each of the remaining factors. (Table IV) During this final virtual meeting, consensus was only obtained from the experts who were present (77%).

Intra- and interobserver reliability testing. Following construction of the final classification system, two consultant grade surgeons (TB, SP) independently classified 100 consecutive revision cases. Scoring was performed blinded to the outcome of the surgery and using preoperative data only, as provided on an amalgamated slide deck of all cases. The classification level of every case was recorded, and the process was repeated four weeks later. Kappa statistics were calculated to allow assessment of inter- and intraobserver reliability.

Results

Round 1. Figure 1 shows a word cloud based on all responses received when the expert panel was asked to list the top ten factors they considered important in governing the complexity of rTHA. All surgical factors proposed from round 1 were included for round 2. These factors are grouped into the main domains. Figure 2 shows the top three factors deemed most important for complexity by each expert with infection, bone loss, and systemic patient factors consistently being considered as important factors.

The majority (94%; n = 33) thought that the RHCC could provide a useful reference for discussion for the management of rTHA in a local revision network. The majority (80%; n = 28) did not have any experience of using RKCC as part of revision practice. This is largely due to most experts not performing revision total knee arthroplasty as part of their practice.

When asked about preferred classification, there was an overwhelming majority of experts choosing Vancouver/Unified Classification System for periprosthetic fractures, Paprosky for bone loss, and ASA for patient's physical status (Table V).

Round 2, Round 3, and final virtual consensus meeting. The results from rounds 2, 3, and the final virtual consensus meeting are shown in Table VI. We were able to achieve consensus in all but six factors after round 3. Following the final virtual consensus meeting, we were still unable to achieve consensus in four of the 35 factors. The individual elements are discussed below.

Bone loss (acetabulum). We achieved a strong consensus for all Paprosky acetabular defect grades. Following round 2, there were questions raised with regard to

Table VI. Percentage of consensus achieved for each category and during which round it was achieved.

Category	H1	H2	H3
Paprosky (acetabulum)			
I	97%	3%	0%
IIA	77%	20%	3%
IIB	8%	89%	3%
IIC	11%	74%	14%
IIIA	3%	17%	81%
IIIB	0%	11%	89%
Pelvic discontinuity	0%	0%	100%
Removal of well-fixed uncemented socket with > 1 cm lysis into ischium, ramus, or ilium*	0%	81%	9%
Paprosky (Femur)			
I	97%	3%	0%
II	8%	83%	8%
IIIA	6%	74%	20%
IIIB	0%	31%	69%
IV	0%	9%	91%
Removal of well-fixed uncemented metaphyseal filling femoral implant*	0%	44%	56%
Periprosthetic fracture			
A	88%	9%	3%
B1	4%	96%	0%
B2	11%	74%	14%
B3	0%	34%	66%
C	38%	50%	12%
D*	4%	59%	37%
E*	0%	21%	79%
F*	0%	18%	82%
Infection			
DAIR	44%	52%	4%
First time revision	6%	69%	26%
Revision for atypical organism (fungal, Tuberculosis, or multi-drug resistant organisms)	0%	11%	89%
Re-revision	0%	3%	97%
Soft-tissue			
No evidence of abductor muscle compromise	97%	3%	0%
Some evidence of abductor compromise	29%	69%	3%
Evidence of complete abductor deficiency	0%	85%	15%
Case requiring plastic or vascular surgical support	0%	3%	97%
Previous revisions			
First time revision	80%	14%	6%
Revision of proximal femoral arthroplasty	0%	12%	88%
Revision of total femoral arthroplasty	0%	0%	100%
Dislocation			
First time revision for dislocation	21%	76%	3%
Re-revision for dislocation	0%	32%	68%

% second round.
% third round.
% open meeting.
% consensus not achieved.
*American Society of Anesthesiologists (ASA)† 76% voted for ASA III/IV to be a qualifier whereby case is added with *
DAIR, debridement, antibiotics, and implant retention.

the complexity of revision of a well-fixed uncemented implant with significant bone loss (defined as > 1 cm lysis into ischium, ramus, or ilium) and whether this should be considered in the RHCC, as this is not taken into account by the Paprosky classification. Experts commented that "a well-fixed socket is frequently the bigger issue", "Osteolysis on radiograph is often more significant intraoperatively", and "potential difficulties if equipment are not on the shelf". During round 3, 89% thought this was an important factor to be considered in final classification. This was classified as H2 during the virtual meeting with 81% consensus.

Bone loss (femur). We also achieved a strong consensus for all Paprosky femoral defect grades. A similar query was raised regarding complexity of implant removal, in particular with removal of well-fixed uncemented

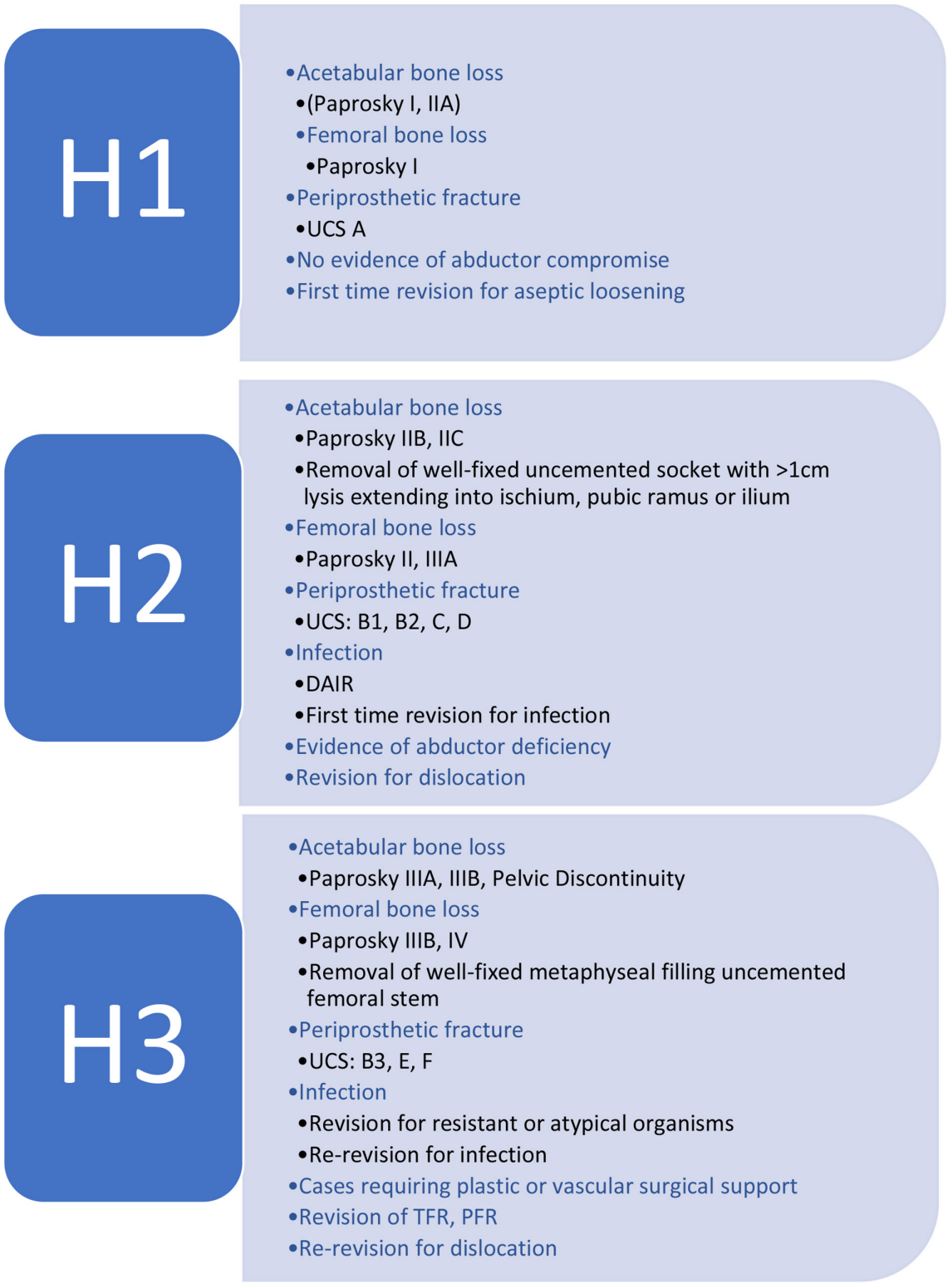

Fig. 3

Final Revision Hip Complexity Classification (RHCC). American Society of Anesthesiologists (ASA) ≥ 3 adds * to final classification grade. The highest classification of any individual element is the overall grade. Possible overall grades are: H1, H1*, H2, H2*, H3, H3*. DAIR, debridement, antibiotics, and implant retention; PFR, proximal femoral replacement; TFR, total femoral replacement; UCS, Unified Classification System.

metaphyseal filling stem such as the Furlong. Ultimately, 86% thought that this was an important factor to be included in the classification. There were concerns raised regarding "different level of complexities for

different types of stems (proximally coated or fully coated with distal fixation)" and the "need to deal with proximal third that crumbles as opposed to uncomplicated ETO". Due to the complex nature of scenarios, we were unable to achieve consensus with simple majority (56%), classifying this scenario as H3.

Periprosthetic fracture. Following round 2, the experts agreed that UCS is more comprehensive than the original Vancouver classification and should be used within the RHCC. We were able to achieve strong consensus on all but three grades before the virtual meeting. During the final meeting these three remaining grades were discussed and voted upon. Following discussion, we achieved strong consensus for UCS B1 to be classified into H2. UCS C and D were classified into H2 with 50% and 59% consensus, respectively.

Infection. Consensus was achieved during round 2 for different types of revision for infection apart from debridement and implant retention (DAIR). There were comments from experts such as "a poorly done DAIR in inexperienced hands can make a difficult situation worse", "significant debridement required with appropriate implants", and "need support of infection team". The final outcome was a simple majority of experts (52%) agreed that DAIR should be classified as H2.

Soft-tissue. We were able to achieve strong consensus in factors involving abductor muscle deficiency and cases that require plastic or vascular surgical support during round 3. Complete abductor deficiencies raise the complexity of a case that is otherwise classified H1 to H2 while cases requiring vascular and plastic support raises the complexity to H3.

Previous revision THA. We achieved strong consensus with regard to previous revision surgeries, revision of a proximal femoral arthroplasty (PFA) or a total femoral arthroplasty (TFA) was classified as H3.

Dislocation. First-time revision for dislocation was thought to be complex enough to warrant a H2 while re-revision for dislocation was classified as H3.

ASA. Patient factors were high on the consideration for rTHA for most experts, with 25 out of 36 citing this as one of their top three factors. Following round 2, ASA was grouped into I/II (H1), III (H2), and IV (H3). Concerns were raised by the SG that with a significant number of patients being elderly with multiple comorbidities, there was a risk that a disproportionate number would be classified into H2/3 while undergoing a relatively "simple" revision. Hence, during round 3, the question was posed of ASA being an escalator (raises one level of complexity) or a qualifier (being recognized with an * if ASA III/IV). We achieved strong consensus that patients with ASA III/IV should be a qualifier and patients will have an * added to final classification. In clinical use of the classification, this will allow the highlighting of both the technical complexities of surgeries as well as medical/anaesthetic complexities or potential higher level of support required for such patients.

Final vote. At the close of the virtual meeting, the final complete RHCC system was presented. A final vote was taken as to whether the RHCC as presented reflected the process that had been undertaken, with 100% of the experts voting in agreement. The final classification is shown in Figure 3.

Intra- and interobserver reliability testing. The classification was shown to have good intraobserver reliability on repeat testing with Kappa values of 0.88 to 0.92. Interobserver reliability was also good with kappa values of 0.77 to 0.85.

Discussion

The aim of GIRFT is to improve patient care, experience, and outcome by reducing variation of care, especially in complex surgery such as rTHA.[1] We believed that the use of the RHCC developed in a scientifically robust manner by the BHS will help with the development of revision hip networks, thereby improving management and outcome of patients requiring rTHA. Current available classifications are specific to one particular diagnosis, such as a periprosthetic fracture, or assess one factor that may influence complexity, such as the amount of bone loss, but do not encompass all aspects of potential complexity of rTHA. The RHCC classification system is simple, reproducible, comprehensive, and relies on pre-existing validated classification systems. It will allow surgeons to evaluate on a case-by-case basis the facilities, skills, and equipment required for the management of the patient. The classification is patient-centred, including both surgical complexities and the patient's medical and anaesthetic needs. The RHCC allows surgeons to evaluate a case preoperatively based on routinely performed investigations.

We did not achieve a strong consensus for six out of a total of 36 factors despite going through three rounds of the Delphi process, and the modification to the Delphi process of the addition of a virtual meeting for further discussion. This further illustrates the complexity of rTHA. For example, removal of a well-fixed metaphyseal filling uncemented stem was discussed. As mentioned previously, the difficulty of each case depends on the type of stem and quality of proximal bone stock. During the open meeting, we presented data on a number of different techniques of stem removal and outcomes based on a review of literature.[11-13] The literature is limited in this regard and might therefore explain why we only achieved a simple majority vote for this type of case. We also had an extensive discussion with regard to UCS classification grades B1, C, and D for periprosthetic fracture. The reason for difficulty in achieving consensus was the fact that these cases are generally managed with internal fixation rather than with revision, and therefore caused some confusion in a revision classification process. Following the open

meeting, the expert group felt that a surgeon who internally fixes a B1 fracture should have the ability to change the management plan intraoperatively and revise the stem.[14] If this is not possible, a colleague who is able to do so should be readily available if required. Furthermore, there may be complex situations where a B1 fracture does require revision.[15,16] As a result of these discussions, B1 was classified into H2 complexity (96%). Classifying C and D was also a challenge for similar reasons. Although fixation was thought to be straightforward, revision in these instances was noted to be complex. Ultimately, we only achieved a simple majority on these two grades with both C and D classified as H2. Classification of infected cases was achieved early in the process except in the situation where a debridement, antibiotics, and implant retention (DAIR) was required, and this proved to be the most contentious factor discussed. While surgical complexity may well be less challenging than most revision surgery, it was noted that the complexity of decision-making and the requirements of a true MDT approach in the management of patients with periprosthetic joint infection, particularly expert microbiological input, was such an important factor that many of the panel felt this element should be reflected in the classification of DAIR. There was a strong belief from the panel that DAIR should only be performed by revision hip arthroplasty surgeons. During the final meeting, the SG presented outcomes of DAIR. Following extensive discussion and voting, a simple majority was achieved in agreement to classified DAIR as H2 (52%).

Our work was conducted with a systematic Delphi process approach with multiple iterations and review of the current available literature. The SG felt that this was the most scientifically robust method in developing the RHCC in a surgeon consensus approach. The Delphi methodology has been used extensively in orthopaedics in development of core outcomes and achieving consensus.[17,18] Our expert group was composed of volunteer experienced surgeons throughout the UK who met defined criteria for inclusion. The first three rounds of surveys reduced interactions between experts, following the Delphi method, thereby reducing the chances of decisions being influenced by other participants. Using an online questionnaire also increased the response rate by allowing the return of answers, achieving a 100% response rate from the expert group. We chose to form a SG rather than have an individual facilitator, to avoid facilitator bias during the process. Our final virtual meeting was a modification of the original Delphi process; however, the SG felt that this was the best way forward to try and maximize consensus and produce a workable classification.

There are some limitations with regard to this classification. Limiting number of responses to ten factors could result in important points being missed. However, only ten out of 35 experts has used all ten factors, with repetitions and elaboration of factors covered for these experts in the process. The RHCC was developed based on the opinion of experts who may have their own biases based on their clinical experiences. Moving to a modified Delphi process which included a virtual meeting with online discussion could have also potentially influenced the outcome of the final few contentious factors, with the risk of dominant individuals influencing other members. However, we only achieved consensus on a further two factors despite the open meeting. Dropout in participants has been reported as an issue with the Delphi technique.[19] However, we only observed dropout for the final virtual meeting, with 27 out of the original 35 experts (77%) attending the meeting. Dropout of this rate is unlikely to influence the final outcome of this study.

The RHCC incorporates pre-existing classification systems such as Paprosky, UCS, and ASA. Although these systems have been validated and shown to be reproducible, there is an inevitable compounding of potential unreliability when using multiple classifications in one overall score. In most cases, however, only one diagnosis exists (such as periprosthetic fracture) and therefore only one surgical and one anaesthetic classification system would be used. We have shown good inter- and intraobserver reliability in the classification of 100 consecutive cases.

The RHCC has been developed in a scientifically robust manner through a modified Delphi process. It is currently the only classification that is comprehensive, and includes all indications for revision hip surgery. It provides a framework for discussion at MDT meetings and will act as a tool to assist with the development of local revision networks within the UK healthcare setting. We strongly believe that adoption of the RHCC will provide a comprehensive, objective, and methodical way of assessing surgical complexity and the medical or anaesthetic support required to undertake revision hip arthroplasty.

Take home message

- Revision Hip Complexity Classification (RHCC) is currently the only classification that is comprehensive and includes all indications for revision hip surgery.
- RHCC provides a framework for discussion within the multidisciplinary team and will act as a tool to assist with development of local revision network.
- RHCC will provide comprehensive, objective and methodical way of assessing surgical complexity and the medical or anaesthetic support required to undertake revision hip arthroplasty.

Supplementary material

The three rounds of Delphi questionnaires.

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Ethical review statement:
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