Consensus review on peri-implant femur fracture treatment: Peri-Implant Spanish Consensus (PISCO) investigators’ recommendations

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• A peri-implant femoral fracture (PIFF) is defined as a femoral fracture in the presence of a pre-existing non-prosthetic implant. Classification systems, treatment guidelines and fixation strategies exist for peri-prosthetic fractures, but there is no standard of care regarding PIFFs.

• The aim of the Peri-Implant Spanish Consensus (aka PISCO) investigators is to reach an agreement regarding current practices for management of PIFFs and to propose four main principles to assess surgical treatment and prevention of these fractures.

• This consensus review was conducted according to the Delphi method. Twenty-two expert orthopaedic trauma surgeons performed the consensus and the definitive statements were approved unanimously.

• Biological fixation principles must be utilized in the surgical treatment of peri-implant femur fractures, which include closed or minimally invasive reduction techniques. The osteosynthesis must protect the entire bone.

• Gaps between two implants should be avoided. If implant overlap is not possible to achieve, then spanning inter-implant fixation systems must be used, especially in osteoporotic bone.

• Previous implants should be retained during surgical treatment of peri-implant femur fractures. Only those implants that would interfere with current fixation goals should be removed.

• If the previous implant is in the femoral neck region, then femoral neck protection must be maintained when treating the peri-implant fracture, even if the neck fracture has already healed.

Keywords: femur; peri-implant fractures; hip fracture; consensus
Introduction

Population aging has become a widely known phenomenon in industrialized nations. In 2030, there will be about 1 billion people aged 65 and older globally (1). The growing life expectancy will be associated to an increase of chronic diseases, like osteoporosis and the fractures related to it. Therefore, the incidence of lower extremity fractures around pre-existing fixation hardware will also increase (2, 3).

A peri-implant femoral fracture (PIFF) is defined as a femoral fracture in the presence of a pre-existing non-prosthetic implant (4, 5). Even with implant improvement, several reports have shown a potential risk of femoral fractures after osteosynthesis due to changes in bone elastic modulus, ‘stress riser’ effect, and poor bone quality inherent to the aging process (6, 7). Peri-prosthetic femoral fractures (PPFFs) have been extensively studied and there are different classification systems and treatment guidelines (8, 9). Fixation strategies exist for peri-prosthetic hip and knee fractures, but there is no standard of care regarding PIFFs (5).

PIFF is an under-reported entity and evidence available proceeds from retrospective studies, case reports and experts’ opinion (5, 10). Although some peri-prosthetic surgical techniques could be applied to PIFFs, both are different entities, which should be assessed separately (11). Some authors hypothesized that a specific algorithm for PIFF could guide trauma surgeons in the difficult decision-making process, but these algorithms can be complex and confusing (12). Three classification systems have been proposed as an attempt to address the best treatment option (13, 14, 15). Vergilius classification system is focused on fractures around trochanteric nails (13). Egol et al. proposed a method to classify fractures related to a previously implanted device in both the upper and lower limb (14). The classification by Videla et al. is being tested through a validation process in three phases, and recently the second classification has been published (15, 16).

Management of these fractures is challenging for some reasons: alterations in anatomy, the presence of osteosynthesis fixation devices and phenomena such as stress shielding, disuse osteopenia and fracture remodelling (5). Despite the proposed algorithms and classifications, the decision-making process is still unclear and there is lack of systematization and consensus. In addition, not only are these fractures treated by specialized orthopaedic trauma surgeons in level I trauma centres, but they are also treated in tertiary centres by general orthopaedic surgeons.

Application scope of the consensus

The aim of the Peri-Implant Spanish Consensus (PISCO) investigators is to reach an agreement regarding current practices for management of PIFFs and to propose four main principles relevant to assess surgical treatment and prevention of peri-implant femoral fractures.

Development process of the consensus

The proposed consensus was conducted according to the Delphi method (17). This technique has previously been used to develop guidelines and achieve consensus on trauma care or on peri-prosthetic joint infection (18, 19).

The process of generating the consensus spanned over 13 months and five specific steps were followed.

Step 1 (October 2021): Selection of delegates. The lead author (Dr Castillón) selected a consensus group of 22 expert orthopaedic trauma surgeons, from 15 hospitals in 7 autonomous communities in Spain (Supplement 1).

The 22 expert orthopaedic trauma surgeons selected as delegates had more than 10 years of surgical experience, they were working in level I trauma centres, and they performed twenty or more peri-prosthetic or peri-implant femur fractures per year.

Step 2 (November 2021): Identification of potential main principles in peri-implant femoral fracture treatment. The lead author proposed four principles in PIFF treatment: principle 1: biological osteosynthesis; principle 2: inter-implant protection; principle 3: pre-existing implant retention and principle 4: femoral neck protection. These four principles arose from literature research, lectures, and expert opinions.

All 22 delegates were invited to discuss these four principles, modify them or add a different one, during a 30-day period.

Step 3 (December 2021 to November 2022): Validation process. Every 4 months since December 2021, the Delphi technique was used to collect the 22 delegates’ opinions on a set of questions about the four principles, as follows:

- Set of questions: Each principle was assigned to two delegates and the lead author. A set of questions (issues) related to that principle was collected.
- Ranking of questions: The lead author and the two delegates discussed about the questions proposed and prioritized them.
- Evaluation of ranked questions: The questions selected were rewritten in a multiple-choice question design, and they were sent to all 22 delegates, as an independent document, by email (in Microsoft Word format).
- Literature review: The two delegates and the lead author were actively engaged in researching about the questions sent, and preparing a preliminary document related to the questions.

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• Answers: All 22 delegates sent back their answers by email. All answers, clarifications and arguments were copied in an Microsoft Excel database. Frequencies of answers and percentages of agreement and disagreement were calculated with Microsoft Excel.

Step 4. (November 29th, 2022). Inter-delegate discussions. The delegates participated in a consensus meeting. Frequencies of answers and percentages of agreement for each question were explained to all delegates at the meeting. The strength of the consensus was ranked by the following scale (20):

- Simple Majority: No consensus (50.1–59% agreement).
- Majority: Weak consensus (60–65% agreement).
- Super Majority: Strong consensus (66–99% agreement).
- Unanimous: 100% agreement.

During the meeting, each one of the four principles was validated only if a strong or unanimous consensus was reached for the set of questions related to it. If agreement was less than 65%, the review of the literature was revisited and discussed by all delegates. A second voting round took place to reach a strong consensus or a 100% agreement.

Step 5. (November 29, 2022). The four principles document edition. During the consensus meeting, delegates modified the final statements corresponding to each one of the four principles. The definitive statements were approved by all the delegates with unanimous consensus and ordered from one to four.

Four principles relevant to assess surgical treatment and prevention of PIFFs

1. First principle: principle of biological respect. Five questions were sent to the delegates (Table 1). Twenty-one delegates (95.4%) answered the set of questions related to the first principle.

The default fracture reduction strategy, for simple or comminuted fractures, was the subject of the first and the second questions respectively. Closed reduction and minimally invasive techniques for fracture fixation were supported by 100% of delegates, independently of fracture type. Chance to open reduction to achieve better results was discussed. All delegates agreed that the aim of the procedure is to reduce the fracture adequately (gap between bony fragments should be as short as possible), restoring length, axis and rotation of the femur. Despite the advantage of minimally invasive techniques on fracture healing, open reduction should be considered, when necessary, to avoid malreduction resulting in hardware failure, nonunion or malunion.

The third and fourth questions addressed the characteristics of the extra-medullary systems utilized in the osteosynthesis of simple or comminuted diaphyseal and metaphyseal PIFFs. Unanimous consensus was reached for bridging locking plates in comminuted fractures. The delegates also agreed that the ‘plate span width’ should ideally be two to three times the length of the fracture or longer, to span the whole femur to protect it from further injuries. In case of simple fracture patterns an 86% agreement (strong consensus) was reached around the same considerations explained for comminuted fractures. Three delegates (14.2%) considered compression plates in simple transverse femur fractures and in simple oblique or spiral patterns they advocated for inter-fragmentary screws and protection plates. Only one (4.76%) considered the utilization of cortical onlay allografts (struts) in this type of fractures. Eighteen delegates (85.7%) agreed with the first principle statement in the last question.

After the inter-delegate discussion, the first principle statement was edited until a unanimous agreement was reached:

*Biological fixation principles must be utilized in the surgical treatment of peri-implant femur fractures, which include closed or minimally invasive reduction techniques. The osteosynthesis must protect the entire bone.*

2. Second principle: principle of inter-implant protection. Four questions were sent to the delegates (Table 2). All delegates answered the set of questions related to the second principle.

The overlapping technique was the subject of the first question. Delegates were asked about the necessity of
bypassing or overlapping the implant already present in the femur, with the system used to treat the PIFF. All agreed to apply the overlapping technique, whenever possible. There was no consensus to define the optimal overlapping distance. A simple majority (59%) agreed that a minimal overlap of at least 6 cm should be recommended in osteoporotic bone to avoid stress concentration.

The second question was related to ‘kissing implants’ technique. Seventeen delegates (77.2%) agreed that it should not be considered a prophylactic technique for inter-implant fractures; on the contrary, between both implants’ tips, new stress rises and new ruptures can arise. The clinical relevance of the biomechanical evidence of a safe zone between two implants was discussed (more than 2.5× diameter of the femoral diaphysis, over 6 cm or over 110 mm) (21, 22, 23). Delegates recommended that, especially in osteoporotic bone (decreased cortical width and increased medullary diameter), any gap between both implants’ tips should be avoided, even if the distance could be considered adequate according to the stress riser biomechanical criteria previously cited (21, 22, 23).

Strong consensus was reached for the third question. Eighty-six percent agreed that if is not possible to achieve implant overlapping, then spanning inter-implant fixation devices must be used. Nevertheless, there was no consensus to set the distance or femur characteristics that make the inter-implant space protection mandatory. Eight delegates (36%) considered to use the inter-implant fixation systems regardless of the gap length between the tips of the implants, the femoral cortex thickness or the medullary canal size. Another 36% considered that gaps <110 mm between the tips of the implants increases the risk of femoral fracture and 14% defended that decreased cortical width and increased medullary diameter are the main indicators to use an inter-implant protection system.

All delegates agreed with the second principle statement.

During the inter-delegate discussion, the second principle statement was discussed until a unanimous agreement was reached:

Gaps between two implants should be avoided. If implant overlap is not possible to achieve, then spanning inter-implant fixation systems must be used, especially in osteoporotic bone.

The four principles for management of PIFFs are applied in Figs. 1 and 2.

3. **Third principle: principle of conservation of existing implants.** Eight questions were sent to the delegates (Table 3). Twenty-one delegates (95.4%) answered the set of questions related to the third principle.

The current practice for implant removal in asymptomatic patients was the subject of the first and the second questions. All agreed that they do not remove osteosynthesis metal hardware in asymptomatic patients after fracture healing. There was also unanimous consensus about not removing the hardware to prevent new fractures.

In the third question, 90% of the delegates answered that they have had an intra-operative or post-operative complication related to hardware removal at least once.

Delegates unanimously agreed that the pre-existing osteosynthesis could be retained and combined with a new one, in the fourth question.

Also 100% agreement was reached for the fifth question. Delegates prefer to retain the pre-existing implant, whenever possible, to save surgical time and decrease the morbidity of the procedure. Just the removal of metal hardware (screws or cables), from the previous osteosynthesis, that could interfere the fixation goals, is required.

On questions 6 and 7 supermajority (strong consensus) was reached about retaining an intra-medullary nail and using an extra-medullary implant to treat a fracture at the tip of the nail. There was 90% agreement with long nails and 76% when the fracture was around a short nail. Five delegates (23.8%) preferred to exchange a short intra-medullary nail with a longer one. Nevertheless, complications should always be considered before deciding to exchange a nail.

Unanimous consensus was reached for the third principle statement in the last question. After the document edition, the third principle was proposed as follows:

**Previous implants should be retained during surgical treatment of peri-implant femur fractures. Only those implants that would interfere with current fixation goals should be removed.**

4. **Fourth principle: principle of protection of the femoral neck.** Four questions were sent to the delegates (Table 4). All the delegates answered the set of questions related to the fourth principle.

The fourth principle was included for two reasons. First, apply the general agreement of the third principle (previous implant should be retained) to the particularity
of the femoral neck. The preexisting systemic osteoporosis, local osteoporosis as a result of preloading by the fixation device in the femoral neck, and the removal of hardware from the femoral neck, with reduction of the failure strength, are risk factors for femoral neck fractures after implant removal (55). Second, discuss if in the fractures at the proximal end of short retrograde intramedullary nails (RIMN) or short distal femur plates, (in the middle shaft of the femur), the extension of the new fixation into the femoral neck, to protect against a femoral neck fracture, should become advisable. Although the first principle recommended to protect the entire bone, there is not strong evidence about the role of prophylactic femoral neck fixation when treating femoral diaphyseal fragility fractures, even though the treatment of peri-implant femoral neck fractures may be particularly challenging.

Unanimous agreement was reached about retaining cephalo-medullary implants after proximal femur fracture healing.

The current practice of the 22 delegates in case of pain, prominence of hardware or impaired function due to a cephalo-medullary device, after proximal femur fracture healing, was the subject of the second question. Eighteen (strong consensus) proposed not to remove the osteosynthesis or to exchange it for a new one. Four (18%) remove the cephalo-medullary system and fill the screw hole with bone graft or bone substitutes and do not allow full weight bearing.

The third question is, if the pre-existing femoral implant is not located in the neck region, and the PIFF being
treated involves the femoral diaphysis segment, should the new fixation be extended into the femoral neck to protect against femoral neck fracture? No consensus was reached. Half of the delegates considered appropriate to include a recommendation about this topic, but the other half did not.

Strong consensus was reached about the fourth principle statement (95% agreement) in the last question. One of the delegates considered that this recommendation should be more specific to pathologic fractures (osteoporosis or metastasis).

After the inter-delegate discussion, the delegates decided with unanimous agreement the following fourth principle statement:

If the previous implant is in the femoral neck region, then femoral neck protection must be maintained when treating the peri-implant fracture, even if the neck fracture has already healed.

The four principles for management of PIFFs are summarized in Table 3.

### Discussion

PISCO investigators propose four principles, with the aim of systematize the PIFF treatment and provide a consensus tool in the challenging decision-making process of this under-reported entity. The four principles have been classified from the most general recommendation of the first principle to the specific advice of the fourth principle.

**First principle: principle of biological respect**

Closed reduction and minimally invasive techniques for fracture fixation were supported by all delegates unanimously. Kanakaris et al. conducted a multicentre prospective randomized trial and concluded that a good reduction and respect of the local fracture biology was more important than the particular plate design characteristics in the treatment of PPFFs (24). Closed reduction and minimally invasive techniques for fracture fixation were their preferred option. The AO (Arbeitsgemeinschaft für Osteosynthesefragen, Switzerland) proposed the need for biological fracture management (25), and for Sondeger et al. the goal in modern fracture stabilization, using either a plate or nail osteosynthesis, is to maintain the fracture hematoma and bone perfusion, the so-called biological osteosynthesis (26).

Ricci et al. reported a surgical technique for the treatment of PPFFs and PIFFs (27). The hallmark of the described technique is the application of modern biologic fracture fixation principles that minimize the soft-tissue disruption around the fracture and therefore maximize the healing potential. Also, Ruchholtz et al., Ehlinger et al. and Wood et al. concluded that minimally invasive techniques should be the preferred treatment for PPFFs fixation (28, 29, 30). Kanakaris et al. and Wood et al. discussed that despite the potential advantage of smaller less invasive procedures with less blood loss and improved fracture biology, this should not be at the expense of a malreduced fracture (24, 30). There is clear data that adequate fracture reduction and femoral axis alignment, avoiding varus deformity, are crucial to prevent delayed union or mechanical complications (31, 32, 33). All delegates agreed that open reduction should be considered, when necessary, to avoid malreduction. Ebraheim et al. and Buttaro et al. reported high complication rates (37% and 42%) in the treatment of PPFFs with locking compression plates. The loss of endosteal healing potential and the soft tissue stripping required for fracture reduction under direct vision and for the placement of struts, wires, and plates could have played an important role in the failures in these series (34, 35).

Patsiogiannis et al. confirm that the use of bridging locking plates is nowadays the most popular technique.

### Table 3 Summary of the eight questions about the third principle, principle of conservation of existing implants.

<table>
<thead>
<tr>
<th>Question</th>
<th>Retain</th>
<th>Remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is your current practice for implant removal in asymptomatic patients after fracture healing?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2. Do you recommend implant removal in asymptomatic patients after fracture healing to prevent peri-implant fractures?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3. Have you ever had an intra-operative or post-operative complication related to hardware removal?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4. Do you agree that a pre-existing osteosynthesis could be retained and combined with a new one?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5. Do you prefer to retain the pre-existing implant, whenever possible, in order to save surgical time and decrease the morbidity of the procedure?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6. Which is your preferred treatment strategy for a fracture at the tip of a short cephalo-medullary nail?</td>
<td>Retain</td>
<td>Exchange</td>
</tr>
<tr>
<td>7. Which is your preferred treatment strategy for a fracture at the tip of a long cephalo-medullary nail?</td>
<td>Retain</td>
<td>Exchange</td>
</tr>
<tr>
<td>8. Do you agree with the third principle statement?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
of fixation of PPFFs. The plate length should be two to three times the width of the femur at the level of the fracture, protecting the plate from stress concentration and early fatigue failure and to promote callus formation (36). Ruchholtz et al. and Ehlinger et al. reported that long plates can be applied with low rates of soft-tissue complication and implant failure (28, 29). Wood et al. inferred that when minimally invasive techniques are applied, the screw number can be decreased with certain fracture patterns (30). Delegates considered that with a longer plate the surgeon can balance better the fixation construct (working length, plate span width, plate screw ratio).

### Second principle: principle of inter-implant protection

All delegates agreed to apply the overlapping technique and if is not possible to achieve, then inter-implant fixation devices must be used. Walcher et al., Harris et al. and Kubiak et al. have demonstrated in their biomechanical studies that overlapping instrumentations increases load to failure and creates a more biomechanically stable constructs than gapped implants (22, 37, 38). The safe inter-prosthetic distance (IPD) remains an item of discussion (10). For some authors the IPD has no influence. Quirynen et al. concluded that the resistance was maximal for a IPD of zero (39). Iesaka et al. suggested that the distance between two well-fixed stems has only a minor influence on the development of an inter-prosthetic (IP) fracture (40), and Weiser et al. also suggested that the thickness of the cortex seems to be the decisive factor (41). The radiographic findings of Lipof et al. showed that those patients with radiographically decreased cortical width, increased medullary diameter, and increased medullary diameter to cortical width ratio, may be at increased risk of inter-prosthetic fracture (42). On the other hand, Soenen et al., in a finite element model, have shown that stem tip distances shorter than 110 mm dramatically increased the risk of inter-prosthetic fracture and, in osteoporotic bone, thus should be avoided (23). Delegates recommended that, especially in osteoporotic bone any gap between both implants’ tips should be avoided, even if the distance could be considered adequate according to the stress riser biomechanical criteria, previously cited (21, 22, 23).

Lehmann et al. demonstrated that two intra-medullary implants in the femur are associated with a decreased fracture strength between these implants (43). The complex scenario of an inter-prosthetic fracture has pushed some authors to use overlapping prophylactic plates. Peiró et al. treated unstable proximal femur fractures above a knee revision stem with a combination of a short nail and an overlapping lateral plate and resulted in a 100% bone healing and well tolerated early weight bearing without records of major local complications (44). Campillo-Recio et al. also concluded that, instead of treating such complex fractures, they

### Table 4  Summary of the four questions about the fourth principle, principle of protection of the femoral neck.

<table>
<thead>
<tr>
<th>Question</th>
<th>Retain</th>
<th>Remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is your current practice for cephalo-medullary implant retaining in asymptomatic patients after proximal femur fracture healing?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. What is your current practice in cases of pain, prominence of hardware or impaired function due to the osteosynthesis material of a cephalo-medullary system, after proximal femur fracture healing?</td>
<td></td>
<td>Exchange Remove + prevention</td>
</tr>
<tr>
<td>3. If the pre-existing femoral implant is not located in the head-neck region, and the fracture being treated involves the femoral diaphysis segment, should the new fixation be extended into the femoral neck to protect against femoral neck fracture?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4. Do you agree with the third principle statement?</td>
<td>Yes</td>
<td>No</td>
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preferred an effective, safe and reproducible preventive surgical approach, which would involve internal femoral splinting and a prophylactic plate (45).

**Third principle: principle of conservation of existing implants**

The indications for surgical removal of metal implants are not well defined and there are not clear guidelines. In a clinical questionnaire among orthopaedic surgeons in the UK, 87% agreed that retaining metal hardware was safe. Only 11% believed that implants should be removed (46). In a questionnaire addressing 655 trauma surgeons from 65 countries only 15% agreed that routine implant removal is necessary (47). Acklin et al. concluded that the literature reports no benefits with removed or retained hardware to prevent peri-implant or post-implant removal fracture (48).

Intra-operative complications during hardware removal are common. In locked plate osteosynthesis, stripping of the screw head while removing is a major problem. Titanium implants show a stripping of the screw head in up to 10% (49, 50). The PIFFs require prolonged surgery in older frail patients. The physiologic insult to such a frail patient is considerable and can be reduced by anticipating potential problems such as large blood loss. Wood et al. observed the highest blood loss in patients requiring revision fixation and removal of previously retained hardware (30). Goodnough et al. observed that, after fractures below short and long cephalo-medullary nails, in patients treated with revision nailing, there was greater estimated blood loss, blood product utilization and complication rates but a trend towards unrestricted post-operative weight-bearing compared to patients treated with plate and screw constructs (51).

Vilar-Sastre et al. concluded that nail exchange could be beneficial in cases where the proximal segment is too short to obtain sufficient proximal fixation with a plate or those fracture patterns in which the mechanical performance of a lateral plate is more limited, like transverse or comminuted fractures. Nail exchange will be conditioned by the feasibility of removing the previous implants (52).

Finally, there is a risk of refracture after implant removal. Brooks et al. reported a mean 55% reduction in energy absorbing capacity in the presence of a single 2.8 mm or 3.6 mm drill hole (21). In young adults, single-photon absorptiometry of screw holes showed incomplete filling of the hole until 18 weeks after plate removal (53).

Liporace et al. published a nail-plate combination technique for treatment of native and peri-prosthetic distal femur fractures to offer a stable and balanced fixation allowing for immediate weight bearing and early mobilization in the elderly (54). This technique also demonstrates that it is possible to combine effectively an intra-medullary and an extra-medullary implant in the same femur.

**Fourth principle: principle of protection of the femoral neck**

Delegates unanimously agreed that previous femoral neck protection should not be removed in the treatment of the peri-implant fracture. Although hardware removal in healed trochanteric fractures is rarely indicated, in patients with persistent pain and prominent material, the implant is eventually removed. A systematic review found that the overall median incidence of femoral neck fracture after removal of implants from healed trochanteric fractures was 14.5%. They concluded that removal of hardware in healed trochanteric fractures is justified only in very selected cases (55). For Zielinski et al. implant removal after internal fixation of a femoral neck fracture positively influenced quality of life and it should be considered in young patients if pain persists or functional recovery is unsatisfactory (56). In cases of painful proximal hardware, Shaer et al. recommended using a shorter hip screw to minimize hardware prominence (57). Rosen et al. described a treatment option that would limit morbidity and the need for proximal locking device or implant removal by excising the portion of the iliotibial band causing hip irritation (58). Yang et al. recommended to fill up the defect after hardware removal with bone graft or bone graft substitute (59). Legnani et al. recommended that cephalo-medullary nails should only be removed in the presence of a convincing indication (60).

All delegates agreed that PIFFs proximal to long RIMN or to long distal femoral plates involve the subtrochanteric or the intertrochanteric region and should be treated with proximal femur fixation devices (cephalomedullary nail or sliding hip screw).

PIFFs proximal to short RIMNs or short distal femoral plates involve the diaphyseal region. Delegates discussed if, in these cases, the extension of the new fixation into the femoral neck to protect against femoral neck fracture should become advisable. No consensus was reached, and delegates considered that further investigation was needed. Little attention has been paid to the role of prophylactic femoral neck fixation when treating femoral diaphyseal fragility fractures, even though the treatment of peri-implant femoral neck fractures may be particularly challenging (61). Bögl et al. concluded that intra-medullary nails with femoral neck protection in the treatment of low-energy femoral shaft fractures prevent secondary hip fractures and decrease the overall risk for reoperation. On the other hand, the addition of femoral neck fixation may result in increased surgical time, fluoroscopy use, and expense (62). Faucett et al. determined that the use of reconstruction nails for femoral shaft fractures is cost-effective when the incremental costs of implants are less than $650 and if the rate of associated femoral neck fracture is over 7% (63). Marecek concluded that, although further evaluation of this practice is warranted to refine the indications and improve our understanding...
of the limitations, the strategy would seem to be cost-effective (61).

Delegates acknowledge that this consensus review on the treatment of PIFFs has its limitations. The proposed standard of care in the management of PIFFs and the recommendations of the delegates are based in the best available evidence. Research solely focusing on PIFFs is scarce and the evidence is of moderate or low quality. Furthermore, the four principles for managing PIFFs may be revised in the future on the basis of solid clinical data from studies that may use these recommendations. Finally, this consensus was derived from discussions within a relatively small group of experts. Increasing the number of participants within the group would be attractive, and further international discussions would be desirable.

Conclusion

In the absence of clear guidelines or standard of care regarding PIFFs, the four principles for treatment of peri-implant femur fractures, proposed by the PISCO investigators, provide a consensus tool to guide trauma surgeons about how to treat these injuries.

Biological fixation principles must be utilized in the surgical treatment of peri-implant femur fractures, which include closed or minimally invasive reduction techniques. The osteosynthesis must protect the entire bone.

Gaps between two implants should be avoided. If implant overlap is not possible to achieve, then spanning implant fixation systems must be used, especially in osteoporotic bone.

Previous implants should be retained during surgical treatment of peri-implant femur fractures. Only those implants that would interfere with current fixation goals should be removed.

If the previous implant is in the femoral neck region, then femoral neck protection must be maintained when treating the peri-implant fracture, even if the neck fracture has already healed.

ICMJE Conflict of Interest Statement

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this review.

Funding Statement

This review did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Acknowledgements

The list of the investigators of the Peri-Implant Spanish Consensus is as follows: Héctor Aguado (Hospital Clínico Universitario de Valladolid), Samer Amhaz (Complejo Hospitalario Universitario de Santiago de Compostela), Miguel Aroca (Hospital Universitario 12 de Octubre), Pedro Caba (Hospital Universitario 12 de Octubre), Arantxa Capel (Hospital Universitario 12 de Octubre), Pablo Castillón (Hospital Universitari Mutua Terrassa), Santiago Gallardo (Hospital Aspeyoeo Barcelona), Miguel Ángel Giraldez (Hospital Universitario Virgen del Rocío), Vicente Guimera (Hospital Can Misses), José Manuel Martínez (Hospital Universitario La Paz), Josep Maria Muñoz (Hospital Althaia Manresa), Carlos Olaya (Hospital Universitario 12 de Octubre), Alina Ortega (Hospital Clínico Universitario de Valladolid), Eudald Romero (Hospital de San Juan Despli Moisés Broggi), Raquel Ruiz (Hospital Universitario Ramón y Cajal), Jordi Salvador (Hospital Universitari Mutua Terrassa), José Carlos Saló (Hospital Universitari Arnau de Vilanova), Jordi Selga (Hospital Universitario Vall d’Hebrón), Jordi Teixidor (Hospital Universitario Vall d’Hebrón), Jordi Tomàs (Hospital Universitari Vall d’Hebrón), Miquel Videla (Hospital de San Juan Despli Moisés Broggi), and José Ramón Pérez del Valle (Hospital Intermutual de Levante).

The authors would like to thank Dasha G. Blanco (Fiverr: @ddasha_illustra) for Fig. 3 graphic.

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