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Title page

Hip fractures in the non-elderly – who, why and whither?

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Abstract

Nonelderly hip fracture patients have gathered little scientific attention, and our understanding of the group may be biased by patient case-mix and lack of follow-up. Preconceptions may thwart adequate investigation of bone health and other comorbidities. This literature review focusses on who these patients between 20 and 60 years are, how to treat them and how to evaluate the outcome.

2-11% of the hip fractures occur in non-elderly, equally common in men and women. Every second to fourth patient smoke, have chronic diseases, and abuse alcohol. Poor self-rated health, sleep disturbances, low cognitive function and education are associated with increased hip fracture risk in young adults. Bone health is poorly investigated, but literature suggest young patients to have lower bone mineral density regardless of trauma mechanism.

Studies contradict on whether surgery within 8-12 hours reduce the risk of avascular necrosis in femoral neck fractures (FNF). Based on rationality, surgery ought to be performed promptly, in order to reduce pain and permit rehabilitation. There is no convincing support from the existing literature to use open reduction. Good reduction is mandatory, preferably using a closed reduction technique. The failure rate following internal fixation of displaced FNF in younger patients can be as high as 59%. In some cases a displaced FNF is better treated with a primary arthroplasty; in case of rheumatoid arthritis or osteoarthritis for example. Complications after extracapsular fractures vary from 6 to 23%.

The relatively few studies looking at functional outcome in non-elderly use a multitude of outcome measures, precluding comparisons. Many non-elderly patients seem not to fully recover.

While some non-elderly hip fracture patients are healthy individuals sustaining high energy trauma, others have low-energy fractures and comorbidities including reduced bone strength (either as a primary or secondary condition). I.e. non-delaying medical optimization, proper surgical technique, bone health investigation and secondary fracture prevention is necessary. Younger hip fracture
patients are at risk of permanent loss of function, and negative socioeconomic and psychological consequences. High-energy trauma does not exclude the presence of osteopenia. A hip fracture in adulthood and middle-age is very seldom caused by bad luck only!

Key words: hip fracture; femoral neck fracture; young; osteopenia; trauma mechanism; avascular necrosis, non-union, patient reported outcome

Introduction

Hip fracture treatment has improved in the last decades and is by many, including the Fragility Fracture Network, seen as a spearhead for the future treatment of other fragility fractures, e.g. when it comes to multidisciplinarity, secondary prevention, national guidelines, standards, and the use of registries [1].

Literature reflects that most hip fractures occur in the elderly, and although a spearhead for also the non-elderly hip fracture patients, the questions are how this group is at all defined and whether the same treatment principles and evaluation tools used for the elderly can be adapted hereto without significant modification. Also, it seems to us that many health workers wrongly categorise the non-elderly hip fracture patients as standard trauma patients, despite rising evidence for special requirements among hip fracture patients, regardless of their age.

We speculate that a large proportion of the non-elderly are also frail with bone fragility, thus also in need of the multidisciplinary approach, known from the elderly. The non-elderly patients might, however, have higher demands, not detectable in the present outcome parameters or achievable with the present treatments options, all developed for the elderly.
This review focusses on the non-elderly hip fracture patients; who are they, how to treat them and how to evaluate the outcome. Also, necessary future study areas will be addressed after each section throughout the review.

The Patient

Definition

The age limit for non-elderly hip fracture patients varies in literature. As fractures in the growing skeleton should be regarded separately, the lower age is usually 18 or 20 years, even though some trauma papers include patients as young as 12 years [2]. The cut-off towards geriatric fractures may reflect the age when arthroplasty becomes the implant of choice for displaced femoral neck fractures, which vary between countries. Another cut-off is where the postmenopausal osteoporosis sets in, and finally, some authors include only young adults with very high functional demands and high energy trauma patterns. Hence, the upper limit varies from 40 to 70 years. In this review paper, we consider patients aged 20 to 60 years as non-elderly.

Demographics

2-11% of hip fractures occur among non-elderly [3-7]. In contrast to the geriatric population, some studies find men more prone to fracture their hip than women. These studies either focus on the youngest segment [8, 9], or could represent local conditions in regional trauma centres [2, 10, 11], or India and Chile [12-15]. In papers from Scotland, Ireland, Canada, Sweden, and Taiwan there are as many men as women [5, 16-20]. Thus, we find that larger demographic studies of non-elderly hip fracture patients are warranted, including gender and type of triggering traumas.

Patient characteristics

A large proportion of younger hip fracture patients appears to have comorbidity or a biologically advanced age. 16 to 55% of the patients in published cohorts are assessed to have chronic or
disabling diseases [10, 11, 16, 19] that imply risk factors for fall (seizures, impaired balance) or for osteopenia (malnutrition, hemiplegia, osteopenia secondary to medication). 15 to 47% have alcohol abuse [9, 10, 16, 17, 19, 20], and notably also 18% in an all-female population [4]. Alcohol abuse is a known risk factor for fracture, leading to falls and secondary osteoporosis [6, 19] and impede hip fracture care [19]. However, the literature is conflicting as to whether alcohol excess is associated with higher risk of hip complications [17, 21] or not [19]. The higher mortality of younger hip fracture patients, compared to the general population, may to a certain extent be explained by alcoholism [21]. Smoking is noted for 25% to as many as 67% [3, 4, 16, 17, 19, 22]. Tobacco use may reflect an adverse lifestyle-related behaviour in general and is also associated with low peak bone mass and increased risk of hip and spine fractures [23, 24]. Thus, future studies should in our opinion include the use of both alcohol and tobacco, as well as a detailed assessment of comorbidity.

Psychological factors

Based on data from conscription for military service, Nordstrom et al. found low cognitive function and education in young men to be associated with the later risk of especially hip fractures [25]. This can be interpreted as individuals with poor judgement both exposing themselves to risk of injury and making bad choices regarding life style, hence producing a combination of high energy trauma and poor bone health.

Together with diabetes, smoking and any previous fracture, both poor self-rated health and sleep disturbances were found to be associated with risk of hip fracture in a middle-aged population [23]. Shown as independent predictors of later fractures, we thus recommend assessment of psychological factors in future studies of non-elderly hip fracture patients.

Bone health

It is a general misconception that young patients by definition have healthy bone. In the elderly hip fracture patients, examination for osteoporosis is highly recommended for initiation of secondary prevention, but only a few papers report on the prevalence of osteopenia or osteoporosis amongst
the non-elderly. Just asking for “any history of osteoporosis” [26] is presumably of little value, as decreased bone mineral density (BMD) is a silent condition. Two cohort studies invited patients for BMD assessment several years after injury and found BMD to be significantly lower in hip fracture patients than in controls [9, 27], the Norwegian study found BMD to be lower, regardless of whether it was a low or high energy fracture [9]. One can argue that this loss of bone mass may be secondary to inactivity after the injury. Future studies should ideally include DEXA measurement at the time of injury, and to what extent it predicts further fractures.

The Trauma and the Fracture

Trauma mechanism

Several authors state that hip fractures in the non-elderly are almost exclusively caused by high energy trauma [2, 5, 7, 11-14, 22], but this could reflect an inclusion bias in the local setting where the study was made, e.g. trauma centres or hospitals in developing countries. An old Swedish study found high and low energy trauma to be equally common and identified two separate groups of patients: the healthy ones struck by significant trauma versus those with predisposing diseases only sustaining low-energy trauma [20]. More recent papers have found patients to have one or several risk factors for osteoporosis regardless of the trauma mechanism, as well as lower BMD than controls [3, 4, 9, 16, 19, 27]. Overall, sociocultural factors, such as types of leisure activities, traffic behaviour, and alcohol consumption differ between countries and will influence these analyses. In Western countries, middle-aged individuals maintain youthful activities such as bike racing and alpine skiing, maybe without reflecting on whether they have reduced bone density or not. In low and middle-income countries, lack of road and work safety leads to other types of high energy trauma. We suggest that particular local conditions and trauma mechanism should be thoroughly described in future studies of non-elderly hip fracture patients.
Fracture types

As in the elderly, the distribution between intra- and extracapsular fractures appears even. Two studies found intracapsular fractures to be associated with somewhat less comorbidity and higher trauma energy \([3, 8]\). Also, Karantana et al. \([4]\) found women under 65 years to have fewer extracapsular fractures than their older counterparts. Thus, more studies on fracture type rates and associations in the non-elderly are warranted.

The Surgical Treatment

Timing

In the elderly, surgery is recommended on the day of admission or the day after due to a higher mortality with surgical delay \([28]\). This is however not as clear for the non-elderly hip fracture patients. The one single major study, which uses data from the American College of Surgeons National Trauma Data Bank, shows a worse outcome with delay more than 24 hours \([10]\). However, there could be confounding by severity due to including poly-trauma, and the results are at best associations, so causality studies hereof are warranted. Hopefully, the ongoing multicentre RCT on early versus standard surgery, which includes patients aged 45 and older, will be able to indicate the effects of early surgery for the non-elderly separately \([29]\).

Early surgery might, however, reduce the risk of avascular necrosis if femoral neck fractures are operated within 8-12 hours \([5]\). Delay more than 20 or 24 hours were found to be associated with higher complication rates in two studies \([17, 18]\), whilst two others did not find any association with delayed surgery \([12, 22]\). Consequently, a meta-analysis of 648 patients did not show any relation between failure and timing of surgery \([30]\). Nevertheless, based on rationality, surgery ought to be performed promptly, in order to reduce pain and permit rehabilitation.
General surgical principles

While awaiting larger prediction studies on fracture and implant complications exclusively on non-elderly hip fracture patients, it is fair to assume that hip fracture biomechanics is as for the elderly. Thus, choice and positioning of implants should use the same general principles [31]. Two issues, however, merit additional attention in the non-elderly patients: 1) Open reduction for securing an anatomically-reduced femoral neck fracture and 2) When to insert a prosthesis despite the risk of younger patients outliving it?

ORIF or CRIF for Femoral Neck Fractures

Non-anatomical reduction of the femoral neck fracture seems to lead to a poor result [5, 32, 33] and anatomical reduction with stable fixation should be the goal, especially to meet the functional demands and risk of subsequent complications such as avascular necrosis in the non-elderly patients. For achieving anatomical reduction, an open reduction and internal fixation (ORIF) technique has been advocated [34].

A survey among active members of the Canadian Orthopaedic Association revealed that when treating non-elderly femoral neck fractures, 61% of surgeons used ORIF in less than 25% of cases, while 16% used ORIF in more than 75% of cases [35]. Only one randomised controlled trial has investigated ORIF versus closed reduction internal fixation (CRIF), this without a difference in subsequent nonunion or avascular necrosis [12], but with a higher infection rate following ORIF than CRIF (9.1% vs. 2.1%). Ghayoumi et al. [36] reviewed 21 non-randomised studies and confirmed that there was no difference when comparing ORIF with CRIF concerning non-union (14.9% vs 11.6%) and avascular necrosis (17.7% vs. 17.2%), but there was an increased risk of deep wound infection for ORIF (3.9% vs 0.5%). The evidence is of suboptimal quality, including relatively small patient numbers, with just 181 patients in the ORIF versus 612 patients in the CRIF group. While awaiting further evidence e.g. for patient/fracture subgroups, the recommendation based on the existing literature is, therefore, to achieve good reduction preferably using a CRIF technique.
Arthroplasty

There is consensus for treating displaced femoral neck fractures in patients above 70 years of age with a hip arthroplasty, either a hemiarthroplasty or a total hip arthroplasty (THA) [37]. In the age group of 60-70 years, some clinics have during recent years shifted towards THA as it is expected to give a better outcome [38]. The treatment of choice in patients younger than 60 years of age is internal fixation [39], as these individuals usually can withstand a secondary arthroplasty as a salvage procedure if the internal fixation fails. Also, those who heal will presumably benefit from keeping their native hip joint. Thus, considering treatment of all patients with a THA from the beginning will result in overtreatment of many patients.

Some specific non-elderly patients with pre-fracture hip joint disorders are candidates for a primary THA. They have to be identified prior to surgery (Table 1). Even patients with rheumatoid arthritis without specific hip joint lesions should be treated with a THA due to high complication rates following internal fixation [40, 41].

Secondly, THA might also be necessary if the fracture cannot be perfectly reduced – and as THA in a hip fracture patient may be more difficult than in elective patients, relevant backup of a capable surgeon must be secured prior to entering the theatre. Thirdly, THA will be a suitable salvage procedure after healing disturbances (non- or mal-union, avascular necrosis of the femoral head) and/or later osteoarthritis [31]. These patients can be planned to have access to optimum quality of a THA, which also allows time for the patient to psychologically accept that their hip will not be perfectly normal again. With the exception of very few patients with severe functional limitations, hemiarthroplasties should never be used for non-elderly patients, due to the risk of acetabular erosion [42] associated with high activity levels during many remaining life years. The salvage procedure has been shown to be associated with more complications than patients having primary THA, though this may be explained by selection bias [43].
For the elderly patients, the prognosis of THA after fracture is worse compared to osteoarthritis and rheumatoid arthritis cases - even when adjusted for co-morbidity, age, and sex - presumably underscoring the frailty among fracture patients. The most significant differences are revisions due to early subsequent femoral fracture, loose cups, dislocation, and deep infection - revision causes that may be life-threatening to the patient [44]. However, such studies exclusively among non-elderly hip fracture patients are so far lacking and thus highly warranted.

In general, younger patients with osteoarthritis achieve the best outcome when treated with an uncemented THA [45]. A subgroup of healthy non-elderly hip fracture patients is comparable to them; can expect to live another 30 years and must thus be expected to benefit from the same modern uncemented THA. Others have osteoporosis and/or severe co-morbidities, leading to falls and short life expectancy. If an arthroplasty is considered in these groups, either as primary or secondary treatment, a cemented stem may reduce the risk of periprosthetic fractures [46]. It is also important to consider prosthetic concepts which reduce the risk of dislocation, such as a dual mobility cup [47], and more studies of this are expected within a few years.

(Table 1)

The Outcome

Surgical outcome

In general, hip fractures in the non-elderly carry the same high failure risk as in the elderly population. The failure rate following internal fixation of femoral neck fractures can be as high as 59% [48], and around 40% is probably to be expected when including both undisplaced and displaced fractures [49], although some authors have published rates down to 16% [50]. Data on complications after extracapsular fractures vary substantially, from 6 to 23% [7, 8, 11, 51, 52], presumably due to different definitions of complications. More predictive studies on complications are warranted, including e.g. bone quality, fracture patterns, surgical timing, implant choice and implant positioning.
Functional and patient-reported outcome

Many different functional outcome parameters can evaluate hip fracture patients. Regrettably, they are not often used in studies on non-elderly patients. A 2015 systematic review by Sprague et al. of femoral neck fracture patients aged 15 to 60 years found fewer than half of the included 42 studies reported functional outcomes or health-related quality of life data \[53\]. In our search from 2015 onwards, we identified seven studies with a total of 1711 patients, aged 16 to 70 years reporting on such outcome data 4 to 24 months postoperatively. As shown in Table 2, the reported outcomes varied and both hip-specific and generic scores, like e.g. the Oxford Hip Score and EQ-5D index respectively, were added to the already many outcome measures \[53\] used to evaluate the outcome of the non-elderly hip fracture patients.

(Table 2)

No matter which outcome measures used, many non-elderly patients seem not to fully recover. Thus, less than 25% had fully recovered \[57\], 35% had not returned to work \[59\] and the use of walking aids increased from 11 to 35% \[56\]. On average, patients needed about 50% more time performing the Timed Up and Go test and the SF-36 (PCS) was about half of a non-injured population \[54\]. One-third had only fair to poor Oxford hip scores after 12 months \[51\]. Nonetheless, we found only one study \[55\] specifically aiming to evaluate the psychometric properties of outcome measures used in the non-elderly hip fracture patients. Here, the EQ-5D-3L was highly correlated and with similar responsiveness as the more time-consuming SF-36, and superior to the Harris Hip Score in predicting later improvements after sustaining a hip fracture \[55\]. As EQ-5D-3L is easily applicable and used in hip fracture registries of the elderly patients, we see this as an obvious health-related quality of life tool to be included in a core set of outcome measures for the non-elderly patient.

The outcome in the non-elderly is challenged by the patient maybe still being at work, and with an active lifestyle, which have to be assessed and taken into consideration during rehabilitation. Assessment may include the level of return to work, sporting/leisure activities, and other activities of
daily living, hip-fracture-related pain, limping, patient satisfaction and objectively assessed functional performance, enabling comparison with established reference values for non-injured people. For further discussion and validation, we propose a core set of outcome measures (Table 2) and suggest that consensus is reached, enabling better comparison of outcome for the non-elderly hip fracture patients, across settings and countries.

The need for future research

As concluded under each section above there is a need for more thorough research on who the patients are, what the patients themselves find most important during hospitalisation and thereafter, the optimum treatment (surgical, medical, rehabilitation and secondary prevention) and outcome parameters. This can be achieved by patient interviews, clinical trials and register studies. National quality registers are important in order to improve patient outcome [60] and give more robust statistical power in analyses of rare complications, which is also why the Fragility Fracture Network currently focuses on national registries [1]. Eight national hip fracture registers have been publishing annual reports for some years now, however mainly with a focus on the elderly population [61, 62]. The Swedish, Scottish, Australian and New Zealand registers include patients above 50 years old. Only the Norwegian hip fracture register, together with the newly started National Hip Fracture register in the Netherlands, includes patients younger than 50 years [63, 64].

Thus, so far other resources must be used for retrieving national data on the non-elderly hip fracture patients, such as The Danish Fracture Database, the Swedish Fracture Register, the Finnish PERFECT database [65-67] and in the USA the National Surgical Quality Improvement Program (NSQIP)[68]. These registers either actively register fractures/operations or retrieve data on all admitted fracture patients. Large studies from registers can help us to find small differences in complications and patient-reported outcome thereby generating hypotheses for clinical studies. As an example, the above-mentioned question of CRIF versus ORIF seems very challenging to answer within the frames
of an RCT, as cases are so rare. Given such surgical details are reported, a register study can shed light.

Conclusion

This review demonstrates that although some non-elderly hip fracture patients are healthy individuals sustaining high energy trauma, most patients sustained low-energy fractures and present with pre-disposing diseases, alcoholism or reduced bone strength (either as a primary or secondary condition). Non-elderly hip fracture patients should, therefore, be treated carefully with non-delaying optimal medical optimisation, proper surgical technique, bone health investigation and secondary fracture prevention. Suffering a hip fracture in young adulthood or middle age implies a risk of permanent loss of function and may have socioeconomic and psychological consequences as well. Hip fracture related to high-energy trauma does not exclude the presence of osteopenia, which should be examined. A hip fracture in adulthood and middle-age is very seldom caused by bad luck only!

Conflict of interest

None of the authors (Cecilia Rogmark, Morten Tange Kristensen, Bjarke Viberg, Sebastian Strøm Rønnquist, Søren Overgaard and Henrik Palm) have any financial or personal relationships with other people or organisations that could inappropriately influence (bias) their work with this paper.

References


Tables

Table 1 Non-elderly hip fracture patients, who are candidates for a Total Hip Arthroplasty

<table>
<thead>
<tr>
<th>Pre-operatively identified:</th>
<th>Osteoarthritis of the hip</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inflammatory arthritis of the hip</td>
</tr>
<tr>
<td></td>
<td>Symptomatic dysplastic hips</td>
</tr>
<tr>
<td>Per-operatively identified:</td>
<td>Unsatisfactorily reduced fracture during surgery</td>
</tr>
<tr>
<td>Post-operatively identified:</td>
<td>Failure following internal fixation</td>
</tr>
</tbody>
</table>

Table 2 Outcome parameters used for the non-elderly hip fracture patients

<table>
<thead>
<tr>
<th>Reported outcomes</th>
<th>Domains assessed</th>
<th>*Number of studies in 2015 review (age 15 to 60y) [53] / ‡studies published after review with time point following index (age 16 to 70y)</th>
</tr>
</thead>
</table>

**Patient evaluation scales and systems:**

*Overall patient evaluation/rating systems developed by authors* Not checked 6 studies

*Friedman and Wyman scale, level rated as good, fair or poor* Pain, ROM (hip and knee), ADL 5 studies

*Judet scale, 3 items, total 3-18 points* Pain, ROM, walking ability 2 studies

*Arnold evaluation guide (modified), recovery rated as good, acceptable or poor* Pain, ROM, walking activity, ADL 1 study

*Merle D’Aubingne-Postel scoring system, 3 items, total 0-18 points* Pain, ROM, walking ability 1 study

*Harris hip score, 10 items, total 0-100 points* Pain, limping, ADL, ROM 4 studies / ‡pre-fracture and 4 to 24 months [54], [55]
‡Oxford hip score, 12 items, total 12-60 points
‡Barthel, 10 items, total 0-20 points
‡UCLA, 10 levels, 1-10 points
‡Extended Glasgow Outcome scale (GOS-E), 8 levels, 1-8 points

Outcomes, not presented as a component of a patient evaluation score:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Description</th>
<th>Value</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>*‡Pain, VAS 0-100</td>
<td>(Operated hip)</td>
<td>*6 studies / ‡4 to 12 months [58]</td>
<td></td>
</tr>
<tr>
<td>*Range of motion</td>
<td>(Operated hip)</td>
<td>*5 studies</td>
<td></td>
</tr>
<tr>
<td>*‡Return to work</td>
<td>Occupation</td>
<td>*4 studies / ‡12 months [59]</td>
<td></td>
</tr>
<tr>
<td>*‡Activities of daily living</td>
<td>ADL</td>
<td>*4</td>
<td></td>
</tr>
<tr>
<td>*‡Assessment of gait/walking ability</td>
<td>Walking ability, use of walking aid</td>
<td>*2 studies / ‡Pre-fracture, 3 and 12 months [56]</td>
<td></td>
</tr>
<tr>
<td>*Return to sporting activities</td>
<td>Leisure/occupation</td>
<td>*1 study</td>
<td></td>
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Performance-based outcomes:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Description</th>
<th>Value</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timed Up &amp; Go test, seconds</td>
<td>Functional mobility skills</td>
<td>‡12 months [54]</td>
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</table>

Health-related quality of life:

<table>
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<tr>
<th>Outcome</th>
<th>Description</th>
<th>Value</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>*‡Short-form 36, 36 items; total 0-100 score</td>
<td>Physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health.</td>
<td>*2 studies / ‡Pre-fracture and 4 to 24 months [54], [51], [55]</td>
<td></td>
</tr>
<tr>
<td>*Womac, 24 items, total 0-96 score</td>
<td>Pain, stiffness, physical function</td>
<td>*1 study</td>
<td></td>
</tr>
<tr>
<td>‡EQ-5D index, 5 items, (3L or 5L answer levels) converted into an index score of 0-1.0</td>
<td>Mobility, self-care, usual activities, pain/discomfort and anxiety/depression</td>
<td>‡Pre-fracture and 4 to 24 months [58], [51], [55]</td>
<td></td>
</tr>
<tr>
<td>‡EQ-5D VAS, 0-100 score</td>
<td>From worst to best imaginable health state</td>
<td>‡4 to ≥ 12 months [58], [51]</td>
<td></td>
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</table>

Patient satisfaction:

<table>
<thead>
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<th>Outcome</th>
<th>Description</th>
<th>Value</th>
<th>References</th>
</tr>
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<tbody>
<tr>
<td>‡VAS, 0-100 score</td>
<td>From very satisfied to very unsatisfied</td>
<td>‡4 to 12 months [58]</td>
<td></td>
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</table>

Our recommendations for a minimum core outcome data set:

Level of; return to work, sporting/leisure activities, other activities of daily living, hip-fracture related pain, limping; EQ-5D-3L, EQ-5D-VAS, and objectively assessed functional performance, e.g. evaluated by the Timed Up & Go or 10-meter gait speed test.
*Included in 2015 Injury review by Sprague et al [53]; ‡Included in studies published after the 2015 review; †High scores indicate high level; §Low scores indicate high level.