Interest in how victims of traumatic injuries recover is increasing and a number of observational studies have now been done. There are very few intervention studies aimed at enhancing recovery, but there will be more as our knowledge base grows. Older recipients of traumatic injuries differ from the young in the types of injuries they sustain, in the way they respond to their injuries and in the consequences of even relatively minor injuries on their future independence. In this paper, we summarise our understanding of recovery after injury and consider this in more depth for older people with specific injuries.

Why is it important to consider recovery after traumatic injury, particularly in older people? The answer to this question is best considered from the perspective of history. Over the last 50 years or so, the pathophysiology of traumatic injuries has become well understood, and this understanding has been, to a great extent, translated into clinical practice. The resulting improvements in the likelihood of survival of even extremely severely injured people have been nothing short of dramatic. It is one of the great success stories of biomedical research.

Distinct phases of research activity can be recognised. First of all, systematic observational studies were needed to determine the biochemical and physiological consequences of traumatic injuries. As our knowledge base expanded, so too did research activity and the phase of hypothesis-driven research began. It was during this phase of research that pathophysiological explanations emerged and possible intervention strategies were explored. An important enabling factor for the progression of this research strategy was the development of scoring systems so that different groups of patients could be compared and intervention strategies could be properly targeted and evaluated. It soon became clear that ‘time’ was a critical factor for many injured patients who, in order to derive maximum benefit for survival from intervention strategies, needed to receive them as soon as possible after sustaining their injuries. This opened a new dimension in trauma research: how to organise trauma services to optimum effect. *Pari passu*, the importance of injury prevention was appreciated and epidemiological studies have assumed increasing importance.
The burgeoning successes of trauma research and the translation of results into clinical practice have posed new problems. Many people now survive who, in previous years, would have died, but at what cost? Many of these survivors of severe injuries have considerable physical and psychological impairments, but little research has been done on the quality of their survival and how it may be modified. Even injuries of lesser severity can be associated with significant functional impairments for long periods after the injury. Rehabilitation has not been incorporated into trauma services as an integral part, even in the US (which has the most sophisticated systems for trauma care in the world). Thus, there are no proper standards or triage guidelines for this aspect of trauma care. This is regrettable, as trauma is the commonest cause of disability in the young and is a major cause in all age groups. In a sense, our understanding of recovery after injury is still in the phase of observational research and we have only a sketchy view of how it takes place and what factors might determine functional outcomes.

**Functional state of trauma survivors**

To study recovery properly, we must be able to measure function, disability, handicap and quality of life, as well as their rates of change. All of the available scales that have been used so far exhibit ‘floor’ and/or ‘ceiling’ effects at either end of the functional spectrum and, as the scales are ordinal in nature, they are poor measures of the rate and/or magnitude of change, especially when patients start at different baselines. Despite these difficulties, Mackenzie, who recruited 479 patients from two North American Trauma Centers and followed functional change, found that at one year, 27% had quite marked limitations and 16% had more modest ones. Those who survived injuries to the thorax or abdomen generally had a good functional outcome with only 5% still convalescing at one year. Those with minor injuries to the head and spine also had good functional recovery, though this is not necessarily true for the old. However, moderate-severe brain, spine and limb injuries were associated with persistent, often marked, impairments. Even minor injuries to the limbs were associated with substantial morbidity at one year. Another study, using the Sickness Impact Profile (SIP) to evaluate function in a group of patients with lower limb fractures reported that about half had some detectable disability a year later, and about half of these rated the disability as moderate-severe. Interestingly, the domain most markedly affected was ‘psycho-social’.

Emhoff et al have reported the use of the Functional Independence Measure (FIM) to study 109 consecutive trauma patients, all with multiple injuries and fully independent before injury. They showed that those with...
the most marked impairments on admission were the most likely to present discharge problems and require rehabilitation. Furthermore, those with the slowest rates of improvement soon after admission presented similar discharge problems. Recently, a series of weighting factors has been described for the FIM which the authors claim to transform the scale to behave as if it were interval in nature and this transformed scale appears to be robust in practice. Similarly, the recently described London Handicap Scale is also claimed to behave as an interval measure. Neither of these ‘interval’ functional scales has been appropriately applied in the setting of traumatic injury.

The nature of recovery

Recovery from injury has at least three components:

(i) the return to function of injured body parts;
(ii) a more generalised process of restoration of the deficits that arise from the acute and subacute changes that characterise the well-known ebb and flow phases of the injury response; and
(iii) the psychosocial adjustment of the patient.

These components of recovery will be modulated by:

(i) the presence of pre-existing impairments;
(ii) co-existing diseases and conditions (e.g. undernutrition);
(iii) medication use; and
(iv) the availability of resources and support.

Most accounts of the response to injury detail the ebb and flow phases and go on to refer to a third phase known variously as the recovery, convalescent or anabolic phase. This phase remains largely uncharacterised: we do not even know if it occurs simply by resolution of the stimuli that induce the ebb and flow phases, or whether it is driven by specific signals of its own. Our knowledge of psychosocial adjustment to physical injuries (other than head injuries) is similarly scant.

The anabolic phase

Much of our limited understanding of recovery comes from studies of patients recovering from elective surgical procedures, usually abdominal operations of moderate severity. Moore studied large numbers of such patients and concluded that the restoration of lean body mass takes
many weeks and is associated with persistent fatigue and weakness. The resumption of a normal diet has a permissive effect but does not appear to initiate the process. Only after restoration of lean body mass is fat deposited and usual body weight is not restored for weeks/months.

Apart from a very limited study of glucose and protein kinetics, the only aspect of the whole body response to have been studied extensively beyond the flow phase is postoperative fatigue: this lasts beyond 2 months in about a third of patients. There is some evidence that older people may be more resistant to some sorts of neuromuscular fatigue than younger ones. Mild muscle weakness and reduced exercise capacity have been reported in patients with postoperative fatigue. Although fatigue is related to the magnitude of the surgical procedure, the relative roles of undernutrition, protein catabolism, inactivity and physiological deconditioning have yet to be resolved. Psychological factors are not thought to play a major role, though they have only been examined in a limited fashion.

Several studies have investigated the acute effects of trauma on cardiovascular control mechanisms. Trauma leads to changes in ‘resting’ autonomic activity causing a simultaneous elevation of the blood pressure and heart rate, sympatho-excitation and a reduction in the sensitivity of the baroreflex. The controlled trauma of surgery causes reduced heart rate variability, which indicates a reduction in both vagal and sympathetic influences on the sino-atrial node, and the duration of this reduced heart rate variability seems to be markedly prolonged in the old. In other settings, such as after myocardial infarction and in the general elderly population, reduced heart rate variability is independently associated with an increased risk of death.

**Psychosocial adjustment**

Using a Quality of Well-Being (QWB) scale, functional impairments have been shown to persist for at least 18 months, but most of the recovery takes place in the first 6 months. Interestingly, these patients with persistent impairments performed well on activities of daily living (ADL) items and psychosocial items accounted for most of the impairment. These findings are similar to those from a study using the SIP. This may argue for a disproportionate importance of psychosocial items, but could also be explained by a deficiency in the measurement scale with the physical items being effectively capped at a fairly basic level (ceiling effect). Paradoxically, owing to rather different expectations and abilities of old and young people, the scale may operate better for older patients.
Injuries in the aging

The old, unlike the young, are a heterogeneous population with a high prevalence of pre-existing illness, medication consumption, disability and malnutrition. At all levels of injury severity (other than the most trivial and most severe), they are more likely to die than are young people with injuries of similar (or even greater) severity, they have a greater physiological response at any given level of the Injury Severity Score (ISS)\(^{18}\) and late deaths are common. In contrast to the heterogeneity of injuries in the young, a single type of injury, fractures of the proximal femur, account for many of the hospital admissions of old people with traumatic injuries.

The causes of injury in the old

Falls are the major cause of injury-related morbidity in the elderly, and the leading cause of accidental death in those over 75 years of age\(^{19}\). One-third of community-dwelling people aged over 65 years and half of women over 85 years fall each year\(^{20}\). In one recent survey of fallers attending accident and emergency departments, 65\% reported a fall in the previous year\(^{21}\). Typically, only falls leading to injury or loss of function are reported and many reported figures are probably underestimates. Fractures, soft tissue injury, joint dislocations and mobility impairments occur after 15–20\% of falls\(^{22}\). The psychological consequences of falls are equally disabling. Fear of falls is reported to occur in up to 60\% of fallers\(^{23-25}\) and one-third of such subjects report avoidance of activity as a consequence\(^{23,25}\). Limiting activity after a fall may lead to physical deconditioning, functional deterioration and further increase falls risk. Falls commonly precipitate admissions for continuing care\(^{26}\).

The importance of falls for public health is well recognised. To reduce the death rate from accidents in people 65 years and over has been a health target of our previous and present governments. Similar concerns have prompted the US National Institute on Aging and the National Institute for Nursing Research to sponsor the multi-centred study called Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) on therapeutic strategies to reduce falls\(^{27}\).

A large number of epidemiological studies have been carried out on falls and hundreds of risk factors have been identified. Complex interactions between host-related factors and the environment lead to falls. The greater the number of risk factors, the greater the likelihood of falls. This complexity makes intervention studies to reduce falls difficult. General interventions will not usually address specific risks and potentially beneficial interventions might be overlooked if studied in...
Table 1 Major musculoskeletal injuries in the old

<table>
<thead>
<tr>
<th>Injury</th>
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<tr>
<td>Head and face injuries</td>
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<tr>
<td>Cervical spine injuries</td>
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<tr>
<td>Sternoclavicular subluxation</td>
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<tr>
<td>Clavicle fractures (often near the coracoclavicular ligaments)</td>
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<tr>
<td>Proximal humerus fractures (usually the surgical neck)</td>
</tr>
<tr>
<td>Rotator cuff tears</td>
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<tr>
<td>Radial head fractures (not common)</td>
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<td>Olecranon fractures (not common)</td>
</tr>
<tr>
<td>Distal radius fractures</td>
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<tr>
<td>Fractures around the hip</td>
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<tr>
<td>• Subcapital hip fracture</td>
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<tr>
<td>• Intertrochanteric hip fracture</td>
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<td>• Acetabulum fractures</td>
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<td>Pubic ramus fractures</td>
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<td>Femoral shaft and supracondylar fractures</td>
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<td>Meniscus tears</td>
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<td>Tibial plateau fractures</td>
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<td>Patella fractures</td>
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<tr>
<td>Tibial shaft fractures</td>
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<tr>
<td>Quadriceps and patella tendon ruptures</td>
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...inappropriate subjects. Despite these limitations, interventions examining exercise, home assessment, education, falls in institutional settings and interventions to reduce injuries from falls have been performed. Systematic reviews assessing falls interventions have been published recently.28

Reducing fall-related injury

Injuries, especially fractures, are the most serious consequences of falls (Table 1). It is not clear that interventions leading to reduction of falls necessarily reduce the incidence rates of major fractures, but the hypothesis that they do is very appealing. Most studies assessing falls' risk intervention have been too small to detect reductions in fracture rates apart from those targeted at osteoporosis and others evaluating mechanical hip protectors.

Vitamin D levels decline with age and lower levels are seen in the house-bound and during winter months. Trials have examined supplementation with vitamin D with or without calcium on fracture risk. Chapuy et al found a 20% reduction in fractures over a 3 year period in
Injury in the aging, recovery and rehabilitation

residential home subjects given calcium and vitamin D²⁹. Lips et al found no benefit from supplementation with vitamin D alone³⁰. The optimum regimen for fracture prevention is yet to be determined²⁸. Observational studies suggest reductions in hip fracture risk with hormone replacement therapy (oestrogens) and the bisphosphonates, etidronate and alendronate, but only alendronate has been proven to reduce hip fracture incidence in a controlled trial³¹. Mechanical hip protectors may have a role in those at the greatest risk of falls. The hip fracture incidence rate was more than halved in residential home subjects wearing them³²,³³. However, compliance with the intervention was problematic in both studies and acceptability is being assessed in a further FICSIT study³⁴. A recent review by the Cochrane Collaboration recommends further trials with economic evaluation before community fracture prevention programmes are introduced²⁸.

Common traumatic injuries of the old

Presentation
Most old people who have sustained traumatic injuries present to accident and emergency departments. Those with multiple injuries or are otherwise seriously ill, will successfully and speedily engage with the appropriate specialties. Likewise, arrangements for admission of those with lower limb fractures will usually be effected, though often with considerable delay. Many centres have developed ‘fast-track’ admission policies for those with hip fractures, thus ensuring patient comfort and minimising the risks of serious complications like pressure ulcers.

Much more problematic are those injuries not requiring operative intervention and for which enforced ‘non-weight bearing’ is not needed. Many orthopaedic surgeons may not consider these patients to be appropriate for admission to their wards. Geriatrics services are generally amenable to accepting them, but geriatricians are often uneasy about managing ‘orthopaedic problems’ such as spinal fractures treated with a plaster jacket (often poorly tolerated by patients) or patients with tibial plateau fractures who are ‘non-weight bearing’ and are in need of repeated reviews. Systems need to be in place to have prompt advice from orthopaedic surgeons on request.

More minor injuries, with which younger patients may be expected to cope with little problem, may render older patients extremely vulnerable. Accident and emergency staff are generally ill-equipped to deal with these problems adequately. Even the obvious fact that the patient will have fallen for some reason may be overlooked. It is not uncommon for geriatricians to encounter patients recently discharged from accident and emergency departments who have been seen there frequently on account of recurrent falls. No adequate explanation for
the falls is recorded and no referral for assessment and investigation has been made. Mechanisms need to be in place to respond to the needs of this patient group, particularly because timely interventions may prevent non-injurious falls becoming injurious ones. However, there is no good evidence to show what an appropriate and cost-effective intervention system comprises.

Types of injuries
Upper limb injuries are of special concern because they are common and because the upper limb enables us to interact with the world around us. Impairment or loss of upper limb function can be immensely disabling. In fact, upper limb function should be quickly assessed in any old person being considered for discharge from an accident and emergency department.

Injuries to the neck and shoulder are very common after falls and their precise diagnosis can be challenging. Patients whose shoulder pain centres on the scapula or radiates beyond the elbow need careful assessment of the cervical spine. Tears in the rotator cuff are commonly missed at initial presentation. They often follow a fall on an outstretched hand (FOOSH) and render the patient unable to raise the arm, despite appropriate analgesia. Distal radius fractures are the commonest fractures of the upper limb and usually follow FOOSH. The commonest functional impairments that follow these fractures in the old are shoulder stiffness, finger stiffness and the carpal tunnel syndrome.

The lower extremity is principally concerned with locomotion and the negotiation of the immediate environment. Compromise or loss of lower limb function can be very disabling and a previously independent person may be rendered completely unable to manage at home without considerable and costly modification of the home environment. Any older patient under consideration for discharge from an accident and emergency department should have lower limb function quickly checked. Proximal femur fractures are the commonest significant injuries to the lower limbs, though acetabulum and pubic ramus fractures often occur after a similar type of fall.

Proximal femur fractures
Most patients with proximal femur fractures are admitted to orthopaedic departments where the fractures are stabilised operatively. About 30% of these patients will die within 6 months in sharp contrast with the sporadic deaths in young people with injuries of similar severity (ISS 9). Most deaths directly attributable to the fracture occur within the first month.
Of the survivors, about half will have a slow and complicated rehabilitation and will have permanent impairments in their ability to undertake activities necessary for independent living (ADL)\textsuperscript{35}. The factors that predict survival after hip fracture are not well understood but are reported to include prefracture fitness and health\textsuperscript{36,37}, depression and dementia\textsuperscript{38}. Many people with hip fractures are undernourished\textsuperscript{39}, but the relationship between this and survival is not well established. The old do not die as a result of failing to mount a response to the injury. On the contrary, some aspects of the injury response are known to be unusually prolonged. For example, old women have raised plasma cortisol concentrations for at least 8 weeks after the fracture\textsuperscript{40}, which contrasts markedly with what is seen in the young with injuries of similar, and even greater, severity. We have also shown that the concentrations reached may be sufficient to exert effects peripherally in that they are associated with impaired glucose transport in circulating mononuclear leucocytes\textsuperscript{41}.

These and other factors have been reported to be associated with poor functional outcomes after hip fractures: pre-fracture fitness and health\textsuperscript{36}, postoperative complications, undernutrition\textsuperscript{39,42-44}, depression and dementia\textsuperscript{38,45-47} and poor social supports\textsuperscript{45,48}. It has also been suggested that acute undiagnosed stroke may be associated with hip fractures\textsuperscript{49} and they can be difficult to detect in this clinical setting except by impeding recovery.

\textit{Optimising femur fracture outcome}

This obviously depends on which outcome is being sought. Most commonly, the desired outcome is to discharge from hospital as quickly as possible rather than to pursue a management strategy to optimise function and maintain independent living. The former approach has cost-containment as a sub-agendum. Regrettably, health accounting does not yet appear to be up to the task of realistically costing components of management strategies so that they may be fairly compared over the longer term. Various systems for hip fracture management exist and have been researched, though we know little of how longer term function and quality of life are affected.

\textit{Orthogeriatrics units}

Probably the first reported orthopaedics-geriatrics liaison was established in Hastings in 1962\textsuperscript{50}. The orthopaedic surgeons selected patients for transfer to a dedicated orthogeriatrics ward and shared responsibility for them with the geriatricians. Many similar units have
been set up with operational policies adapted to local circumstances. Two influential reports have recommended the Hastings system as a valuable model for other units.51,52

**Liaison services**

Resource implications have probably discouraged the establishment of orthogeriatrics units more widely and some centres have established liaison-based systems. In one scheme, a senior nurse with both orthopaedic and geriatric experience liaised between the two units and was able to give advice on rehabilitation, common medical problems, and the availability of community care. Geriatricians were available for medical advice, but few patients each month required transfer to the geriatrics unit.

A junior doctor-led service requiring input for around 3 h each week has been described. This service depended on a multidisciplinary ward round at which advice was given on symptoms management, holistic care, medical investigation, rehabilitation and discharge goal setting. Improved care and fewer patients transferred for rehabilitation were seen as the main benefits.

**The rapid transit system**

This is based on the ideas of Ceder and colleagues and was popularised by Sikorski et al in Australia. The aim is to minimise the amount of time spent in hospital (as little as 5 days). Only essential investigations are done, narcotic and sedative drugs are not used and general anaesthesia is avoided. Surgery is done early, often after direct transfer from the accident and emergency department to the operating theatre. Full weight bearing is encouraged within hours of surgery. Discharge planning starts on the first postoperative day and patients are discharged when they can move about the bed, are reasonably safe with transfers and can walk a few steps with or without an aid. High levels of domiciliary support are provided at discharge, which is reduced over 2–3 weeks towards prefracture levels.

**Hospital-at-home**

This was established on an existing general practice-based, community nursing service in Peterborough. The aim is immediate rehabilitation and discharge planning by a team that oversees both in-hospital and post-discharge management. Intensive home nursing (24 h/day, if needed) is provided plus occupational therapists and physiotherapists. It is reported that up to 50% of hip fracture patients are suitable for this management.
Consultant geriatricians in the trauma wards

As little is known about the ideal approach to the management of hip fracture patients (and older people with other traumatic injuries), further research is needed. Our own approach has been to integrate our clinical practice with the trauma service so that we can utilise our clinical practice as a research tool. A consultant geriatrician visits the trauma wards daily and sees all new admissions, to advise on fitness for surgery, to provide on-going medical supervision, to select patients most likely to benefit from transfer to a dedicated orthogeriatrics rehabilitation unit and to identify those in need of continuing care. He also supervises the care of those transferred to the specialist unit. We also provide a structured assessment service to evaluate those factors underlying falls (including dynamic cardiovascular testing, where indicated). Longer term follow-up is maintained. This approach should improve the quality and consistency of medical care, not only by the prompt recognition and treatment of co-existing medical and psychiatric disorders and reducing the risk of further falls, but also by changing the mind-set of the staff in the trauma wards so that they become more attuned to the particular problems of older patients.

Table 2 The rehabilitation approach

| Identify and treat co-morbid problems |
| Clarify present and previous functional abilities |
| Record usual domicile and support availability |
| Establish realistic goals |
| Formulate management plan |
| Assess progress, modify management plan |
| Initiate discharge planning early |
| Plan post-discharge management |

The rehabilitation approach

As we have already stated, rehabilitation involves a radically different approach from the traditional ‘diagnose-treat-cure’ model of medical practice. It utilises a spectrum of skills from different disciplines to identify problems, suggest solutions, set goals and assist the patient to accommodate to a new set of circumstances that may radically alter their lifestyle. The ideas and aims that underlie rehabilitation are discussed in detail by Barnes (this issue) and will not be re-iterated here. Table 2 summarises our own approach.
Hip fractures

Many younger, previously reasonably fit patients will recover quickly and can be discharged quickly with the remaining problems being addressed on an outpatient basis or by domiciliary therapy services. Others, largely because of co-morbidity or pre-existing impairments will be deemed unlikely to recover sufficient function to be sustained independently at home and will require continuing care. The remainder will very likely benefit from transfer to a dedicated rehabilitation ward or unit. While on the trauma ward, these patients will be mobilised within 48 h of surgery and active steps will be taken to prevent complications (contractures, undernutrition, venous thrombosis, disuse, medication side-effects, constipation, dislocation of a prosthesis, etc.). If a patient uses a trapeze in bed, they should exhale while using it (to prevent a Valsalva manoeuvre). Range of motion and isometric exercises will be done with progression to resistive exercises. These will then be integrated into a programme of transfer and gait retraining. For patients with hemiarthroplasties, excessive adduction of the hip (risk of dislocation) may be prevented by a triangular foam wedge while in bed. If the surgery was by a posterior approach, the knee may occasionally be immobilised in extension to prevent excessive hip flexion. Dislocation is also minimised by using high chairs and raised toilet seats.

Prolonged non-weight-bearing is to be avoided (worsens balance and causes deconditioning), but partial weight bearing is often impossible to achieve for older people. Virtually all patients undergo full weight-bearing as soon as feasible. The adequacy of analgesia is addressed, medical problems are stabilised and depression is actively sought. Leg-length discrepancy must be detected and corrected as soon as possible. At this stage, patients must be assessed for factors predisposing to falls which need to be corrected, where possible. Gains in strength and range of motion will be translated into self-care and independent living.

Case conferences will take place at weekly intervals when progress is evaluated and new goals are set. Home circumstances and available support will determine the timing of discharge home, after which, therapy may need to continue, either at home or on an out-patient basis. We also undertake a formal review several weeks after discharge from hospital, principally to address fall-related issues and to assess whether function has been maintained.

Pelvic fractures

Pubic ramus and undisplaced acetabular fractures are often admitted directly to our wards rather than to the trauma wards. They are initially
treated by analgesic drugs and bed-rest. Once reasonable analgesia has been achieved, weight-bearing commences, as with hip fractures. Also, underlying factors for falls are sought. Pain can be reduced by the use of an appropriate walking aid. Undisplaced acetabular fractures are sometimes treated with one or more weeks of traction followed by several weeks of non-weight-bearing activity.

**Wrist fractures**

Underlying factors for falls should be sought. Range of motion exercises of the digits, elbow and shoulder commence immediately after the orthopaedic intervention (usually casting). Weight-bearing activities and strong gripping are avoided. Upon cast removal, wrist range of movement exercises begin. The hand should be assessed for median nerve entrapment. Some patients with wrist fractures may be rendered unable to live at home. These patients do not really need a rehabilitation ward until the cast is removed and are better managed in a residential/convalescent home setting.

**Humerus fractures**

These are generally managed non-operatively. Underlying factors for falls are sought. Range of motion exercises commence when the fracture is stable and pain permits. Pendulum exercises then start and weight bearing is avoided. After 2–3 weeks, active range of movement exercises can usually start, followed by isometric exercise and strengthening exercise. Persistent range of movement impairment of 25–50% is usual and assistive devices will usually be required for self-care.

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