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Regional bone loss following femoral neck fracture: A comparison between cemented and cementless hemiarthroplasty

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ABSTRACT

The aim of this prospective, randomised study was to measure and evaluate regional bone mineral changes and clinical results following the use of cemented and cementless hemiarthroplasty (HA) for treatment of femoral neck fracture in elderly patients. The study comprised 60 patients, 30 with cemented HA (group A) and 30 with cementless HA (group B). All patients underwent osteodensitometry of the contralateral hip, lumbar spine and bilateral distal femur. Dual-energy x-ray absorptiometry (DEXA) was scheduled at 1 month, 6 months and 1 year after surgery. Harris Hip Score (HHS) was used for functional assessment. Overall mortality rate was 20.3% within 1 year after surgery. There were no significant differences in morbidity, mortality and hospital stay between the two groups of patients. The implantation of cemented prosthesis took statistically significantly longer than that of cementless prosthesis (79.03 ± 3.59 vs 68.02 ± 5.97 min; $p = 0.00$). Functional score in patients treated with cemented HA was significantly higher compared with those with cementless HA. There was a trend of less intensive reduction of bone mineral density (BMD) in regions of interest of the lumbar spine and ipsilateral distal femur in patients with cemented HA (group A), whereas bone loss was less pronounced for the contralateral hip and distal femur in patients treated with cementless HA (group B). Management of displaced femoral neck fractures in elderly patients with cemented and cementless HA provides a comparable outcome with regard to morbidity and mortality; however, functional outcome of patients treated with cementless HA tends to be lower. There is less intensive BMD reduction in lumbar spine and ipsilateral distal femur in patients treated with cemented HA, whereas BMD reduction in patients treated with cementless HA is more likely to be less intensive in contralateral hip and distal femur.

Introduction

Surgical options for the treatment of displaced femoral neck fractures include internal fixation, hemiarthroplasty (HA) and total hip arthroplasty. There is no definitive management algorithm regarding optimal treatment for displaced femoral neck fractures in elderly patients. Hemiarthroplasty is usually the standard procedure for displaced osteoporotic femoral neck fractures in elderly patients because of the simple technique, shorter operative time, reduced blood loss and lower dislocation rate compared with total hip arthroplasty. The choice between cemented or cementless HA for treatment of displaced osteoporotic femoral neck fractures continues to be debated despite the numerous studies conducted on the subject [1–5]. Many authors analysed outcome with sufficiently long-term follow-up and there appears to be no significant difference between cemented and cementless HA in terms of morbidity, mortality or length of hospital stay. Vidovic et al. recently investigated the influence of cemented and cementless HA on periprosthetic bone loss [6]; however, regional bone loss, including that of the uninjured limb, following either type of HA has not yet been published. Studies have shown that during the recovery phase of an injury, there are three factors that influence bone mineral changes: the injury itself, which can cause a catabolic effect on the bone and leads to a decrease in bone mineral quantity; operative trauma, which has an additional catabolic effect; and prolonged disuse or reduced weight-bearing,

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which is associated with decreased bone mineral quantity. The persistence of initial bone loss is significantly influenced by the severity of injury, the treatment chosen and functional recovery.

Bone loss observed after injury affects not only the injured bone, but also the uninjured bone; it can persist for a long time and increases the risk of later fractures at other sites. These observations support results reported by Karlsson and Finsen [7,8]. Hence, any significant functional impairment may considerably contribute to the development of post-traumatic osteopenia and consecutive implant failure or later fracture [9].

The first aim of this prospective, randomised clinical study was to evaluate the magnitude and course of regional bone mineral changes following femoral neck fracture treated with cemented or cementless HA in contralateral hip, lumbar spine, and bilateral distal femur. The second aim of the study was to evaluate and compare clinical factors, including functional outcome, between two groups of patients.

Material and methods

A total of 142 elderly female patients (mean age 85.2 years) with displaced femoral neck fracture (Garden 3 and 4) were enrolled in the study. Patients were divided into two groups: one group was treated with cemented HA (group A) and the other with cementless HA (group B). Patients were excluded from the study if they could not comprehend the study protocol, sustained pathological fracture, or had known local or systemic infection, hip osteoarthritis, complete pre-injury immobility, previous fracture of lower limbs, immunosuppresion or other disease that interferes with bone metabolism. Sixty-three patients were excluded from the study. The study comprised 79 patients: 38 with cemented HA in group A and 41 with cementless HA in group B. A total of 19 patients did not complete 1-year follow-up: 17 patients died within 1 year postoperatively and two were lost to follow-up. The final study population comprised 60 patients who completed all follow-up examinations, 30 in group A and 30 in group B.

Age, operative time, duration of hospital stay, morbidity and mortality were recorded. All patients underwent osteodensitometry to evaluate bone mineral density (BMD), which was measured by dual-energy x-ray absorptiometry (DEXA) at 1 month, 6 months and 1 year after surgery (Hologic® QDR 1500 dual X-ray absorptiometry system, Hologic, Waltham, MA, USA). Changes in BMD in the contralateral hip were measured in the neck, Ward triangle and trochanter; the total value of the femur was also obtained, Fig. 1. Measurement of BMD of the distal femur involved using one region of interest in the distal metaphysis and the global value according to Sievannen [10], Fig. 2. Osteodensitometry of the lumbar spine was measured in four regions of interest (from L1 to L4), see Fig. 3.

Harris Hip Score (HHS) was used to evaluate functional outcome at 3, 6 and 12 months after surgery. Institutional review board approval was obtained before initiation of the study and all patients provided informed consent for participation in the study.

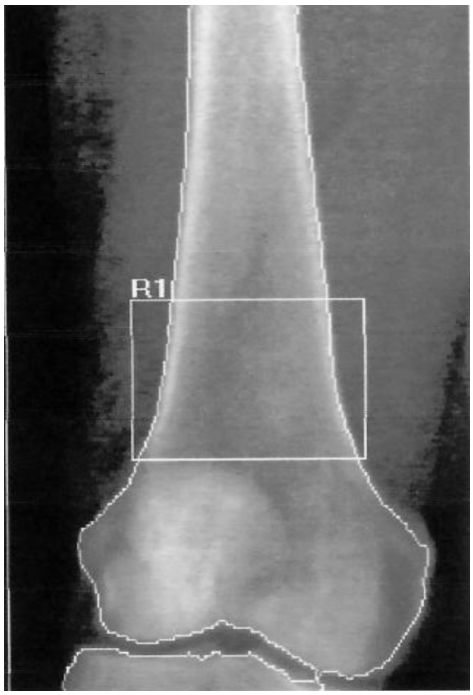

Fig. 2. Region of interest of distal femur.

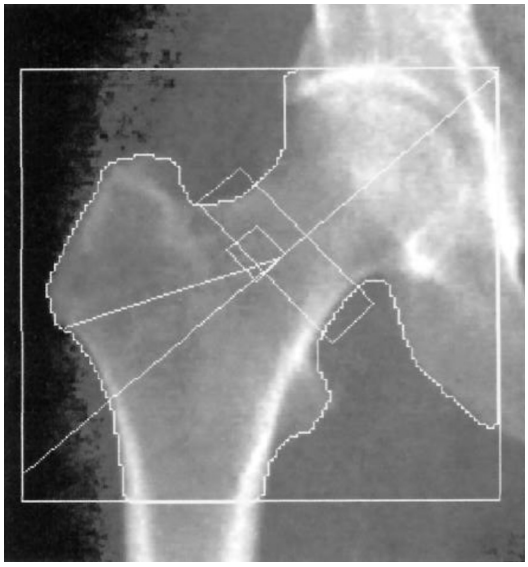

Fig. 1. Region of interest dual-energy x-ray absorptiometry (DEXA) scan of the contralateral hip.

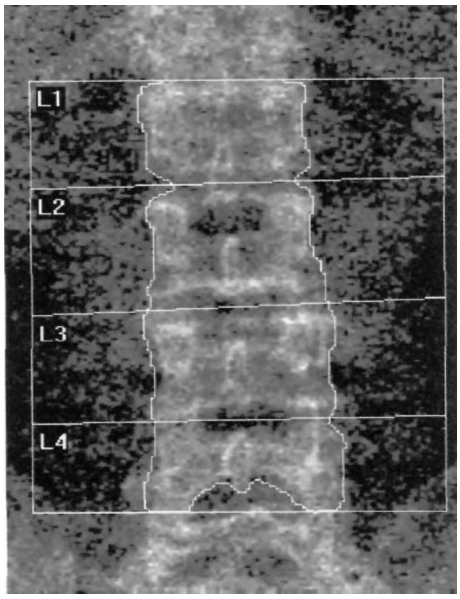

Fig. 3. Evaluation of bone mineral density (BMD) was conducted at each one of the four regions of interest in lumbar spine.

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Table 1
Comparison of Harris Hip Score (HHS) between two groups of patients.

HHS	Group A	Group B	*p*-value
3 months	68.22 ± 4.12	63.19 ± 6.02	0.004
6 months	76.44 ± 5.28	70.21 ± 5.62	0.010
12 months	80.53 ± 5.92	75.43 ± 7.29	0.012

Surgery was conducted using the modified Hardinge approach. After preparation of the medullary canal, patients in group A received cemented modular HA and those in group B received cementless modular Moore HA. Age, operative time, duration of hospital stay, and early and late systemic and local complications were recorded. Student's t test was used for statistical analysis. A beta-coefficient of less than 0.05 was considered statistically significant.

Results

There was no statistically significant difference in the average age of patients in group A compared with group B (85.39 ± 4.32 vs 84.97 ± 2.36 years; $p = 0.401$). The procedure took statistically significantly longer in group A compared with group B (79.03 ± 3.59 vs 68.02 ± 5.97 min; $p = 0.00$). There was no statistically significant difference in average duration of hospital stay: 7.82 ± 1.85 days for group A and 8.02 ± 1.72 days for group B ($p = 0.697$). The overall complication rate was 22.7%. There were two cases of pneumonia, two cases of pulmonary embolism (one case was fatal), and one case of stroke. Deep vein thrombosis (one case), gastrointestinal bleeding (two cases) and urinary infections (six cases) were also noted. There was one superficial wound infection in a patient with cementless HA; this was treated successfully with antibiotics and local wound treatment and the patient required no revision. There was no statistically significant difference in complication rate between the two groups of patients ($p = 0.92$). The mortality rate was 20.3% within 1 year after surgery, with no statistically significant difference in mortality rate between the two groups of patients ($p = 0.697$). Average HHS was 76.97 ± 7.49 1 year postoperatively, and was significantly higher in patients in group A compared with patients in group B at follow-up examinations. Table 1 contains comparison of HHS between the two groups of patients. There was BMD loss measured at three consecutive DEXA scans in all regions of interest. There was a trend of less intensive BMD reduction in regions of interest of lumbar spine and ipsilateral distal femur in patients with cemented HA (group A), whereas bone loss of contralateral hip and distal femur in patients treated with cementless HA (group B) was less pronounced.

Tables 2–4 contain comparisons between the two groups of patients for average BMD in regions of interest in contralateral hip, lumbar spine and bilateral distal femur.

Discussion

Surgical management of displaced femoral neck fractures in the elderly remains a topical issue because of increased incidence of this type of fracture, high mortality and the numerous proposed surgical procedures [11–17].

Hemiarthroplasty has been considered the standard procedure for displaced femoral neck fractures in elderly patients because of the simple technique, shorter operative time, reduced blood loss

Table 2
Comparison of average bone mineral density (BMD) values in region of interest (ROI) of contralateral hip between two groups of patients.

ROI	Group	1 Month (g/cm^2)	*p*-value	6 Months (g/cm^2)	*p*-value	12 Months (g/cm^2)	*p*-value
Neck	A	0.579 ± 0.081	0.048	0.574 ± 0.080	0.034	0.569 ± 0.061	0.015
	B	0.611 ± 0.117		0.618 ± 0.079		0.615 ± 0.081	
Ward	A	0.329 ± 0.099	0.053	0.319 ± 0.045	0.017	0.312 ±0.045	0.021
	B	0.358 ± 0.071		0.349 ± 0.051		0.342 ± 0.052	
Trochanter	A	0.541 ± 0.074	0.049	0.532 ± 0.071	0.016	0.525 ± 0.071	0.015
	B	0.592 ± 0.117		0.589 ± 0.105		0.581 ± 0.111	
Total	A	0.664 ± 0.102	0.049	0.654 ± 0.101	0.029	0.651 ± 0.013	0.019
	B	0.718 ± 0.106		0.712 ± 0.110		0.715 ± 0.118	

Table 3
Comparison of average bone mineral density (BMD) values in region of interest (ROI) of lumbar spine between two groups of patients.

ROI	Group	1 Month (g/cm^2)	*p*-value	6 Months (g/cm^2)	*p*-value	12 Months (g/cm^2)	*p*-value
L1	A	0.781 ± 0.111	0.017	0.770 ± 0.014	0.025	0.764 ± 0.107	0.015
	B	0.711 ± 0.109		0.706 ± 0.100		0.685 ± 0.116	
L2	A	0.860 ± 0.116	0.000	0.857 ± 0.018	0.000	0.854 ± 0.230	0.008
	B	0.746 ± 0.086		0.746 ± 0.103		0.728 ± 0.089	
L3	A	0.898 ± 0.114	0.059	0.887 ± 0.118	0.056	0.906 ± 0.085	0.007
	B	0.837 ± 0.131		0.836 ± 0.123		0.827 ± 0.128	
L4	A	0.956 ± 0.158	0.019	0.973 ± 0.168	0.001	0.947 ± 0.221	0.018
	B	0.866 ± 0.130		0.846 ± 0.113		0.833 ± 0.129	

Table 4
Comparison of average bone mineral density (BMD) values in region of interest (ROI) of bilateral distal femur between two groups of patients.

ROI	Group	1 Month (g/cm^2)	*p*-value	6 Months (g/cm^2)	*p*-value	12 Months (g/cm^2)	*p*-value
R1 ipsilateral	A	0.505 ± 0.148	0.046	0.494 ± 0.150	0.011	0.491 ± 0.141	0.027
	B	0.444 ± 0.081		0.413 ± 0.077		0.403 ± 0.066	
Global	A	0.729 ± 0.173	0.032	0.717 ± 0.111	0.003	0.712 ± 0.161	0.005
	B	0.646 ± 0.019		0.614 ± 0.107		0.613 ± 0.110	
R1 contralateral	A	0.587 ± 0.181	0.048	0.582 ± 0.167	0.020	0.570 ± 0.164	0.010
	B	0.672 ± 0.140		0.671 ± 0.119		0.670 ± 0.127	
Global	A	0.729 ± 0.143	0.046	0.709 ± 0.144	0.021	0.704 ± 0.128	0.012
	B	0.810 ± 0.162		0.802 ± 0.157		0.799 ± 0.156	

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and lower dislocation rate compared with total hip arthroplasty. There have been no papers published so far that have offered definitive conclusions regarding the use of cemented or cementless HA. The results of careful analysis with sufficiently long-term follow-up indicate that the use of cemented or cementless HA has no significant influence on clinical results such as hospital stay, morbidity and mortality [1,18–23]. However, the routine use of cement in elderly patients has been reported to be a technically more demanding procedure and may be associated with cardio-pulmonary complications [24,25]. In the present study, the average duration of hospital stay after either procedure was similar (approximately 7 days). The overall morbidity and mortality rate was high (20.3%), but there was no statistically significant difference between the two patient groups; these rates are comparable with those reported in the literature [25,26]. In the present study, cemented HA took approximately 11 min longer than cementless HA (79.03 ± 3.59 vs 68.02 ± 5.97 min; $p = 0.000$), because of the time required for cement application, and confirms operative times reported in the literature [27,28]. Most of the papers published on treatment of displaced femoral neck fractures in the elderly reported different functional results with certain trends towards higher functional scores in patients treated with cemented HA [29,30,31,32]. In contrast, some authors have reported better functional outcome with cementless HA [33,34]; however, these authors used hydroxyapatite-coated cementless HA, which is proven to be superior to the Moore HA used in the present study in terms of fixation and stability. Nevertheless, cementless HA may result in higher HHS, but appears to be associated with an unacceptably high risk of later mechanical problems and more frequent reoperations [35]. There were statistically significantly higher functional scores (HHS) in patients treated with cemented HA compared with cementless HA for all three measurements in the present study. Bone loss after trauma and surgical treatment of fractures has been described and measured by numerous authors. Post-traumatic bone loss may result in significant reduction of bone mass and may play a role in occurrence of post-traumatic fractures or implant loosening [36]. Limb disuse and significant postoperative pain may hinder patients from weight-bearing over long periods of time, thus disturbing bone mass recovery. Neander et al. stated that patients with femoral neck fractures are more sensitive to post-traumatic osteopenia than patients with osteoarthritis and that the difference in the magnitude of bone loss is mainly caused by different levels of functional recovery [37]. Post-traumatic bone loss involves not just the injured zone but areas proximal and distal to the injury and uninjured limbs [38,39]. Decrease in BMD of the contralateral hip within 1 year after surgery can be five times greater compared with that in healthy individuals. Drischl et al. reported that the average BMD decrease in the year following hip fracture was 5.4% from the contralateral femoral neck and 2.4% from the lumbar spine [40]. Such significant bone loss may have a serious impact on elderly patients with established osteoporosis. There is a high incidence (5-20%) of second hip fracture following hip fracture surgery [41]. In the present study, there was a trend of less intensive reduction of BMD in lumbar spine and ipsilateral distal femur in patients with cemented HA (group A), whereas bone loss was less pronounced for the contralateral hip and distal femur in patients treated with cementless HA (group B). The most plausible explanation for the difference in bone loss could be that patients who were treated with cemented HA had improved function and weight-bearing on the ipsilateral hip and femur (higher HHS) compared with the patients with cementless HA. However, the latter patients had relative functional impairment of the ipsilateral hip (painful hip, lower HHS) and weight-bearing was relatively more intensive on the contralateral hip and femur compared with group A (cemented HA). Weight-bearing has become increasingly recognised as a significant factor in bone restoration, whereas non-weight-bearing is related to bone resorption [42,43]

In conclusion, management of displaced femoral neck fractures with cemented and cementless HA in elderly patients provides a comparable outcome with regard to morbidity and mortality; however, functional score (HHS) was significantly lower in patients treated with cementless HA. Trends of less intensive reduction of BMD in the lumbar spine and ipsilateral distal femur were observed in patients treated with cemented HA, whereas BMD reduction in patients treated with cementless HA was more likely to be less intensive in the contralateral hip and distal femur. This small series showed significant differences in regional bone loss in patients with femoral neck fractures treated with two different types of HA. Further investigations into regional bone loss after femoral neck fracture are required so that all clinical implications and meaningful data can be obtained.

Conflict of interest statement

None.

References

[1] Langslet E, Frihagen F, Opland V, Madsen JE, Nordsletten L, Figved W. Cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures: 5-year follow-up of a randomized trial. Clin Orthop Relat Res 2014;472(4):1291–9.
[2] Bezwada HP, Shah AR, Harding SH, Baker J, Johanson NA, Mont MA. Cementless bipolar hemiarthroplasty for displaced femoral neck fractures in elderly. J Arthroplasty 2004;19:73–7.
[3] Khan RJ, MacDowell A, Crossman P, Keene GS. Cemented or uncemented hemiarthroplasty for displaced intracapsular fractures of the hip - a systematic review. Injury 2002;33(1):13–7.
[4] Ozturkmen Y, Karamehmetoglu M, Caniklioglu M, Ince Y, Azboy I. Cementless hemiarthroplasty for femoral neck fractures in elderly patients. Indian J Orthop 2008;42:56–60.
[5] Karlsson MK, Hasserius R, Obrant KJ. The ankle fracture as an index of future fracture risk. A 25-40 year follow-up of 1063 cases. Acta Orthop Scand 1993;64:482–4.
[6] Vidovic D, Matejcic A, Punda M, Ivica M, Tomljenovic M, Bekavac-Beslin M, et al. Periprosthetic bone loss following hemiarthroplasty: a comparison between cemented and cementless hip prosthesis. Injury 2013;44(Suppl 3):S62–6.
[7] Finsen V, Benum P. Osteopenia after ankle fractures. The influence of early weight bearing and muscle activity. Clin Orthop 1989;245:261–8.
[8] Finsen V, Haave O. Changes in bone mass after tibial shaft fracture. Acta Orthop Scand 1987;58:369–71.
[9] Jarvinen M, Kannus P. Injury of an extremity as a risk factor for the development of osteoporosis. J Bone Joint Surg Am 1997;79–A:263–76.
[10] Sievanen H, Kannus P, Nieminen V, Heinonen A, Ola P, Vuori I. Estimation of various mechanical characteristics of human bones using dual energy x-ray absorptiometry: methodology and precision. Bone 1996;18(1):17–27.
[11] Tosounidis TH, Sheikh H, Stone MH, Giannoudis PV. Pain relief management following proximal femoral fractures: Options, issues and controversies. Injury 2015. Aug 28.
[12] Maniar H, McPhillips K, Torres D, Wild J, Suk M, Horwitz DS. Clinical indications of computed tomography (CT) of the head in patients with low-energy geriatric hip fractures. Injury 2015. Jul 3.
[13] Jonas SC, Shah R, Al-Hadithy N, Norton MR, Sexton SA, Middleton RG. Displaced intracapsular neck of femur fractures in the elderly: Bipolar hemiarthroplasty may be the treatment of choice; a case control study. Injury 2015. Jul 13.
[14] Wong K, Rich J, Yip G, Loizou C, Hull P. Management of hip fractures pre- and post-Major Trauma Centre activation. Injury 2015. Jul 2.
[15] Özkayın N, Okçu G, Aktuğlu K. Intertrochanteric femur fractures in the elderly treated with either proximal femur nailing or hemiarthroplasty: A prospective randomised clinical study. Injury 2015;46(Suppl 2):S3–8. Jul.
[16] Haubro M, Stougaard C, Torfing T, Overgaard S. Sensitivity and specificity of CT- and MRI-scanning in evaluation of occult fracture of the proximal femur. Injury 2015;46(8):1557–61. Aug.
[17] Cicek H, Seyfettinoglu F, Kilicarslan K, Ogur HU, Öztürk L, İnkaya E. What should be the preferred choice of hemiarthroplasty technique in American Society of Anesthesiologists (ASA) class III patients with femoral neck fractures? Cemented or cementless. Injury 2015;46(8):1567–70. Aug.
[18] Bell KR, Clement ND, Jenkins PJ, Keating JF. A comparison of the use of uncemented hydroxyapatite-coated bipolar and cemented femoral stems in the treatment of femoral neck fractures: a case-control study. Bone Joint J 2014;96-B(3):299–305.
[19] Hay M, Gottschalk F. Cemented versus uncemented hip replacement for fracture of the hip. Disabil Rehabil 2005;27(18–19):1151–5.

Please cite this article in press as: Vidović D, et al. Regional bone loss following femoral neck fracture: A comparison between cemented and cementless hemiarthroplasty. Injury (2015), http://dx.doi.org/10.1016/j.injury.2015.10.069

[20] Parker MI, Pryor G, Gurusamy K. Cemented versus uncemented hemiarthroplasty for intracapsular hip fractures: A randomised controlled trial in 400 patients. J Bone Joint Surg Br 2010;92(1):116–22.
[21] Parker MJ, Rajan D. Arthroplasties (with and without bone cement) for proximal femoral fractures in adults. Cochrane Database Syst Rev 2001;(3):CD001706.
[22] Parker MJ, Gurusamy K. Arthroplasties (with and without bone cement) for proximal femoral fractures in adults. Cochrane Database Syst Rev 2004;(2):CD001706.
[23] Parvizi J, Holiday AD, Ereth MH, Lewallen DG. The Frank Stinchfield Award Sudden death during primary hip arthroplasty. Clin Orthop Relat Res 1999;(369):39–48.
[24] Sierra RJ, Timperley JA, Gie GA. Contemporary cementing technique and mortality during and after Exeter total hip arthroplasty. J Arthroplasty 2009;24(3):325–32.
[25] Weingarten S, Riedinger M, Conner L, Siebens H, Varis G, Alter A, et al. Hip replacement and hip hemiarthroplasty surgery: potential opportunities to shorten lengths of hospital stay. Am J Med 1994;97(3):208–12.
[26] Lennox IA, McLauchlan J. Comparing the mortality and morbidity of cemented and uncemented hemiarthroplasties. Injury 1993;24(3):185–6.
[27] Blacha J, Kolodziej R, Karwanski M. Bipolar cemented hip hemiarthroplasty in patients with femoral neck fracture who are on hemodialysis is associated with risk of stem migration. Acta Orthop 2009;80(2):174–8.
[28] Bell KR, Clement ND, Jenkins PJ, Keating JF. A comparison of the use of uncemented hydroxyapatite-coated bipolar and cemented femoral stems in the treatment of femoral neck fractures: a case-control study. Bone Joint J 2014;96(3):299–305.
[29] Taylor F, Wright M, Zhu M. Hemiarthroplasty of the hip with and without cement: a randomized clinical trial. J Bone Joint Surg Am 2012;94(7):577–83.
[30] Kinmont JC. Cemented versus uncemented Thompson's prostheses: a functional outcome study. Injury 2000;31(7):561–2.
[31] Norrish AR, Rao J, Parker MJ. Prosthesis survivorship and clinical outcome of the Austin Moore hemiarthroplasty: An 8-year mean follow-up of a consecutive series of 500 patients. Injury 2006;37(8):734–9.
[32] Luo X, He S, Li Z, Huang D. Systematic review of cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures in older patients. Arch Orthop Trauma Surg 2012;132(4):455–63.
[33] Figved W, Opland V, Frihagen F, Jervidalo T, Madsen JE, Nordsletten L. Cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures. Clin Orthop Relat Res 2009;467(9):2426–35.
[34] Schewelov Tv, Ahlborg H, Sanzén L, Besjakov J, Carlsson A. Fixation of the fully hydroxyapatite-coated Corail stem implanted due to femoral neck fracture: 38 patients followed for 2 years with RSA and DEXA. Acta Orthop 2012;83(2):153–8.
[35] Yli-Kyyny T, Sund R, Heinänen M, Venesmaa P, Kröger H. Cemented or uncemented hemiarthroplasty for the treatment of femoral neck fractures? Acta Orthop 2014;85(1):49–53.
[36] Karlsson MK, Josefsson PO, Nordkvist A, Akesson K, Seeman E, Obrant KJ. Bone loss following tibial osteotomy: a model for evaluating post-traumatic osteopenia. Osteoporos Int 2000;11(3):261–4.
[37] Neander G, Adolphson P, von Sivers K, Dahlborn M, Dalén N. Bone and muscle mass after femoral neck fracture. A controlled quantitative computed tomography study of osteosynthesis versus primary total hip arthroplasty. Arch Orthop Trauma Surg 1997;116(8):470–4.
[38] Eyres KS, Kanis JA, Bone loss after tibial fracture. Evaluated by dual-energy X-ray absorptiometry. J Bone Joint Surg Br 1995;77(3):473–8.
[39] Kröger H, Kettunen J, Bowditch M, Joukainen J, Suomalainen O, Alhava E. Bone mineral density after the removal of intramedullary nails: a cross-sectional and longitudinal study. J Orthop Sci 2002;7(3):325–30.
[40] Dirschl DR, Piedrahita L, Henderson RC. Bone mineral density 6 years after a hip fracture: a prospective, longitudinal study. Bone 2000;26(1):95–8.
[41] Kok LM, van der Steenhoven TJ, Nelissen RG. A retrospective analysis of bilateral fractures over sixteen years: localisation and variation in treatment of second hip fractures. Int Orthop 2011;35(10):1545–51.
[42] Tandon SC, Gregson PA, Thomas PB, Saklatvala J, Singanayagam J, Jones PW. Reduction of post-traumatic osteoporosis after external fixation of tibial fractures. Injury 1995;26(7):459–62.
[43] Sinaki M, Pfeifer M, Preisinger E, Itoi E, Rizzoli R, Boonen S, et al. The role of exercise in the treatment of osteoporosis. Curr Osteoporos Rep 2010;8(3):138–44.

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