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Original article

Injuries of the trochanteric region: can analysis of radiographic indices help in prediction of recurrent osteoporotic hip fractures?

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Summary. *Objective:* In a context of bone fragility, primitive and subsequent fractures are a growing problem in the industrialized countries where the mean age of the population is constantly increasing. Among the various factors that favor a fragility fracture, the most important is osteoporosis, a pathology that can be prevented through diagnostic screenings and treated by pharmacological and rehabilitative therapies. The aim of this study is to identify the subjects who are likely to have a higher risk of subsequent fractures of the trochanteric region through a retrospective radiographic evaluation of patients affected by low-energy trochanteric fractures and operated by intramedullary fixation between June 2013 and June 2015, so they can be targeted for prevention interventions. *Materials and Methods:* Three hundred and sixty-one patients yet alive were analyzed 2 years after surgery. Fifty-one (group 1), characterized by another contralateral trochanteric femoral fracture, were included. All subjects were retrospectively examined with the analysis of contralateral femur X-ray performed at the time of initial trauma in order to detect a condition of bone fragility and a predisposition to fractures by evaluating three radiographic indices (Singh index, Dorr's classification and Cortical Thickness Index). Patients of group 1 were compared to the other 310 patients (group 2) affected by isolated trochanteric fracture. *Results:* Group 1 had all radiographic indices worse than group 2. *Conclusions:* The results observed suggest that orthopedists can use radiographic indices, in particular Cortical Thickness Index, as a valuable, simple and inexpensive screening tool for prevention of recurrent osteoporotic fractures.(www.actabiomedica.it)

Key words: osteoporosis, radiographic indices, bone mineral density, femoral fractures

Introduction

Fractures in elderly are always a dramatic event and their healing is often not complete. These injuries are a growing problem in the industrialized world, in which the aging population is constantly increasing (1, 2).

In particular hip fractures are an important cause of death and disability among elderly (3, 4), who are characterized by decreased quality of life (walking restrictions, difficulty in climbing stairs and problems in self-care) (5, 6).

Patients who have suffered hip fracture have an increased risk of subsequent fracture of the contralateral hip (second hip fracture) (7). The one-year risk of this complication varies from approximately 2% to 10% (8). The lifetime risk of a second hip fracture has been estimated at 20% but may be as high as 55% (9). A second fracture necessitates further surgery and hospital care and may result in additional disability or death as well as increased economic costs (2).

There are several factors that have a negative impact on the risk of primary and subsequent fractures and, among these, the most important one is a framework of bone fragility which characterizes osteoporosis, a condition that can be prevented and treated with the help of supplementation and pharmacological support. Dual energy x-ray absorptiometry (DXA) is currently the gold-standard technique to measure bone mineral density (BMD) and to diagnose osteoporosis according to the World Health Organization guidelines. However, there are several simple radiographic indices related to bone quality, which show a relationship with T-scores measured by DXA and are more easily available and executable (10, 11). The aim of this study is to identify those subjects who are likely to have a higher risk of subsequent contralateral hip fractures through a retrospective radiographic evaluation of patients affected by low-energy trochanteric fractures and operated by intramedullary fixation, so they can be targeted for prevention interventions.

Materials and Methods

Non-collaborative patients and subjects affected by neurological disorders characterized by numerous falls were excluded from the study. It was assumed that all fractures in this study were the result of banal falls; pathological metastatic fractures and high-impact injuries (traffic accident or falls from more than sitting height) were not included.

Three hundred and sixty-one patients older than 70 years of age, who underwent intramedullary fixation for fractures in the trochanteric region between June 2013 and June 2015, were analyzed 2 years after surgery. Data acquisition were extracted from medical records of the hospital. Informed consent was obtained from all subject studied regarding the management of their personal data and instrumental exams.

Fifty-one patients (group 1) out of 361 had in this period another subsequent contralateral fracture of the trochanteric region. This first group was compared with a second group (group 2) that was composed by the remnants 310 subjects which had been affected by isolated femoral fractures.

In all cases age, gender, body mass index (BMI), days of hospitalization before surgery, hospitalization, period of rehabilitation and type of discharge (at home or in a rehabilitative institute) were collected.

Furthermore, an anteroposterior view of the contralateral femur at the time of initial trauma was evaluated always by the same physician with the software RadiAnt DICOM Viewer (version 1.9.16) in order to identify:

- **Singh index**: numerical value ranging from 1 to 6, where 6 indicates a femur with a bone quality that is normal, 3 is the first pathological value and 1 indicates the most advanced grade of tissue weakness (12) (figure 1).
- **Dorr's classification:** Type A: x-Ray exhibited thick cortices that begin at the distal end of the lesser trochanter and thicken quickly, producing a funnel shape and a narrow diaphyseal canal (figure 2a); Type B: x-Ray exhibited bone loss proximally and widening of the diaphyseal canal

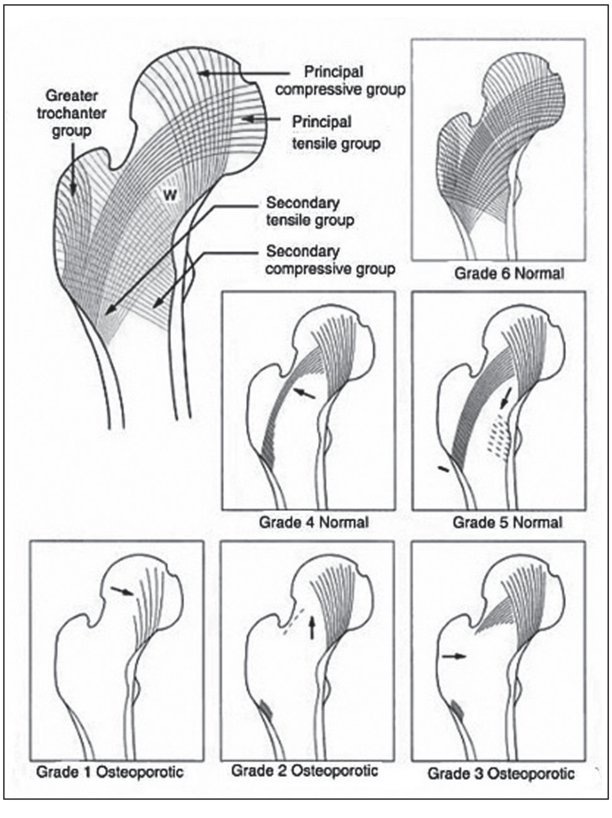

Figure 1. Schematic representation of continuum of trabecular patterns corresponding to Singh Indices

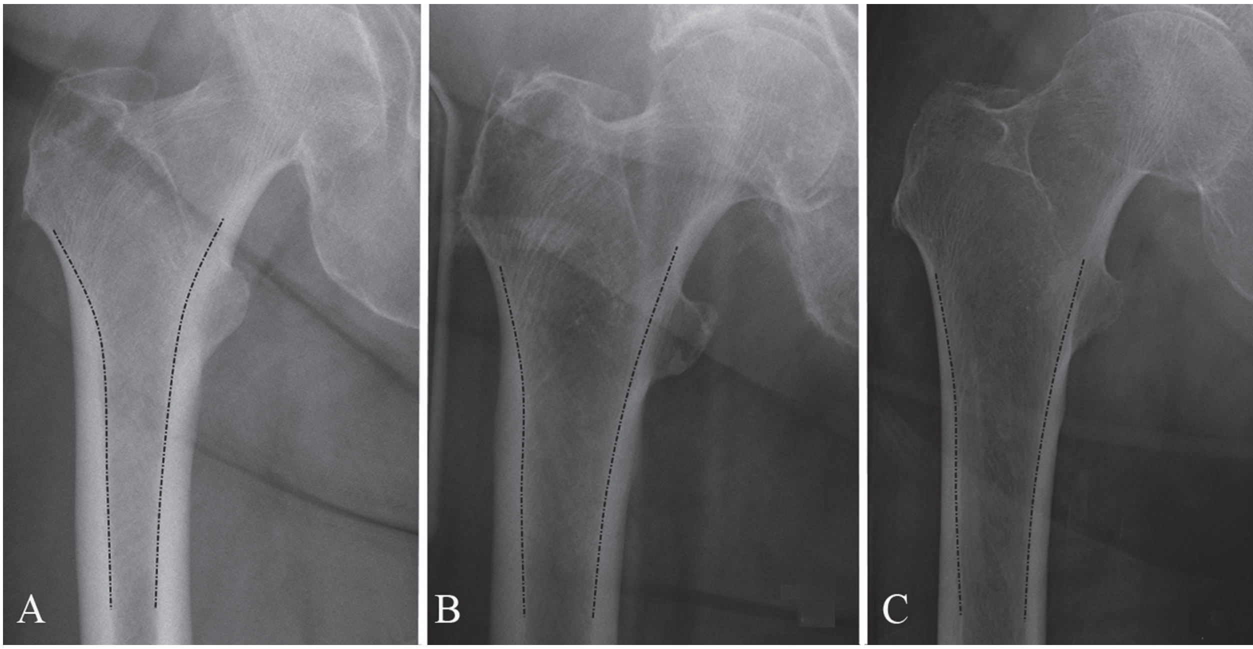

Figure 2. Example of continuum of cortical patterns corresponding to Dorr's classification

(figure 2b); Type C: x-Ray exhibited considerable loss of the thickness of the cortices resulting in a very wide intramedullary canal and fuzzy appearance to the bone cortices (figure 2c).

- **Cortical Thickness Index (CTI)**: the ratio of cortical width minus endosteal width to cortical width at a level of 100 mm below the tip of the lesser trochanter. Higher values indicated thicker cortices. This index is considered anomalous with values inferior to 0.4 (figure 3) (13).

Figure 3. Example of calculation of CTI

Statistical analysis

Statistics were performed using the SPSS software (version 20.0).

Binary logistical regression was performed in order to evaluate if days of hospitalization before the intervention, hospitalization and type of discharge were similar in both groups. Univariate analysis, including the Mann-Whitney test was performed comparing the three radiological indices (Singh index, Dorr's classification and CTI) of group 1 versus group 2.

The differences were considered significant when p value was less than 0.05.

Results

Gender, age, and BMI of group 1 and 2 are reported in table 1. Days of hospitalization before surgery, hospitalization and type of discharge were similar in both groups (table 2).

Patients of group 1 had a worse bone quality at the time of initial injury, as demonstrated by the different results of all indices evaluated. In particular:

- **Singh index**: the majority of the patients (74.51%) of group 1 had a value < of 4, while in the second group this percentage decreased (12.25%) (table 2) (p<0.001)
- **Dorr's Classification:** most of the patients of group 1 (28 cases - 54.9%) and group 2 (173 cases - 55.8%) were distributed in class B. However, in classes A and C, patients were distributed in an opposite way; in group 1, 21 patients were located in Class C and 2 in class A and in the second group 128 were in class A and only 9 in class C (table 3) (p<0.001)
- **Cortical Thickness Index**: in group 2 the average value was 0.4994 (range 0.37 - 0.67) while in group 1 was 0.347 (range 0.21 - 0.71) (figure 4) (p<0.001).

Table 3. Dorr's classification values in group 1 and 2

Dorr's classification	A	B	C
Group 1	2	28	21
Group 2	128	173	29

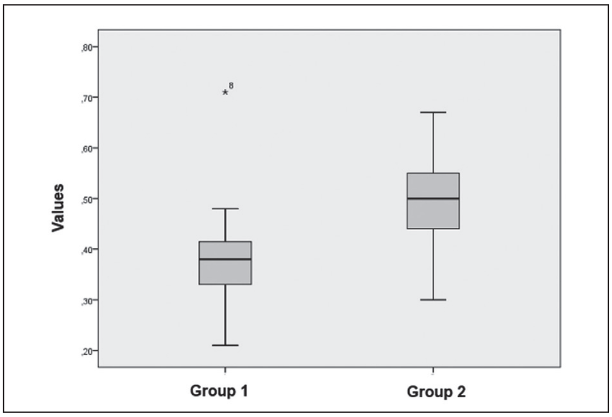

Figure 4. Distribution of CTI values in groups 1 and 2.

Table 1. Characteristics of patients in group 1 and 2

General characteristics			
	Group 1	Group 2	
Women (n. 311)	44	267	
Men (n. 50)	7	43	
Total	51	310	
Mean age (years)	82 (range: 70 - 98)	82.5 (range: 70 - 100)	
BMI	26.2 (range: 22.4 - 28.4)	26.4 (range: 23 - 28.2)	
Days before intervention, hospitalization and type of discharge			
	Group 1	Group 2	p values
Days before surgery	2 (range 1 - 9)	2.1 (range 1 - 7)	0.512
Hospitalization (days)	14.9 (range 7 - 35)	15 (range (7 - 34)	0.893
Type of discharge	at home: 9 at nursing home: 42	at home: 55 at nursing home: 255	0.707

Table 2. Values of Singh Index in group 1 and 2

Singh Index	1	2	3	4	5	6
Group 1	0	6	32	8	5	0
Group 2	0	0	38	152	100	20

Discussion

Osteoporosis represents an important and increasing problem in elderly people and the identification of the modifiable risk factors and an adequate therapy become a research priority in Ortho-Geriatric Medicine (14). Aging is associated with a progressive loss of bone-muscle mass and strength as consequence of altered hormonal balance (15). All these changes increase the risk of osteoporotic fractures such as proximal femoral ones (16). These lesions are common injuries in elderly and their percentage of this type of patients in industrial countries is rising (17-19). Osteoporosis is estimated to cause 1.5 million fractures annually in the United States (18). In Italy, approximately 3.5 million persons are osteoporotic, with over 90.000 fractures yearly in those aged 50 years or older (20). Mortality associated with these fractures ranges from 15 to 30%, a rate similar to breast cancer and stroke (20). Furthermore, 50% of patients with osteoporotic hip fractures develop disability and need institutionalization, with significant impact on the capacity to live independently and on the costs of the public health service (20). These complications are more frequent in those subjects who undergo to a subsequent contralateral injuries, as well demonstrated by results regarding the gait pattern of this study (2).

Despite osteoporosis is a well known disease, often in clinical practice the orthopaedic physician underestimates the importance of its proper analysis (aetiology) and associated medical therapy, which could favour healing and prevent subsequent fractures.

The first-line assessment in the diagnosis of this disease should include the determination of erythrocyte sedimentation rate, blood cell count, protein electrophoresis, serum calcium, serum phosphorus, serum alkaline phosphatase, serum creatinine, and 24-hour urinary calcium excretion, in order to exclude possible causes of secondary osteoporosis (20). DXA is presently considered the gold standard imaging technique for the diagnosis of osteoporosis because it shows the best predictive value for fracture risk (20).

This diagnostic course is impossible to be performed during the daily clinical practice in an Orthopaedic Unit or Emergency Room, even if it should be important to begin specific therapy as soon as possible because the risk of refracture is significantly higher in patients which are not exposed to medical treatment for osteoporosis with respect to patients exposed (2.3-2.8 higher in this type of patients compared to general population) (21, 22). Consequently, the majority of the patients are discharged at home or in a rehabilitative ward and start their physiotherapy without a "true" diagnosis of the aetiology of their fragility fracture and an appropriate treatment for osteoporosis (22). The rate of patients in whom an appropriate therapy for osteoporosis is prescribed remains too low; in particular a multicentric study, performed by Degli Esposti et al. in Italy, showed that exposure to drug treatment for fragility fractures in osteoporotic patients was performed in only 16.3% of the cases (21).

It is also true that not all cases need a specific medical treatment and "generalization" may be dangerous for patient and general health service.

Considering any supplementation and therapy as a potential cause of cost-increase, these supports should be analyzed in terms of cost/effectiveness. Furthermore, the use of drugs is always associated with potential risks and side effects and their use should be reserved for selected patients, especially those at higher risk of fracture (23, 24).

Moreover, persistence and adherence rates for oral medications for osteoporosis are typically low, with up to two thirds of patients discontinuing treatment within 1 year of initiation (25, 26). Regimen complexity and dosing frequency may be one barrier to persistence with and adherence to osteoporosis therapy (25).

For all these reasons authors consider important the identification as soon as possible of those patients who really necessitate this specific therapeutical approach.

The introduction of new clinical tools such as FRAX (http://www.shef.ac.uk/FRAX), have helped physician to focus and highlight the situations which really need this effort (27). In an Emergency Room or Orthopaedic Unit, in which patient's turn-over is extremely high and their discharge has to be as rapid as possible and the treatment is focused mainly on fracture fixation, a less clinical, more confident and easily approach for orthopaedists is preferable. X-ray analysis, through the evaluation of radiographic indices (Singh Index, Dorr's Classification and CTI), may be considered a more confident and more easily available and executable instrumental way to screen the cases at higher risk of osteoporotic fractures.

The aim of this study was to identify those subjects who are likely to have a higher risk of subsequent contralateral hip fractures following initial trochanteric injuries through a retrospective radiographic evaluation of these indices.

The results showed that patients of group 1 had a worse bone quality, as demonstrated by the different results of all the 3 parameters evaluated. This radiological evaluation could be partly conditioned by radiologist experience and somewhat depends on the radiographic quality. Specifically, the Singh Index is the most difficult one to use properly and has a learning curve longer than the other two and it is more affected by the quality of the radiographic image. The class of Dorr is relatively more simple to use and it is less influenced by the quality of the image and by the experience of the radiologist, but it is less precise and there is a tendency to merge most of the patients in an intermediate class of risk. Finally, the CTI is considered the most reproducible since it is based on measurements and a mathematical calculation (12, 13).

Authors consider the main strengths of the study the great number of patients involved and the similarity of the 2 groups regarding their demographic characteristics and patient's therapeutic management. They also believe that the results obtained on radiographic evaluation are valid and reliable because the measurements were always calculated by a single observer and with the same software and x-rays were performed with a single radiographic machine. Nevertheless, the estimation of absolute risk of fractures and, therefore, therapeutic decision-making should not be based solely on BMD determination and it should also require a comprehensive evaluation of the patient, taking into account all of the known risk factors for osteoporotic fractures (20). In this context, authors consider important a multidisciplinary management of these patients, possibly in Outpatient Clinic specialized in osteoporosis, which has to include not only orthopaedic surgeons but also radiologists, geriatricians, occupational and physical therapists, as well demonstrated in several hip pathologies (28-33).

Even if a statistical significant difference between group 1 and 2 was observed for all indices, the authors agree with other reports that judge the CTI the most objective, rapid and reliable (12, 13, 17, 34) and consider as anomalous a value less than 0.4.

Based on the results obtained, authors suggest to calculate CTI, whenever possible, in Orthopaedic Unit and Emergency Room in patients in whom an osteoporotic fracture, could be suspected in order to identify cases at risk of subsequent fractures in order to address these subjects in Outpatient Clinics specialized in osteoporosis and to begin as soon as possible a specific medical therapy.

Conclusion

The results of this study suggest that orthopaedic physicians can do more in terms of medical treatment and prevention of osteoporotic fractures. The routinely use of rapid, economic and repeatable radiographic indices may be a useful screening tool for prevention of recurrent osteoporotic fractures. The objectivity and reliability of CTI seems to be superior compared with other indices.

References

1. Scaglione M, Fabbri L, Di Rollo F, Bianchi MG, Dell'Omo D, Guido G. The second hip fracture in osteoporotic patients: not only an orthopaedic matter. Clin Cases Miner Bone Metabolism 2013; 10(2): 124-8.
2. Pogliacomi F, Pellegrini A, Tacci F, Pedrini MF, Costantino C, Pedrazzini A, et al. Risks of subsequent contralateral fractures of the trochanteric region in elderly. Acta Biomed 2016; 87(3): 275-81.
3. Egan M, Jaglal S, Byrne K, Wells J, Stolee P. Factors associated with a second hip fracture: a systematic review. Clinical Rehabilitation 2008; 22: 272-82.
4. Kannus P, Parkkari J, Sievanan H, Heinonen A, Vuori I, Jarvinen M. Epidemiology of hip fractures. Bone 1996; 18 (suppl): 57S-63S.
5. Randell AG, Nguyen TV, Bhalerao N, Silverman SL, Sambrook PN, Eisman JA. Deterioration in quality of life following hip fracture: a prospective study. Osteoporos Int 2000; 11: 460-66.
6. Hallberg I, Rosenquist L, Kartous L, Lofman O, Wahlstrom O, Toss G. Health-related quality of life after osteoporotic fractures. Osteoporos Int 2004; 15: 834-41.
7. Mitani S, Shimizu M, Abo M, Hagino H, Kurozawa Y. Risk factors for second hip fractures among elderly patients. J Orthop Sci 2010 Mar; 15(2): 192-7.
8. Yamanashi A, Yamazaki K, Kanamori M, Mochizuki K, Okamoto S, Koide Y, et al. Assessment of risk factors for

second hip fractures in Japanese elderly. Osteoporos Int 2005; 16: 1239-46.
9. Formiga F, Rivera A, Nolla JM, Coscujuela A, Sole A, Pujol R. Failure to treat osteoporosis and the risk of subsequent fractures in elderly patients with previous hip fracture: a five-year retrospective study. Aging Clin Exp Res 2005; 17: 96-9.
10. Sah AP, Thornhill TS, LeBoff MS, Glowacki J. Correlation of Plain Radiographic Indices of the Hip with Quantitative Bone Mineral Density. Osteoporos Int 2007; 18(8): 1119-26.
11. Burr DB. Cortical bone: a target for fracture prevention? Lancet 2010; 375(9727): 1672-3.
12. Singh M, Nagrath AR, Maini PS. Changes in trabecular pattern of the upper end of the femur as an index of osteoporosis. J Bone Joint Surg Am 1970; 52: 457-67.
13. Dorr LD, Gaugere MC, Mackel AM, Gruen TA, Bognar B, Malluche HH. Structural and cellular assessment of bone quality of proximal femur. Bone 1993; 14: 231-42.
14. Cederholm T, Cruz-Jentoft AJ, Maggi S. Sarcopenia and fragility fractures. Eur J Phys Rehabil Med 2013; 49(1): 111-7.
15. Ferrucci L, Baroni M, Ranchelli A, Lauretani F, Maggio M, Mecocci P, et al. Interaction between bone and muscle in older persons with mobility limitations. Curr Pharm Des 2014; 20(19): 3178-97.
16. Kalyani RR, Corriere M, Ferrucci L. Age-related and disease-related muscle loss: the effect of diabetes, obesity, and other diseases. Lancet Diabetes Endocrinol 2014; 2(10): 819-29.
17. Baumgärtner R, Heeren N, Quast D, Babst R, Brunner A. Is the cortical thickness index a valid parameter to assess bone mineral density in geriatric patients with hip fractures? Arch Orthop Trauma Surg 2015; 135(6): 805-10.
18. Azagra R, Lopez-Exposito F, Martin-Sanchez JC, Aguye A, Moreno N, Cooper C, et al. Changing trends in the epidemiology of hip fracture in Spain. Osteoporos Int 2014, 25-4: 1267-74.
19. Yoon BH, Lee YK, Kim SC, Kim SH, Ha YC, Koo KH. Epidemiology of proximal femoral fractures in South Korea. Arch Osteoporos 2013; 8(1-2): 157.
20. Bernabei R, Martone AM, Ortolani E, Landi F, Marzetti E. Screening, diagnosis and treatment of osteoporosis: a brief review. Clin Cases Miner Bone Metab 2014; 11(3): 201-7.
21. Degli Esposti L, Sinigaglia L, Rossini M, Adami S, Cagnoni C, Magliaro C, et al. Adherence to therapeutic and diagnostic recommendations in patients with femur fracture and at risk of re-fracture or death: results of an analysis of administrative databases. Reumatismo 2012 Mar 16; 64(1): 18-26.
22. Tarantino U, Feola M, Piccirilli E, Marziali D, Rao C. Fratture da osteoporosi: lo specchio di una fragilità sottostante The osteoporotic fractures: the mirror of the underlying fragility. Giornale Italiano di Ortopedia e Traumatologia 2014; 40: 289-95.
23. Rizzoli R, Reginster JY, Boonen S, Breart G, Diez-Perez A, Felsenberg D, et al. Adverse reactions and drug-drug interactions in the management of women with postmenopausal osteoporosis. Calcif Tissue Int 2011; 89: 91-104.
24. Schilcher J, Koeppen V, Aspenberg P, Michaëlsson K. Risk of atypical femoral fracture during and after bisphosphonate use. N Engl J Med 2014; 4; 371(10): 974-6.
25. Hadji P, Papaioannou N, Gielen E, Feudjo Tepie M, Zhang E, Frieling I, et al. Persistence, adherence, and medication-taking behavior in women with postmenopausal osteoporosis receiving denosumab in routine practice in Germany, Austria, Greece, and Belgium: 12-month results from a European non-interventional study. Osteoporos Int 2015 Oct; 26(10): 2479-89.
26. Netelenbos JC, Geusens PP, Ypma G, Buijs SJ. Adherence and profile of non-persistence in patients treated for osteoporosis-a large-scale, long-term retrospective study in The Netherlands. Osteoporos Int 2011; 22: 1537-46.
27. Kanis JA, Johnell O, Oden A, Johansson H, McCloskey E. FRAX and the assessment of fracture probability in men and women from the UK. Osteoporos Int 2008; 19: 385-97.
28. Pogliacomi F, Pedrini MF, Pourjafar S, Pellegrini A, Paraskevopoulos A, Costantino C, Ceccarelli F. Pubalgia and soccer: real or overestimated problem? Medicina dello Sport 2015; 68: 651-62.
29. Pogliacomi F, Costantino C., Pedrini MF, De Filippo M, Ceccarelli F. Anterior groin pain in athletes as a consequence of bone diseases: Etiopathogenesis, diagnosis and principles of treatment. Medicina dello Sport 2014; 67 (1), 1-26.
30. Pogliacomi F, Costantino C, Pedrini MF, Pourjafar S, De Filippo, M, Ceccarelli, F. Anterior groin pain in athletes as a consequence of intra-articular diseases: Etiopathogenesis, diagnosis and principles of treatment. Medicina dello Sport 2014; 67 (3), 341-68.
31. Pogliacomi F, Paraskevopoulos A, Costantino C, Marenghi P, Ceccarelli F. Influence of surgical experience in the learning curve of a new approach in hip replacement: anterior mini-invasive vs. standard lateral. Hip Int 2012 Sep-Oct; 22(5): 555-61.
32. Pogliacomi F, Stark A, Vaienti E, Wallensten R. Periacetabular osteotomy of the hip: the ilioinguinal approach. Acta Biomed. 2003 Apr; 74(1): 38-46.
33. Pogliacomi F, Stark A, Wallesten R. Pericetabular osteotomy. Good pain relief in symptomatic hip dysplasia, 32 patients followed for 4 years. Acta Orthop 2005 Feb; 76(1): 67-74.
34. Nash W, Harris A. The Dorr type and cortical thickness index of the proximal femur for predicting peri-operative complications during hemiarthroplasty. Journal of orthopaedic Surgery 2014; 22(1): 92-5.

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