Pain Physician 2012; 15:229-236 • ISSN 1533-3159

Observational Report

Changes in Bone Mineral Density in Postmenopausal Women Treated with Epidural Steroid Injections for Lower Back Pain

Seong-Sik Kang, MD, PhD, Byeongmun Hwang, MD, PhD, Heejeong Son, MD, PhD, Il-Young Cheong, MD, PhD, Sang-Jin Lee, MD, and Tae-Yoon Chung, MD

From: Department of Anesthesiology and Pain Medicine, Kangwon National University, Chuncheon, South Korea

Dr. Kang is Associate Professor with Department of Anesthesiology and Pain Medicine, Kangwon National University, Chuncheon, South Korea. Dr. Hwang is Medical Director of the Pain Management Center and Assistant Professor with Department of Anesthesiology and Pain Medicine, Institute of Medical Sciences, Kangwon National University Hospital, Kangwon National University, Chuncheon, South Korea. Dr. Son is Associate Professor with Department of Anesthesiology and Pain Medicine, Kangwon National University, Chuncheon, South Korea. Dr. Cheong is Professor with Department of Anesthesiology and Pain Medicine, Kangwon National University, Chuncheon, South Korea. Dr. Lee is full-time instructor with Department of Anesthesiology and Pain Medicine, Kangwon National University, Chuncheon, South Korea. Dr. Chung is a Resident Physician with Department of Anesthesiology and Pain Medicine, Kangwon National University, Chuncheon, South Korea.

Address correspondence:
Byeong-mun Hwang, MD
Dept. of Anesthesiology and Pain Medicine
School of Medicine
Kangwon National University
Chuncheon, Gangwon-do 200-701, South Korea
E-mail: arim14@kangwon.ac.kr

Disclaimer: There was no external funding in the preparation of this manuscript.
Conflict of interest: None.

Manuscript received: 11/20/2011
Revised manuscript received: 01/20/2012
Accepted for publication: 02/09/2012

Free full manuscript:
www.painphysicianjournal.com

Background: Therapy with corticosteroids often results in bone loss and corticosteroid-induced osteoporosis. In previous studies, bone mineral density (BMD) has been examined after administration of relatively high oral doses of corticosteroids. However, practitioners use comparatively lower doses of corticosteroids for epidural steroid injections (ESI). The interactions and relationships between BMD and ESI remain to be determined.

Objective: The aim of this study was to explore the relationship between BMD and ESI in postmenopausal women treated for lower back pain.

Study design: This study was a retrospective evaluation.

Methods: We reviewed the medical records of postmenopausal women with lower back pain who were treated with or without ESI. BMD was measured before treatment and one year after treatment in the lumbar spine, femoral neck, and total femur. A total of 90 postmenopausal women were divided into 2 groups. Group 1 patients received medications without ESI; Group 2 patients received ESI more than 4 times, with a cumulative administered triamcinolone dose of > 120 mg.

Results: Decreased BMD was observed in patients treated with ESI. However, no significant difference was observed between or within the groups in terms of mean percentage change from baseline BMD.

Limitations: First, this study is limited by the fact that it was retrospective. Second, our study did not consider the use of ESI with high-dose corticosteroids. Third, our study did not include any long-term assessments of the effects of ESI on BMD.

Conclusions: These data suggest that ESI using triamcinolone (over 200 mg) for a period of one year will have a negative effect on BMD in postmenopausal women treated for lower back pain. However, ESI therapy using a maximum cumulative triamcinolone dose of 200 mg in one year would be a safe treatment method with no significant impact on BMD.

Key words: bone mineral density, corticosteroid, epidural steroid injection, lower back pain, postmenopausal women, triamcinolone.

Pain Physician 2012; 15:229-236

Lower back pain is one of the most common symptoms in patients visiting the hospital (1). Therapeutic approaches to treating lower back pain include bed rest, drug therapy, acupuncture, physical therapy, spinal cord stimulation, cryotherapy, radiofrequency thermocoagulation, psychotherapy, and surgery (2-6). Epidural steroid injections (ESI) are relatively effective in the treatment of lower back pain and sciatica and have a low incidence of side effects (5-7). While ESI is one of the most common nonsurgical interventions prescribed for lower back pain symptoms, patients who are concerned about the side effects of corticosteroid use are often reluctant to receive this type of treatment. Therapy with corticosteroids often results in bone loss and corticosteroid-induced osteoporosis (8,9). Previous studies have reported the effects of oral administration of relatively high doses of corticosteroids on bone mineral density (BMD) (8,9). However, practitioners administering ESI use lower doses of corticosteroids. The interactions and relationships between BMD and ESI have not been thoroughly investigated.

We retrospectively studied 90 postmenopausal women in an attempt to detect differences in BMD between those treated with and without ESI. The primary objective of the study was to assess changes in BMD from baseline to one year after ESI treatment in the lumbar, femoral neck, and total femur regions. In this study, we aimed to determine whether the use of epidural corticosteroids is related to BMD in postmenopausal women treated for lower back pain.

Methods

This study is a retrospective analysis of postmenopausal women with lower back pain who were admitted to the pain management practice center of the Kangwon National University Hospital. The study was designed according to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and was approved by the institutional review board (IRB). The study was registered at the Korea Clinical Trial Registry (Code 1107-AFCR-031) and conducted in accordance with the Declaration of Helsinki. We carried out interviews based on reviews of the patients' medical records. The data were collected for consecutive patients from July 2005 through June 2011.

All patients aged 50 years and older who satisfied the inclusion criteria were enrolled in the study. Patients were stratified as follows: Group 1 consisted of 48 patients who received medications (nonsteroidal anti-inflammatory drug and muscle relaxant) without ESI; Group 2 consisted of 42 patients who received ESI more than 4 times, with a cumulative administered dose of triamcinolone > 120 mg.

The inclusion criteria for the study were postmenopausal women with a medical history of lower back pain and BMD assessments performed before treatment and repeated one year posttreatment. The exclusion criteria were a history of hyperparathyroidism, hyperthyroidism, or osteomalacia; a history of taking medication known to affect bone metabolism; and previous lumbar spine surgery.

ESIs were administered to 42 patients at the level of the lower lumbar spine by a staff member—8 mL of lidocaine hydrochloride (0.5%, preservative-free) and triamcinolone were injected. Body mass index (BMI) was calculated from the measured weight and height as weight/height2 (kg/m2). BMDs of the lumbar spine (L2–L4), femoral neck, and total femur were measured by dual energy x-ray absorptiometry using the Lunar Prodigy (DXA, GE Healthcare, Madison, WI). Measurements were expressed as absolute values (g/cm2). Calibration procedures were performed daily using appropriate phantoms provided by the manufacturer. The long-term precision of the daily scans of the spine phantom was 0.994 g/cm2 in BMD units. The interassay coefficient of variation for BMD was between 0.07% and 0.09%. BMD values were also expressed as T-scores and changes from baseline. Baseline BMDs were measured before treatment; BMD measurements were repeated one year after treatment. The time interval from the baseline BMD to the second BMD was 15 ± 1.0 months in Group 1 and 14 ± 1.6 months in Group 2. To control for these intergroup differences (20–30 days), the change in BMD for each patient was annualized.

Statistical analysis

The data were presented as the mean ± standard deviation (SD). Unpaired t-test was used to compare differences in age, weight, height, BMI, duration of BMD measurement, baseline BMD, mean ESI frequency, and mean dose of corticosteroids between the groups. Within each group, changes in BMD compared to baseline were analyzed by a paired t-test. The comparison between the groups for prevalence of osteoporosis was performed using Mann-Whitney test.

In all the comparisons, a *P* value less than 0.05 was considered statistically significant. Statistical analyses were performed using SPSS 19.0 (IBM Corporation, Armonk, New York).

Results

A total of 90 patients were enrolled in the present investigation; baseline characteristics of the patients are presented in Table 1. There were no statistically significant differences between the groups with respect to age, weight, height, BMI, duration of BMD measurement, or baseline BMD. The total number of ESIs was 5.6, and the mean total dose of corticosteroid (triamcinolone) was 212 mg.

The outcomes of BMD for the lumbar spine, total femur, and femoral neck regions before and after treatment are listed in Table 2. In patients not treated with ESI (Group 1), in the lumbar spine the prevalence of osteopenia was 38% and osteoporosis was 48%; in the total femur osteopenia was 56% and osteoporosis was 23%; and in the femoral neck region, osteopenia was 48% and osteoporosis was 23%. In patients treated with ESI (Group 2), in the lumbar spine the prevalence of osteopenia was 36% and osteoporosis was 50%; in the total femur osteopenia was 38% and osteoporosis was 43%; and in the femoral neck region osteopenia was 55% and osteoporosis was 21%. The overall prevalence of osteoporosis was 50% in patients treated without ESI and 57% in patients treated with ESI.

Mean percentage changes in BMD from baseline are illustrated in Fig. 1. The mean changes in BMD in non-ESI patients were 1.04 ± 0.19% in the lumbar spine, -1.32 ± 0.18% in the femoral neck, and -0.39 ± 0.21% in the total femur region. The mean changes in BMD for patients treated with ESI were 0.06 ± 0.12% in the lumbar spine, -2.87 ± 0.17% in the femoral neck, and -1.57 ± 0.14% in the total femur region. A decreasing trend in BMD was observed in the ESI-treated patients. However, no significant difference in mean percentage change from baseline BMD was observed between or within the groups in any of the bones measured.

Discussion

This study demonstrated a decreasing trend in BMD in postmenopausal women who received ESI more than 4 times, with a cumulative administered dose of triamcinolone > 120 mg. However, no significant difference in mean percentage change from baseline BMD in the lumbar spine, femoral neck, or total femur was observed between or within the groups treated with and without ESI. The mean administered dose of triamcinolone was 212 mg in the group treated with ESI. These data suggest that ESI treatment using triamcino-

Table 1. *Characteristics of patients and corticosteroid therapy administrationa*

	No ESI[b] (n = 48)	ESI[c] (n = 42)	P-Value
Age (yrs)	62 (1.8)	63 (1.2)	0.548
Weight (kg)	56 (4.1)	58 (4.3)	0.182
Height (cm)	156 (7.9)	159 (8.4)	0.227
Body mass index (kg/m^2)	23.0 (3.3)	22.9 (2.4)	0.262
Duration of BMD monitoring (months)	15 (1.0)	14 (1.6)	0.648
Baseline BMD (g/cm^2)			
Lumbar spine	0.772 (0.221)	0.781 (0.260)	0.379
Total femur	0.692 (0.215)	0.686 (0.235)	0.412
Femoral neck	0.752 (0.184)	0.749 (0.205)	0.542
Total numbers of ESIs	-	5.6 (0.6)	
Mean total dose of corticosteroid (triamcinolone, mg)	-	212 (32)	

[a] Values are expressed as mean (SD)
[b] Group 1 patients received medications without ESI
[c] Group 2 patients received ESI more than 4 times, with a cumulative administered triamcinolone dose > 120 mg.
Abbreviations: ESI, epidural steroid injection; BMD, bone mineral density
There were no significant differences between the groups.

Table 2. *Bone mineral density outcomes before and after treatment*[a]

	Pre-treatment No ESI[b] (n=48)	ESI[c] (n=42)	Post-treatment No ESI[b] (n=48)	ESI[c] (n=42)
Lumbar spine[d]				
Normal	7 / 48 (14%)	6 / 42 (14%)	7 / 48 (14%)	6 / 42 (14%)
Osteopenia[e]	17 / 48 (36%)	15 / 42 (36%)	18 / 48 (38%)	15 / 42 (36%)
Osteoporosis[f]	24 / 48 (50%)	21 / 42 (50%)	23 / 48 (48%)	21 / 42 (50%)
Total femur[d]				
Normal	11 / 48 (23%)	10 / 42 (24%)	10 / 48 (21%)	8 / 42 (19%)
Osteopenia[e]	27 / 48 (56%)	16 / 42 (38%)	27 / 48 (56%)	16 / 42 (38%)
Osteoporosis[f]	10 / 48 (21%)	16 / 42 (38%)	11 / 48 (23%)	18 / 42 (43%)
Femoral neck[d]				
Normal	15 / 48 (31%)	13 / 42 (31%)	14 / 48 (29%)	10 / 42 (24%)
Osteopenia[e]	23 / 48 (48%)	22 / 42 (52%)	23 / 48 (48%)	23 / 42 (55%)
Osteoporosis[f]	10 / 48 (21%)	7 / 42 (17%)	11 / 48 (23%)	9 / 42 (21%)
Overall [d]				
Normal	7 / 48 (15%)	6 / 42 (14%)	6 / 48 (13%)	4 / 42 (10%)
Osteopenia[e]	18 / 48 (37%)	14 / 42 (33%)	18 / 48 (37%)	14 / 42 (33%)
Osteoporosis[f]	23 / 48 (48%)	22 / 42 (53%)	24 / 48 (50%)	24 / 42 (57%)

[a] BMD data are based on T-scores
[b] Group 1 patients received medications without ESI
[c] Group 2 patients received ESI more than 4 times, with a cumulative administered triamcinolone dose of > 120 mg
[d] Values represent the number of patients/total patients (%)
[e] Osteopenia was defined as −2.5 SD < BMD T score < −1.0 SD
[f] Osteoporosis was defined as BMD T score ≤ −2.5 SD
Abbreviations: ESI, epidural steroid injection.

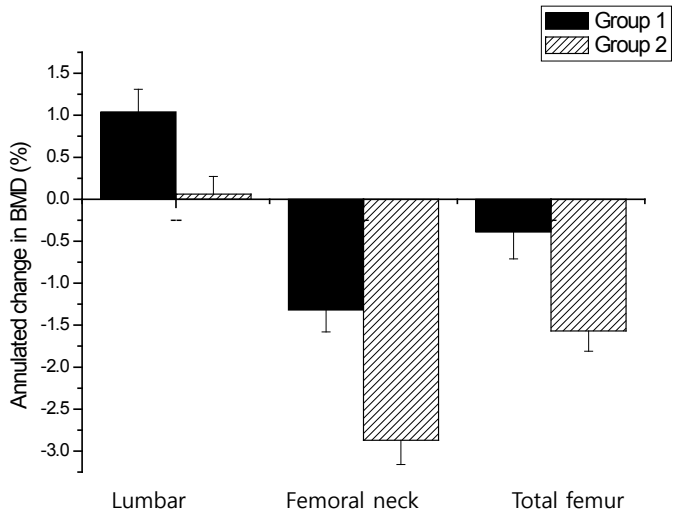

Fig.1. ***Mean percent change in bone mineral density from baseline. Group 1: patients received medications without ESI. Group 2: patients received ESI more than 4 times, with a cumulative administered triamcinolone dose > 120 mg.***
Abbreviations: ESi - epidural steroid injectipn; BMD - bone mineral density (g/cm$^{2)}$
there were not significant differences in BMD between or within the groups.

lone (over 200 mg) for a period of one year will have a negative effect on BMD in postmenopausal women being treated for lower back pain.

Corticosteroids are widely used as effective agents for managing lower back pain, but osteoporosis is a common problem associated with its long-term use (8-10). Corticosteroids are known to affect bones through multiple pathways, influencing both bone formation and resorption. These mechanisms have been reviewed previously (8-10).

Exogenous corticosteroids are used by approximately 0.5% of the population (10). Bone loss with corticosteroid use is most rapid in the first 6 months after initiation of therapy, followed by a slower decline in patients receiving chronic corticosteroids therapy (11-13). We therefore compared changes in BMDs between baseline and one year after treatment.

In patients on chronic low-dose therapy, continuing but slower bone loss has been shown to occur. Corticosteroid-induced bone loss is dose dependent, suggesting that even low doses of corticosteroids can cause bone loss in some patients (10-13). The dose and duration of corticosteroid therapy are considered by many investigators to be the most important determinants of bone loss (11-16). The trabecular bone (including the proximal femur) and cortical rim of the vertebral body are more susceptible to the deleterious effects of corticosteroids than are the cortical regions of long bones (17,18). Thus, the lumbar spine and proximal femur are particularly vulnerable to osteoporosis and related fractures caused by corticosteroids. We therefore compared changes in BMDs in the lumbar spine, femoral neck, and total femur region.

Generally, bone loss occurs with an average decrease of 5% over the first year of long-term corticosteroid treatment (14,15). Thereafter, bone loss is between 1% and 2% per year. In a previous study, the mean decrease in bone densities in the lumbar spine, femoral neck, and greater trochanter in the placebo group after one year was approximately 3% (15). BMD has also been measured in the lumbar spine (0.99–0.92 in Korean postmenopausal women [KPW], 1.04–1.00 in older men), femoral neck (0.84–0.68 in KPW, 0.74–0.71 in older men), and trochanter (0.70–0.64 in KPW, 0.78–0.75 in older men). The BMD in KPW decreased in the lumbar spine by approximately 1% during a 1-year period (22). In this study, the mean baseline BMDs in Group 1 (treated without ESI) were 0.772 in the lumbar spine, 0.692 in the total femur, and 0.752 in the femoral neck; in Group 2 (treated with ESI) baseline BMDs were 0.781 in the lumbar spine, 0.686 in the total femur, and 0.749 in the femoral neck. There were no statistically significant differences between patients treated with and without ESI with respect to the baseline BMD in each area of bone.

In the present study, the mean baseline BMD in the lumbar spine was lower than that of Korean postmenopausal women cited in previous studies (19-22). We used the lowest of the BMD measurements taken in the lumbar spine before treatment in order to avoid errors caused by osteophyte formation. However, previous studies calculated the BMD as the mean of measured values from the lumbar spine (19-22). We used BMD measurements that were taken in the same anatomical location before and after treatment. In this study, BMDs of the lumbar spine increased by 1% in patients treated without ESI and 0.06% in patients treated with ESI at one-year posttreatment. In addition, a decrease in BMDs of the lumbar spine was not observed. These observations could be due to increases in physical activity and exercise, allowed by the therapeutic effects of treatment in patients who had limited mobility due to lower back pain (23,24). We believe that ESI thus had opposing effects on BMD, causing corticosteroid-induced decreases in BMD on the one hand and, on the other, preventing reductions in BMD by promoting increased activity and exercise in patients with lower back pain (8-10). We performed BMD measurements on patients with lower back pain. Perhaps the therapeutic effects of ESI and exercise affects the lumbar spine (region of pre-existing disease) BMD more than the femur BMD. We also observed no differences in the degree of BMD change between the injection site and the other sites. Considering the above results, we assume that ESI does not have a direct effect on the BMD of the lumbar spine.

Thus far, very little information is available regarding the actual incidence and prevalence of osteoporosis in patients receiving ESI therapy. In postmenopausal Korean women, the prevalence of osteoporosis has been reported to be 51% in the lumbar spine and 11% in the femoral neck (25). In the present study, the prevalence of osteoporosis in the group treated without ESI was 48% in the lumbar spine and 23% in the femoral neck; in the group treated with ESI the prevalence of osteoporosis was 50% in the lumbar spine, and 21% in the femoral neck. In postmenopausal Korean women, the overall prevalence of osteoporosis was 56% (26). In the present study, the overall prevalence of osteoporosis in patients treated without ESI was 50%; with ESI,

57%. Thus, the results of this study are similar to those of the cited studies with respect to the incidence and prevalence of osteoporosis.

Long-term therapy with corticosteroids often results in bone loss and corticosteroid-induced osteoporosis (10,27). Corticosteroid-associated adverse effects are not reduced by alternate-day administration (28,29). However, epidural injection of corticosteroids has some advantages over systemic therapy in patients with lower back pain, such as delivering higher concentrations of the drug to the diseased area and having a notably lower rate of systemic adverse effects (30-32). Nevertheless, some bone loss does occur with the use of corticosteroids. In the present investigation, the patients used lower doses of corticosteroids (about 200 mg) than that used in previous studies, in which doses higher than 1000 mg were administered (10-15).

The risk of side effects occurring from epidural steroids may rise when the number and frequency of injections is increased. However, the total dose of corticosteroids administered appears to play a more important role in determining the occurrence of adverse events (12). Complications that are historically attributed to corticoid injections include osteoporosis, vertebral compression fractures, avascular joint necrosis, and immunosuppression (7,9). These problems are greatly reduced by using targeted injection versus systemic routes of administration. Epidural steroids are often preferred over oral and intravenous steroids because they allow targeted delivery of the drug. With due consideration of the risks of any steroid administration, it seems prudent to limit the dose of steroid to the smallest efficacious dose.

BMD is a major determinant of the risk of fracture in patients with corticosteroid-induced osteoporosis. BMD examinations have 3 principal roles: the diagnosis of osteoporosis, the assessment of a patient's risk of fracture, and monitoring the response to treatment. Both the hip and spine should be measured because the hip is the best site for predicting hip fracture risk, the spine is the best site for monitoring response to treatment (33). Dual energy x-ray absorptiometry (DXA) measurements of hip and spine BMD have an important role in the evaluation of individuals at risk for osteoporosis. DXA scan results are affected by both precision and accuracy errors. Precision errors measure the reproducibility of BMD results and can be studied by performing repeated scans in a representative group of patients. The excellent long-term precision of DXA measurements is an important advantage that reflects among other factors the stable calibration of DXA systems and the provision by manufacturers of effective instrument quality control procedures to detect any drifts (33).

All patients initiating long-term treatment with corticosteroids should obtain a baseline BMD measurement (8,10). However, lumbar spine measurements in the elderly may be unreliable because of osteophyte formation. Therefore, if only one site measurement can be obtained, the lumbar spine in patients younger than 60 years of age and the femoral neck in patients older than 60 years should be tested (8,10). In this study, we used the BMD values taken in the lumbar spine (L2–L4), femoral neck, and total femur.

Patients on chronic corticosteroid therapy should have their skeletal health assessed on a regular basis. Such an evaluation should include a complete history and physical examination, with specific attention given to the presence of previous fragility fractures, signs or symptoms of hypogonadism, history of nephrolithiasis, tobacco use, and excess alcohol use. Dietary and supplemental calcium intake should also be assessed. The patient should be evaluated for myopathy, which could increase the risk of falls and fractures (8,10). Appropriate laboratory studies may also be of great help.

This study had several limitations. First, it was a retrospective study. Second, our study did not include the use of ESI with high-dose corticosteroids. We did not collect data from patients who used ESI with high doses of corticosteroids because we did not feel that the use of high-dose corticosteroids would be ethical in these circumstances. Third, our study did not include long-term assessments of the effects of ESI on BMD. In spite of the above limitations, this study is valuable as it is the first to evaluate changes in the BMDs of postmenopausal women after ESI treatments for lower back pain.

In this study, the patients treated with ESI received 10-40 mg triamcinolone at intervals of 1-2 weeks at a time. The mean administered dose of triamcinolone was 212 mg in the group treated with ESI. However, the BMD outcomes for the lumbar spine, total femur, and femoral neck regions were not significantly different between or within the groups treated with and without ESI.

Conclusion

In summary, ESI treatments using less than a total of 200 mg triamcinolone had no significant effect on BMD. However, the decrease in BMDs of postmenopausal women who received more than 200 mg of

triamcinolone in one year indicates that ESI involving doses over 200 mg per year should be avoided. Hence, our data suggest that ESI treatment using a maximum of 200 mg of triamcinolone in one year could be used safely, without any significant impact on BMD.

References

1. Deyo RA, Mirza SK, Martin BI. Back pain prevalence and visit rates: Estimates from US national surveys, 2002. *Spine* 2006; 31:2724-2727.
2. Malmivaara A, Häkkinen U, Aro T, Heinrichs ML, Koskenniemi L, Kuosma E, Lappi S, Paloheimo R, Servo C, Vaaranen V,Hernberg S. The treatment of acute low back pain—bed rest, exercises, or ordinary activity? *N Engl J Med* 1995; 332:351-355.
3. Manchikanti L, Boswell MV, Datta S, Fellows B, Abdi S, Singh V, Benyamin RM, Falco FJ, Helm S, Hayek SM, Smith HS. Comprehensive review of therapeutic interventions in managing chronic spinal pain. *Pain Physician* 2009; 12:123-198.
4. Manchikanti L, Boswell MV, Singh V, Benyamin RM, Fellows B, Abdi S, Buenaventura RM, Conn A, Datta S, Derby R, Falco FJE, Erhart S, Diwan S, Hayek SM, Helm S, Parr AT, Schultz DM, Smith HS, Wolfer LR, Hirsch JA. Comprehensive evidence-based guidelines for interventional techniques in the management of chronic spinal pain. *Pain Physician* 2009; 12:699-802.
5. Manchikanti L, Datta S, Derby R, Wolfer LR, Benyamin RM, Hirsch JA. A critical review of the American Pain Society clinical practice guidelines for interventional techniques: Part 1. Diagnostic interventions. *Pain Physician* 2010; 13:E141-174.
6. Manchikanti L, Datta S, Gupta S, Munglani R, Bryce DA, Ward SP, Benyamin RM, Sharma ML, Helm S 2nd, Fellows B, Hirsch JA. A critical review of the American Pain Society clinical practice guidelines for interventional techniques: Part 2. Therapeutic interventions. *Pain Physician* 2010; 13:215-264.
7. Botwin KP, Gruber RD, Bouchlas CG, Torres-Ramos FM, Freeman TL, Slaten WK. Complications of fluoroscopically guided transforaminal lumbar epidural injections. *Arch Phys Med Rehabil* 2000; 81:1045-1050.
8. Chiluka, V.L., Banji, D., Banji, O.J.F., Sollu, M., Pandra, S.B. Glucocorticoid induced osteoporosis. *Intern J Pharm Sci Rev Res* 2010; 53:124-131.
9. Mitra R. Adverse effects of corticosteroids on bone metabolism: A review. *PM and R* 2011; 3:466-471.
10. Bouvard, B., Legrand, E., Audran, M., Chappard, D. Glucocorticoid-induced osteoporosis: A review. *Clin Rev Bone Miner Metab* 2010; 8:15-26.
11. Everdingen AA, Reesema S, Jacobs J, Bijlsma J. Low-dose glucocorticoids in early rheumatoid arthritis: Discordant effects on bone mineral density and fractures? *Clin Exp Rheum* 2003; 21:155-160.
12. van Staa TP, Leufkens HG, Abenhaim L, Zhang B, Cooper C. Oral corticosteroids and fracture risk: Relationship to daily and cumulative doses. *Rheumatology* 2000; 39:1383-1389.
13. van Staa TP, Leufkens HG, Cooper C. Use of inhaled corticosteroids and risk of fractures. *J Bone Miner Res* 2001; 16:581-588.
14. Baxter JD. Advances in glucocorticoid therapy *Adv Intern Med* 2000; 45:317-349.
15. Cohen S, Levy RM, Keller M, Boling E, Emkey RD, Greenwald M, Zizic TM, Wallach S, Sewell KL, Lukert BP, Axelrod DW, Chines AA. Risedronate therapy prevents corticosteroid-induced bone loss. *Arthritis Rheum* 1999; 42:309-318.
16. Laan RF, van Riel PL, van de Putte LB, van Erning LJ, van't Hof MA, Lemmens JA. Low-dose prednisone induces rapid reversible axial bone loss in patients with rheumatoid arthritis. *Ann Intern Med* 1993; 119:963-968.
17. Carbonare LD, Arlot ME, Chavassieux APM, Roux JP, Portero NR, Meunier, PJ. Comparison of trabecular bone microarchitecture and remodeling in glucocorticoid-induced and postmenopausal osteoporosis. *J Bone Miner Res* 2001; 16:97-103.
18. Laan RF, Buijs WC, van Erning LJ, Lemmens JAM, Corstens FHM, Ruijs SHJ, Van de Putte LBA, Van Riel PLCM. Differential effects of glucocorticoids on cortical appendicular and cortical vertebral bone mineral content. *Calcif Tissue Int* 1993; 52:5-9.
19. Jeong IK, Cho SW, Kim SW, Choi HJ, Park KS, Kim SY, Lee HK, Shin CS. Lipid profiles and bone mineral density in pre- and postmenopausal women in Korea. *Calcif Tissue Int* 2010; 87:507-512.
20. Park JJ, Shin J, Youn Y, Champagne C, Jin E, Hong S, Jung K, Yeom S. Bone mineral density, body mass index, postmenopausal period and outcomes of low back pain treatment in Korean postmenopausal women. *Eur Spine J* 2010; 19;1942-1947.
21. Kim HY, Choe JW, Kim HK, Bae SJ, Kim BJ, Lee SH, Koh JM, Kim GS. Negative association between metabolic syndrome and bone mineral density in Koreans, especially in men. *Calcif Tissue Int* 2010; 86:350-358.
22. Hong S, Ahn YH, Choi WH. Age-, gender- and region- related changes in bone mineral density of Korean adult. *Journal of KSO* 2010; 8:188-195.
23. Smith EM, Comiskey CM, Carroll AM. A study of bone mineral density in adults with disability. *Arch Phys Med Rehabil* 2009; 90:1127-1135.
24. Karakiriou SK, Douda HT, Tokmakidis SP. The role of exercise in the prevention and treatment of osteoporosis in postmenopausal women. *Archives of Hellenic Medicine* 2011; 28: 479-490.
25. Cui LH, Choi JS, Shin MH, Kweon SS, Park KS, Lee YH, Nam HS, Jeong SK, Im JS. Prevalence of osteoporosis and reference data for lumbar spine and hip bone mineral density in a Korean population. *J Bone Miner Metab* 2008; 26:609-617.
26. Kim KC, Shin DH, Lee SY, Im JA, Lee DC. Relation between obesity and bone mineral density and vertebral fractures in Korean postmenopausal women. *Yonsei Med J* 2010; 51:857-863.
27. Goldstein MF, Fallon JJ Jr, Harning R. Chronic glucocorticoid therapy-induced osteoporosis in patients with obstruc-

tive lung disease. *Chest* 1999; 116:1733-1749.

28. Ruegsegger P, Medici TC, Anliker M. Corticosteroid-induced bone loss. A longitudinal study of alternate day therapy in patients with bronchial asthma using quantitative computed tomography. *Eur] Clin Pharrnacol* 1983; 25:615-620.
29. Libanati CR, Baylink DJ. Prevention and treatment of glucocorticoid-induced osteoporosis. A pathogenetic perspective. *Chest* 1992; 102:1426-1435.
30. Smith BJ, Phillips PJ, Heller RF. Asthma and chronic obstructive airway diseases are associated with osteoporosis and fractures: A literature review. *Respirology* 1999; 4:101-109.
31. Buenaventura RM, Datta S, Abdi S, Smith HS. Systematic review of therapeutic lumbar transforaminal epidural steroid injections. *Pain Physician* 2009; 12:233-251.
32. Ghahreman A, Ferch R, Bogduk N. The efficacy of transforaminal injection of steroids for the treatment of lumbar radicular pain. *Pain Med* 2010; 11:1149-1168.
33. Blake GM, Fogelman I. The clinical role of dual energy X-ray absorptiometry. *Eur J Radiol* 2009; 71:406-414.