An Accounting of Pathology Visible on Lumbar Spine Radiographs of Patients Attending Private Chiropractic Clinics in the United Kingdom

KENNETH J YOUNG and AAMER AZIZ

ABSTRACT: *Objective:* To enumerate the types of pathology seen on lumbar spine plain radiographs of patients reporting to private chiropractic clinics in the United Kingdom. *Design:* Retrospective analysis of radiology reports from a chiropractic radiology consultancy. Setting: Private chiropractic radiology practice. *Patients/Participants:* All lumbar spine radiograph reports from a chiropractic radiology consulting practice over the course of one year were reviewed and the diagnoses were noted. 276 reports were reviewed and 262 were included in the study. Reports were included if they had definitive diagnoses, contained all relevant clinical information such as patient age, and reported on the lumbar spine only (e.g. full spine and thoraco-lumbar reports were excluded). *Intervention:* None. *Main Outcome Measures*: The types of pathology and number of times each was encountered were entered on to a spreadsheet and totaled by type and category. *Results:* Postural alterations and degenerative arthropathies were the most common pathologies encountered. The most serious pathologies encountered included two patients with tumours, three with acute compression fractures, 31 with osteoporosis and 80 with atherosclerosis. Seven patients with potentially significant findings were lost to follow up. *Conclusions:* This study was limited by convenience sampling and small sample size, however some indication of the types of pathologies that chiropractors find on their images was obtained. Improved communication between manual therapy practitioners and the medical community would benefit all parties involved, including patients.

INDEX TERMS: SPINE; LUMBAR VERTEBRAE; RADIOGRAPHY; PATHOLOGY; CHIROPRACTIC; RETROSPECTIVE STUDIES.

Chiropr J Aust 2009; 39: 63-9.

INTRODUCTION

The peer-reviewed literature contains relatively little descriptive data on the pathology seen on spinal radiographs of chiropractic patients. There are medical studies that have quantified pathology visible on spinal plain films,[1-4] and some quantification of pathology has also been done in the effort toward maximising diagnostic yields by the implementation of clinical criteria for taking x-rays.[5-7]

Kenneth J Young, DC, DACBR
School of Chiropractic and Sports Science
Murdoch University
Murdoch WA 6166 Australia

Aamer Aziz, MBBS, MSc (Nuclear Medicine), PhD (Radiology)
School of Dentistry and Health Sciences
Charles Sturt University
Wagga Wagga NSW 2678 Australia

This work was originally undertaken as partial fulfillment of the Master of Applied Sciences (Medical Imaging – Radiographic Image Interpretation) at Charles Sturt University, Wagga Wagga, Australia.

No funding or any kind of material support was received for this research from any source

Conflict of Interest Notification: No conflict of interest is known for this work.

Received 12 December 2008, accepted 25 January 2009

Although chiropractic and diagnostic radiography have both been in existence since 1895, it is only relatively recently that some effort has been undertaken to expand this information. There have been a few peer-reviewed studies examining the prevalence of pathology in chiropractic patients,[8-12] however, all this research was performed using the outpatient clinic populations of chiropractic teaching institutions. No studies were found that have been performed using the patient populations of privately run chiropractic clinics.

METHODS

The method used was a retrospective analysis of patient records. Specifically, the reports written on plain film radiographs, both digital and plain film, obtained from a chiropractic radiologist were reviewed. Retrospective designs are only as reliable as the data that was originally collected.[13] In this case, a retrospective design is appropriate because the radiology reports will not have changed over time and therefore reflect the pathology that was actually reported. In addition, it gives the required information while resulting in no alteration to patient management, including, most crucially, no increase in radiation dose compared to that which the patients would normally receive.

While chiropractors in the UK are qualified to read and report on diagnostic images without specialist training,[14] it has been demonstrated that a chiropractic radiologist's level

of specialist ability regarding radiographic interpretation is higher than that of a non-specialist practicing chiropractor.[15] A chiropractic radiologist attends a 3-year, full-time radiology residency at an accredited chiropractic teaching institution and must pass written and *viva* examinations.[16]

The images sent to the chiropractic radiologist to be used in this study were from chiropractors in various parts of England as well as from Scotland and Wales, therefore geographical health differences, which are known to exist in the United Kingdom,[17] were reduced.

Seasonal changes in public health have been noted,[18] specifically in ways that may be relevant to this study. For instance, Krolner[19] found seasonal variance in bone mineral content of the spine. Therefore the prevalence of pathology on spine radiographs, for instance fractures, may be different at different times of the year. In order to help account for this, the records from an entire year were examined.

The primary investigator in this study was the chiropractic radiologist to whom the images were sent. The data collected included age and gender as well as the types of pathology found on the images. The pathology category classification was modified from the system devised by the American College of Radiology,[20] a commonly used standard. Age data was recorded as "50 years or younger" or "over 50". Because of the increased incidence of pathology with age, the 50-year mark is a commonly used criterion for the justification of the use of ionising radiation,[21] and therefore may be a useful point of data regarding incidences of pathologies.

A final diagnosis is not always possible from radiographs alone[22] and many times must be correlated with advanced imaging, historical information, laboratory test findings or biopsy results. In cases where a diagnosis was uncertain, the referring chiropractor was contacted to find out if follow up information was obtained after the initial findings were reported.

The inclusion criteria were plain film radiograph reports of the lumbar spine, which had been received between August 2006 and July 2007. There were several exclusion criteria. These included, first, reports for which one or more tentative diagnoses were unable to be confirmed. Not infrequently in the UK, once referred for follow up studies, patients enter the National Health Service and do not return to the chiropractor or report back their findings. Exclusion criteria also included reports on images that did not capture the entire lumbar spine, and reports on diagnostic series that did not include at least two views at 90-degrees to each other of the entire lumbar spine. Full spine images were also excluded due to their limited diagnostic quality, particularly of the lateral views.[23] Additional exclusion criteria considered before data collection began included lost or illegible reports. This was deemed to be unlikely, since reports were stored electronically and regularly backed-up.

Pathology Classification

The categories of findings were modified from the American College of Radiology's classification of pathology, widely regarded as the standard. These categories included alignment, congenital anomaly/normal variant, arthropathy, trauma, metabolic/endocrine bone disease, surgical artefact, soft tissue pathology/calcification, haematological/vascular disease of bone, and tumours/malignancy.

Alignment findings included postural changes, scoliosis, and spondylolisthesis. Postural changes were defined to include any of the following: lateral spinal curvatures of less than 10-degrees, lateral tilt of the spine, lateral pelvic tilt, increased (greater than 60-degrees) or decreased (less than 50-degrees) lordosis,[24,25] or anterior or posterior weight bearing as determined by the lumbar gravity line.[26] Scoliosis was defined as lateral spinal curvatures of greater than 10-degrees[22] as measured by the Cobb-Lippman method.[27] Spondylolisthesis was defined anterior, posterior or lateral shift of one vertebral body on another, or on the sacral base and Wiltse's classification of aetiology was used.[28]

The congenital anomaly/normal variant category included many different individual entities. Bone island (enostoma), although often taught with tumour and tumour-like conditions because of its radiographic appearance, is a benign focus of cortical bone within the medullary cavity, carrying no clinical significance[29] and was included as a normal variant in this study.

Schmorl's nodes and limbus bones have the same aetiology, that is, developmental protrusion of part of the nucleus pulposus of the intervertebral disc through the vertebral endplate, forming a focal impression (Schmorl's node) or separate fragment at the corner of a vertebral body (limbus bone)[22] and therefore were counted together.

Spina bifida occulta was defined to include clasp-knife deformity, in which failure of complete ossification of the posterior elements of a vertebra is seen in conjunction with an elongated spinous process from the level above.[26] Hypoplastic intervertebral disc was defined in this study as reduction of disc height with no evidence of osteophyte formation, subchondral sclerosis, or vacuum phenomenon, nor evidence of transitional elements at that level. Pubic spur was defined as calcification or ossification in the area of the suprapubic ligament without evidence of degeneration such as subchondral sclerosis, subchondral cyst or joint space narrowing.[30] Pars defect was included in this category because it is thought to have a developmental component[22] and to differentiate it from isthmic spondylolisthesis, in which the vertebral body has displaced in relation to the one below in addition to demonstrating a fracture of the pars interarticularis.

Styloid process of a vertebral body has been described in the literature[30] was defined as an osseous excrescence from the vertebral body with a narrow end, to differentiate it from an osteochondroma, which usually has a flared or wide end distal to the attachment to the parent bone.[31]

Sacral defect was defined as a missing part of the sacrum with a well-defined and well-corticated edge as well as no evidence of an osseous destructive pathology when correlated with clinical evidence or follow-up examinations.

The arthropathy category included spondylosis, degenerative disc disease, facet arthrosis, diffuse idiopathic skeletal hyperostosis, sacroiliac degenerative joint disease, pubic degenerative joint disease and Baastrup's disease. In the literature, there is a distinction between osteophyte formation with no other degenerative changes, spondylosis and osteophytes, reduced disc height and subchondral sclerosis, herein termed degenerative disc disease, sometimes referred

to as intervertebral osteochondrosis.[32] That distinction was applied here.

Within the category of trauma, acute fracture of the vertebral body was differentiated from chronic and counted as a separate, independent entity because of the differing clinical implications.[33,34] Fracture of the posterior elements was counted in this category and included fractures in any area except the pars interarticularis. Finally, a defect in the ilium with traumatic history was included here.

The surgical artefact category contained two types of findings. First was retained medical devices, and they included vascular, tubal ligation, hernia and other clips, pins, intra-uterine devices, pessaries, sternal wires and any other human-implanted object. The other finding in this category was an absent breast with history of mastectomy.

The final category was soft tissue pathology/calcification. First here was atherosclerosis, the visible calcification of the aorta or the iliac or femoral arteries. Aortic dilatation was noted under a separate heading if the maximum visible aortic diameter exceeded 3cm.[35]

Splenic artery calcification, although considered the third most common artery to calcify with atherosclerosis,[36] was counted separately from atherosclerosis if it was seen without aortic, iliac or femoral artery involvement.

ETHICAL CONSIDERATIONS

The main ethical issue necessary to consider in this study was patient confidentiality. The only investigator was the chiropractic radiologist who wrote the radiology reports, and no transcriptionists or assistants were used. Since no names or clinic facilities were recorded for the study, it conformed to European data protection standards.[37] Ethical compliance was certified by the ethical review board at Charles Sturt University.[38]

RESULTS

For the composition of the sample and full results, please see Tables 1 and 2.

A total of 276 reports were reviewed. 262 reports were included in the study. Seven reports were excluded for lack of follow-up information after patients were referred for further investigation. Two reports were excluded because they were labelled "thoracolumbar spine" and therefore the radiographs may not have included the entire lumbar spine. Two reports were excluded because an element of patient data was missing, specifically, the date of birth of the patient. In addition, three full spine reports were excluded.

Although findings in the hips were sometimes recorded on the reports used in this study, they were not included for this paper, because hips were not universally present on the images due to narrow collimation or a high-placed central ray.

Findings by category

There were no diagnoses of haematological/vascular disease of bone found in this study.

Under the category of alignment, 246 were found with postural changes, 11 with scoliosis, 37 with degenerative spondylolisthesis and 5 with isthmic spondylolisthesis.

Table 1

SAMPLE COMPOSITION

Total number of reports included	262
Total number of males	130
Total number of females	132
Total number of patients 50 years or under	115
Total number of patients over 50 years old	147
Number of males 50 years or under	59
Number of males over 50 years old	71
Number of females over 50 years or under	57
Number of females over 50 years old	75

The congenital anomaly/normal variant category included 7 patients with bone island, a single block vertebra, 24 with one or more transitional segments, 7 with Schmorl's nodes and/or limbus bones, 10 with spina bifida occulta, 8 with hypoplastic intervertebral disc, 7 with a pubic spur, 2 with pars defect without vertebral body displacement, 4 incomplete ossification of a secondary growth centre, one styloid process of a vertebral body, 3 with idiopathic intervertebral disc calcification, one sacral defect, one hypoplastic coccyx and one accessory ossification centre of a vertebra.

The category of arthropathy included 166 patients with spondylosis, 117 with degenerative disc disease, 94 with facet arthrosis, 4 with diffuse idiopathic skeletal hyperostosis (DISH), 20 with sacroiliac degenerative joint disease, one with pubic symphysis degeneration and 5 with Baastrup's disease.

The trauma category included 3 patients with acute compression fracture, 6 with chronic compression fracture, 2 with fracture of the posterior elements (not the pars interarticularis) and one traumatic defect in the ilium.

Under the surgical artefact category, many different surgical/medical devices were seen, and included hernia clips, pessaries, tubal ligation clips, a prosthetic intervertebral disc, pacemaker lead, sternal wires, intra-uterine devices, vascular clips from cholecystectomy and surgical mesh. These were not differentiated and were all accounted for under the same heading; the total number of patients with one or more of these was 26. The only separately accounted surgical finding was mastectomy, of which there were 3 patients with radiographically visible evidence.

Soft tissue pathology/calcification included 80 cases of atherosclerosis, 2 of aortic dilatation, 22 patients with calcified lymph nodes, 5 cases of cholelithiasis, 4 of nephrolithiasis, enthesopathy in 6 patients, 2 calcified splenic arteries, one injection granuloma, 5 with uterine leiomyoma (fibroid), one with a calcified vas deferens, and one case of myositis ossificans.

The only pathology encountered in the metabolic/endocrine category was osteoporosis, of which there were 31 cases.

The tumour category had only two entries. Scalloping was found on a vertebral body, and upon referral, the patient

Table 2

RESULTS

Category	Findings	Males < 50	Males > 50	Females. < 50	Females > 50	Totals
Alignment	Postural changes	58	68	57	63	246
	Scoliosis	1	1	2	7	11
	Degenerative Spondylolisthesis	1	14	0	22	37
	Isthmic Spondylokisthesis	1	2	1	1	5
	Total	**61**	**85**	**60**	**93**	**299**
Congenital anomaly	Bone island	0	2	2	3	**7**
Normal variant	Congenital block vertebra	0	0	0	1	**1**
	Transitional segment	7	4	6	7	**24**
	Schmorl's node/Limbus bone	2	2	3	0	**7**
	Spina bifida occulta	4	3		2	**10**
	Hypoplastic intervertebral disc	7	0	1	0	**8**
	Pubic spur	2	1	3	1	**7**
	Pars defect (no displacement)	1	0	1	0	**2**
	ncompl ossific 2nd grwth cntr	1	1	0	2	**4**
	Styloid process, vertebral	0	0	1	0	**1**
	Idiopathic disc calcification	0	1	2	0	**3**
	Sacral defect (developmental)	0	0	1	0	**1**
	Hypoplastic intervertebral disc	7	0	1	0	**8**
	Accessory ossification L/S	0	0	1	0	**1**
	Total	**24**	**14**	**23**	**16**	**77**
Arthropathy	Spondylosis	21	60	30	55	**166**
	Degenerative disc disease	18	46	10	43	**117**
	Facet arthrosis	5	45	6	38	**94**
	DISH	0	3	0	1	**4**
	Sacroiliac joint degeneration	2	10	2	6	**20**
	Pubic symphysis degeneration	0	0	0	1	**1**
	Baastrup's disease	2	2	0	1	**5**
	Total	**48**	**166**	**48**	**145**	**407**
Trauma	Compression fracture (acute)	1	1	1	0	**3**
	Compression fracture (chronic)	0	3	1	2	**6**
	Fx posterior elements	2	0	0	0	**2**
	Defect in ilium (traumatic)	0	0	0	1	**1**
	Total	**3**	**4**	**2**	**3**	**12**

Surgery/prosthesis	Surgical artefacts	4	8	7	7	**26**
	Mastectomy	0	0	0	3	**3**
	Total	**4**	**8**	**7**	**10**	**29**
Soft tissue	Atherosclerosis	2	45	3	30	**80**
path./calcification	Aortic dilatation	0	1	0	1	**2**
	Calcified lymph nodes	1	9	0	12	**22**
	Cholelithiasis	0	2	1	2	**5**
	Nephrolithiasis	1	2	0	1	**4**
	Enthesopathy	0	2	0	4	**6**
	Splenic artery calcification	0	0	0	2	**2**
	Injection granuloma	0	0	0	1	**1**
	Uterine leiomyoma	0	0	0	5	**5**
	Calcified vas deferens	0	1	0	0	**1**
	Myositis ossificans	0	1	0	0	**1**
	Total	**4**	**63**	**4**	**58**	**129**
Metabolic/endocrine	Osteoporosis	**1**	**11**	**0**	**19**	**31**
Tumour/malignancy	Multiple myeloma	0	1	0	0	**1**
	Renal cell carcinoma	0	1	0	0	**1**
	Total	**0**	**2**	**0**	**0**	**2**
All	**Grand total**	**145**	**353**	**144**	**344**	**986**

was found to have renal carcinoma. Another patient had known multiple myeloma and a radiographic finding of osteopaenia.

DISCUSSION

Because the reports of only one chiropractic radiologist were used, and no attempt was made to sample the entire population of the UK, nor the entire population of chiropractic patients in the UK, the method used would be considered convenience sampling.[13]

Since convenience sampling was used, and no information regarding the percentages of chiropractic patients radiographed was gathered, no conclusions about incidence or prevalence of disease can be made from this study. However, the information gathered may be useful as a snapshot of the types of pathologies encountered by chiropractors as well as in helping to direct future study.

As previously discussed, despite the benefits of increased diagnostic accuracy and potential reduction of legal liability, not all chiropractors choose to send their images for interpretation to chiropractic radiologists. Therefore, any given chiropractic radiologist will receive images from a limited number of clinically practicing chiropractors. This may have limited the spectrum of pathological findings seen in this study.

The low number of patient images for the year included in this study also likely impacted the variety of pathology seen. This number was at least partly due to the study year being the first year of operation of radiology reporting consultancy. Future studies with greater patient numbers could help clarify the picture of radiographically visible pathology presenting to British chiropractors.

Plain radiographs are still a useful tool for the assessment of potentially pathological conditions. With the increasing knowledge of the harmful effects of ionising radiation,[39,40] the improvements in diagnostic capabilities of advanced imaging, as well as better knowledge of pathology, the role of plain radiography must continually be reviewed, and the pathologies encountered on plain radiographs taken by chiropractors may be of use in this endeavour.

The most commonly encountered finding on the images reviewed here was postural changes. Few patients were found to be free of alterations from what is considered perfect spinal alignment: vertically linear on frontal views, 50-60 degrees of lordosis distributed evenly over the entire lumbar spine[24,25] and a level pelvis. The significance of this is debatable.[41,42] however since chiropractors focus on biomechanical changes, noting them in reports on images taken for other reasons may be worthwhile. Even though many postural changes are likely visible clinically, the radiographic findings may serve as a reminder or clarification of those changes. Clinicians then may or may not choose to alter their treatment plans according their professional opinion of their significance for each individual patient.

The findings in the congenital anomaly/normal variant category are largely clinically silent and were discovered as incidental findings.

The only arthropathies found were degenerative in nature; none were inflammatory, depositional, or infectious. While the small sample size partially accounts for this, another

factor is that the National Health Service (NHS) has likely identified many of the patients with these types of diseases and already placed them under the care of a rheumatologist and/or physiotherapist.

Various types of surgical artefacts were found, and were identified individually in the reports, but were gathered under one heading for this study, due to their largely incidental nature. This may have been different had a significant surgical artefact been encountered, such as from an aneurysm repair, because such a finding would indicate a potential contraindication to chiropractic adjustment of the lumbar spine.

In the soft tissue pathology/calcification category, atherosclerosis raised an issue worth investigating. Visible calcific plaquing in the aorta or iliac arteries represents a significant finding, worthy of including in a radiology report. Yet it is often not mentioned in the radiology reports from many institutions. The profession of chiropractic prides itself on providing care that includes many different aspects of patients' lives, not solely focusing on a presenting complaint.[43,44] Toward that end, dietary and lifestyle advice are commonly included as part of patients' treatment plans.[45] Since heart disease is the leading cause of death in the UK,[46] it would seem to make sense to include evidence of this significant pathology in reports, so that advice may be given to the patient. A future study tracking patient compliance with lifestyle modification advice (e.g. reduce saturated fats, stop smoking, reduce alcohol consumption, exercise aerobically, etc.) may be worthwhile. Different groups could consist of those who are shown their atherosclerosis on radiographs, those who are only told that they have atherosclerosis but are not shown it, and those who are not informed that they have atherosclerosis, as would be the case when the condition is not included on radiology reports.

Regarding metabolic/endocrine disease of bone, the only finding here was osteoporosis, a condition for which plain radiographs are not very sensitive[47,48] and evidence suggests that digital images may be even less sensitive than conventional plain films.[49] Therefore, there may have been fewer patients who really had osteoporosis, or there may have been more. Some of the cases enumerated here may have had compression fractures, which could support a diagnosis of osteoporosis, but the findings were not cross-referenced for this study. Future studies may find this type of cross-referencing useful as well as correlation of patients with bone densitometry data.

There were only two confirmed patients included in the tumour/malignancy category. One patient had known multiple myeloma and a radiographic finding of osteopaenia. This is a common plain film presentation of the disease.[50] The other patient had a scalloped vertebral body, which did not appear to be a normal variant. The patient was referred and ultimately diagnosed with renal cell carcinoma. Information regarding whether the scalloped appearance was due to metastasis, physical erosion or an unrelated factor could not be obtained. Renal cell carcinoma may present with erosive appearance on bones.[51] Although tumours are relatively rare findings on the radiographs of chiropractors,[8-12] it is worth teaching the signs of aggressive osseous destructive processes since the implications of their presence are so important. The primary author's experience in observing various chiropractic teaching curricula is that often many types of tumours are taught to undergraduate students, which can be quite confusing for them. The question for the schools remains as to how much detail should be taught. Should many individual tumours be identified, or should the principles of radiographic evaluation emphasise the differentiation of aggressive pathological entities from non-aggressive ones, and leave specific differential diagnoses to specialist radiologists?

Finally, a likely reason that a greater amount of serious pathology was not included in this study was the fact that follow up information could not be obtained for seven patients, so their results could not be included. This means that these patients had a finding that warranted further investigation, yet once they were referred on, they were unable to be contacted to discover the outcome. This is a common and frustrating situation for chiropractors in the UK. Improved communication with the NHS would benefit patients by educating chiropractors as to the signs and symptoms of serious disease as well as its differentiation from benign conditions in real patients. Although rigorous in terms of biomechanical pathology and outpatient evaluation and treatment, undergraduate chiropractic educational curricula in the UK include no hospital training and minimal exposure of any kind to seriously ill people. In addition, learning the outcome of their patients would help chiropractors deal with the genuine human empathy generated when patients are suspected of having serious disease. All this could easily be achieved if standard GP protocols included sending a short letter to the referring chiropractor (or any other healthcare practitioner) updating a patients' condition.

CONCLUSION

This study was limited by convenience sampling and small sample size, and cannot be considered as indicative of the prevalence of pathology on lumbar spine films of chiropractors, however some indication of the types of pathologies that chiropractors find on their images can be gleaned. It is hoped that this study and others like it may assist in guiding teaching faculty as to the more important pathologies to emphasise to their students as well as help refine indications for plain film imaging and possibly be useful in helping to find potentially different indications useful for practitioners of manual manipulation such as chiropractors and osteopaths. Improved communication between manual practitioners and the medical community would benefit all parties involved, including, ultimately and most importantly, patients.

REFERENCES:

1. Scavone JG, Latshaw RF, Rohrer GV. Use of lumbar spine films. Statistical evaluation at a university teaching hospital. JAMA. 1981 Sep 4;246(10):1105-8.
2. Butt W.P. (1989) Radiology for back pain. Clin Radiol. 1989 Jan;40(1): 6-10.
3. Deyo RA, Diehl AK. Patient satisfaction with medical care for low-back pain. Spine 1986 Jan-Feb;11(1):28-30.
4. Davies AM, Fowler J, Tyrrell PNM, Millar JS, Leahy JF, Patel K, Hill JS (1993) Detection of significant abnormalities on lumbar spine x-rays. Br J Radiol 1993 Jan;66(781):37-43.
5. Deyo RA, Diehl AK. Cancer as a cause of back pain: frequency, clinical presentation and diagnostic strategies. J Gen Intern Med 1988 May-Jun;3(3):230-8.

6. Aroua A, Decka I, Robert J, Vader JP, Valley JF. Chiropractor's use of radiography in Switzerland. J Manipulative Physiol Ther 2003 Jan;26(1):9-16.
7. Weil Y, Weil D, Donchin M, Mann G, Hasharoni A. Correlation between pre-employment screening X-ray finding of spondylolysis and sickness absenteeism due to low back pain among policemen of the Israeli police force. Spine 2004 Oct 1;29(19):2168-72.
8. Cooley JR, Schultz GD, Phillips RB. Frequency of diagnoses: what do chiropractors see on x-rays. Proceedings of the 1990 International Conference on Spinal Manipulation. Foundation for Chiropractic Education and Research; 1990; Arlington, Virginia, USA.
9. Hall T, Schultz GD, Phillips RB. Why do chiropractors take x-rays? Proceedings of the 1990 International Conference on Spinal Manipulation. Foundation for Chiropractic Education and Research; 1990; Arlington, Virginia, USA.
10. Kovach SG, Huslig EL. Prevalence of diagnoses on the basis of radiographic evaluation of chiropractic cases. J Manipulative Physiol Ther 1983 Dec;6(4):197-201.
11. Marchiori DM. A survey of radiographic impressions on a selected chiropractic patient population. J Manipulative Physiol Ther. 1996 Feb;19(2):109-12.
12. Brown MJ. Prevalence of pathology seen on lumbar x-rays in patients over the age of 50 years. Br J Chiropr 2001;5(1):23-30.
13. Minichello V, Sullivan G, Greenwood K, Axford R, editors. Research Methods For Nursing And Health Science, 2nd ed. Frenches Forest, NSW, Australia: Pearson Prentice Hall; 2004.
14. General Chiropractic Council (UK). Code of Practice. London: General Chiropractic Council; 2005.
15. Harger BL, Taylor JA, Haas M, Nyiendo J. Chiropractic radiologists: a survey of chiropractors' attitudes and patterns of use. J Manipulative Physiol Ther 1997 Jun;20(5):311-4.
16. American Chiropractic Board of Radiology. The American Chiropractic Board of Radiology Candidate Guide. 2007. Available from: URL: http://www.acbr.org/GuideNov2007-15th.pdf.
17. Doran T, Drever F, Whitehead M. Is there a north-south divide in social class inequalities in health in Great Britain? Cross sectional study using data from the 2001 census. BMJ 2004 May 1;328(7447): 1043-5.
18. Ballester F, Michelozzi P, & Iniguez C. Weather, climate and public health. J Epidemiol Community Health 2003 Oct;57(10):759-60.
19. Krolner B. Seasonal variation of lumbar spine bone mineral content in normal women. Calcif Tissue Int 1983;35(2):145-7.
20. ACR (American College of Radiology) codification. 2008. Available from http://www.intrad.ch/intrad/acr/?bolini_acr52780SelectedSIDPatho=77&bolini_acr52780SYS=4.
21. British Chiropractic Association. Radiation Protection in Chiropractic Radiography: Guidance Notes on the Ionising Radiations Regulations. Reading, England: British Chiropractic Association; 2000.
22. Yochum T, Rowe L. Essentials of Skeletal Radiology, 3rd ed. Baltimore: Lippincott Williams and Wilkins; 2005.
23. Greko PJ. Evaluation of quality of lateral full spine radiographs: A statistical study. J Manipulative Physiol Ther 1992 May;15(4):217-23.
24. Busche-McGregor M, Naimen J, and Grice AS. Analysis of the lumbar lordosis in an asymptomatic population of young adults. Journal of the Canadian Chiropractic Association. 1981;25(2):58-64.
25. Banks SD. The use of spinagraphic parameters in the differential diagnosis of lumbar facet and disc syndromes. J Manipulative Physiol Ther. 1983 Dec;6(4):175-80.
26. Ferguson AB. The clinical and roentgenographic interpretation of lumbosacral anomalies. Radiology 1934;22:548-58.
27. Cobb JR. (1948). Outline for the study of scoliosis. Am Acad Orthop Surg Lect. 5:261-266.
28. Wiltse LL, Winter RB. Terminology and measurement of spondylolisthesis. J Bone Joint Surg Am 1983 Jul;65(6):768-72.
29. Greenspan A, Steiner G, Knutzon R. Bone island (enostosis): Clinical significance and radiologic and pathologic correlations. Skeletal Radiol 1991;20(2):85-90.
30. Keats TE, Anderson MW. Atlas of Normal Roentgen Variants that may Simulate Disease, 7th ed. St. Louis (MO): Mosby; 2001.
31. Gokay H and Bucy PC. Osteochondroma of the lumbar spine. J Neurosurg 1955 Jan;12(1):72-8.
32. Resnick D. Diagnosis of Bone and Joint Disorders, 3rd ed. Philadelphia: W.B. Saunders Company; 1995.
33. Mochida J, Toh E, Chiba M, Nishimura K. Treatment of osteoporotic late collapse of a vertebral body of thoracic and lumbar spine. J Spinal Disord. 2001 Oct;14(5):393-8.
34. Denis F. Spinal stability as defined by the three column concept in acute spinal trauma. Clin Orthop Relat Res 1984 Oct;(189):65-76.
35. LaRoy LL, Cormier PJ, Matalon TA, Patel SK, Turner DA, Silver B. Imaging of abdominal aortic aneurysms. Am J Roentgenol 1989 Apr;152(4):785-92.
36. Sylvester PA, Stewart R, Ellis H. Tortuosity of the splenic artery. Clin Anat 1995;8(3):214-8.
37. Parliamentary Office of Science and Technology. Postnote: Data Protection and Medical Research. London: Parliamentary Office of Science and Technology; 2005. Available from: URL: http://www.parliament.uk/documents/upload/POSTpn235.pdf.
38. Chiropractors Registration Board (Australia). Examination for Registration as a Chiropractor in New South Wales. Information Booklet for Candidates. New South Wales, Australia: Chiropractors Registration Board; 2003.
39. National Academy of Sciences (US). Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, National Research Council. Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII – Phase 2. Washington (DC): National Academy of Sciences; 2006.
40. Royal College of Radiologists/National Radiological Protection Board. Patient dose reduction in diagnostic radiology. Documents of the NRPB 1990;1(3).
41. Scannell JP, McGill SM. Lumbar posture--should it, and can it, be modified? A study of passive tissue stiffness and lumbar position during activities of daily living. Phys Ther 2003 Oct;83(10):907-17.
42. Dunk NM, Chung YY, Comptom DS, Callaghan JP. The reliability of quantifying upright standing postures as a baseline diagnostic clinical tool. J Manipulative Physiol Ther 2004 Feb;27(2):91-6.
43. Gatterman MI. The patient-centred paradigm: a model for chiropractic health promotion and wellness. Chiropr J Aust 2006 Sep;36(3):92-96.
44. Pollard HP, Hardy KE, Curtin D. Biopsychosocial model of pain and its relevance to chiropractors. Chiropr J Aust. 2006 Sep:36(3):82-91.
45. Holtzman D, Burke J. 2007 Nutritional counseling in the chiropractic practice: a survey of New York practitioners. J Manipulative Physiol Ther 2008 Mar;31(3):237-46.
46. National Statistics (UK). 2006. Heart disease leading cause of death in England and Wales. Health Statistics Quarterly 30, Spring 2006. Available from: URL: http://www.statistics.gov.uk/pdfdir/hsq0506.pdf.
47. Ardran GM. Bone destruction not demonstrable by radiography. Br J Radiol 1951 Feb;24(278):107-9.
48. Jergas M, Uffmann M, Escher H, Gl¸er CC, Young KC, Grampp S, K˚ster O, Genant HK. Interobserver variation in the detection of osteopenia by radiography and comparison with dual x-ray absorptiometry (DXA) of the lumbar spine. Skeletal Radiol 1994 Apr;23(3):195-9.
49. Wagner S, St‰bler A, Sittek H, Bonel H, Laeverenz G, Reiser MF, Baur-Melnyk A. Diagnosis of osteoporosis: visual assessment on conventional versus digital radiographs. Osteoporos Int 2005 Dec;16(12): 1815-22.
50. Heiser S, Schartzman JJ. Variations in roentgen appearance of skeletal system in myeloma. Radiology 1952 Feb;58(2):178-91.
51. Forbes GS, McLeod RA, Hattery RR. Radiographic manifestations of bone metastasis from renal cell carcinoma. AJR Am J Roentgenol 1977 Jul;129(1):61-6.