CAN CHANGES ASSOCIATED WITH AGING HINDER THE IDENTIFICATION OF INDIVIDUALS SUBMITTED TO LUMBAR SPINE RADIOGRAPHY? A POTENTIAL CONTRIBUTION OF RADIOLOGY TO THE FORENSIC ACTIVITY*

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Abstract **OBJECTIVE: The present study was aimed at evaluating the possibility of a radiological study of the lumbar spine determining the correct identification of an individual despite the changes associated with aging. MATERIALS AND METHODS: The study sample included 60 pairs of lumbar spine radiographic images of both male and female, adult patients of different ages, acquired at different times, at three-year minimum intervals. The pairs of images were mixed up so two experienced radiologists could put them back together. The vertebrae of each pair were compared for similarities and differences in anatomical details. Pairing criteria adopted were finding a specific anatomical variation or detail, or finding two or more similarities among anatomical details, with no point of divergence. RESULTS: Correct pairing of radiographs of the whole sample was achieved by both observers, who presented countless coincidence points in their analyses. The statistical analysis demonstrated a good-to-perfect interobserver agreement. CONCLUSION: Comparison between radiographic images of lumbar spine can determine a correct identification of individuals, despite changes associated with aging. Therefore, radiography represents a potential tool to be utilized in forensic identification studies.**

Keywords: Radiographic comparison; Identification; Forensic anthropology.

Resumo *Alterações decorrentes do envelhecimento podem impedir a identificação de indivíduos submetidos a radiografias da coluna lombar? Potencial contribuição da avaliação radiológica para a atividade forense.*

OBJETIVO: O objetivo deste trabalho foi avaliar a possibilidade de o exame radiológico da coluna lombar determinar a identificação correta dos indivíduos, apesar das alterações evolutivas do envelhecimento. MATERIAIS E MÉTODOS: Foi constituída amostra com 60 pares de radiografias de coluna lombar, feitas em épocas distintas, com intervalo mínimo de três anos, de pacientes de ambos os sexos, adultos e com idades diversas. Os pares foram misturados para que dois experientes radiologistas os reconstituíssem. As vértebras de cada par foram comparadas em relação a semelhanças e diferenças de detalhes anatômicos, sendo estabelecido, como critério de pareamento, o encontro de uma variação anatômica ou de uma particularidade específica, ou o encontro de duas ou mais igualdades entre os detalhes anatômicos, sem pontos de divergência. RESULTADOS: O correto pareamento de todas as radiografias foi alcançado por ambos os observadores, os quais apresentaram inúmeros pontos de coincidência em suas análises. O estudo estatístico demonstrou que a concordância entre os dois observadores foi considerada de boa a perfeita. CONCLUSÃO: A comparação radiográfica da coluna lombar é capaz de determinar a correta identificação dos indivíduos, apesar das alterações evolutivas do envelhecimento. Dessa forma, as radiografias representam potencial instrumento para uso em perícias de identificação forense.

Unitermos: Comparação radiográfica; Identificação; Antropologia forense.

INTRODUCTION

The pioneering utilization of radiological resources to elucidate problems related to forensic identification dates back to 1927. Culbert & Law wrote an interesting article where they report a case of identification based on the comparison between nasal accessory sinuses and mastoid processes on preoperative radiographs and on radiographs of a deceased individual, where they could enumerate 20 coincidental items[1].

From that time on, the comparative analysis of *ante-* and *post-mortem* radiographs in association with studies of fingerprints and dental arcades, and currently with DNA study, started constituting the

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routine protocol in forensic identification studies[2].

A study performed in 2002 by American scientists identified the poor quality of images on *ante*- and *post-mortem* radiographs as the major limitation for the use of this method[3], but nevertheless such limitations usually do not use to affect the performance of experienced professionals, provided protocols are observed. Therefore, a methodology should be adopted in the process of forensic identification in order to facilitate the procedures: radiologists should classify the bone morphological features into categories such as typical morphological differences, anatomical variants, aging degenerative processes, traumatisms and congenital malformations[4].

The present study is aimed at evaluating the possibility of a radiological study of the lumbar spine determining the correct identification of an individual despite changes associated with aging, to demonstrate the potential role of lumbar spine radiography in the forensic activity.

MATERIALS AND METHODS

A survey aiming at finding adult patients with at least two radiographs of their lumbar spine was performed in the Radiological Archives of the Service of Radiodiagnosis at Hospital Universitário Clementino Fraga Filho. The inclusion criterion was patients with two radiographs of the lumbar spine acquired at three-year minimum interval, independently from the degree of degeneration observed or the presence of other osteoarticular diseases. Sixty pairs of studies performed at intervals ranging between three and thirty years (mean 4.8 years and median 4.0 years) were selected. The youngest patient was 20 years old, and the oldest, 88 years old (mean age 60.82 years and standard deviation, 16.14) (Tables 1 and 2).

Once the pairs of films had been selected, they had their register numbers hidden and were mixed up before being analyzed by two experienced radiologists. The comparative study included the analysis of morphological variations of vertebral bodies, spinous processes, transverse processes, pedicles and intervertebral spaces, degenerative aging processes, and also any particular findings that could be of help in the process of images pairing.

Table 1 Sampling for radiographic comparisons.

Interval between radiographs (years)	Men	Women
3	14	15
4	4	14
5	1	4
6	1	1
11	1	2
13	–	1
15	–	1
30	–	1
Total	21	39

Table 2 Distribution of men and women according their age range.

Age range	Men	Women
20–30 years	1	0
31–40 years	6	3
41–50 years	3	3
51–60 years	2	10
61–70 years	3	11
71–80 years	2	9
81 or more years	4	3
Total	21	39

The pairing criterion adopted was a single finding of an anatomical variant or specific detail, or the finding of two or more similarities among anatomical details, with no point of divergence

Besides being evaluated at the negatoscope, the radiographic images were photographed and submitted to an images processing software (Adobe Photoshop), to enhance or reduce their contrast and/or brightness, or for segmentation aiming at optimizing the comparison process.

RESULTS

Both observers could pair off all of the 60 studies. The process of putting the image pairs back together was developed through a careful observation of anatomical details. The first pairs of images were based on findings of anatomical variants or specific details — on the very spinal column or not — capable, by themselves, to allow the identification. The reading of the analyses performed by both observers demonstrated 20 coincidence points, with highlights on the following findings: "partial vertebra collapse", "spondylolysis", "bizarre transverse process", "very short transverse process", "elongated left transverse process", "upward transverse process", "transverse mega-apophysis" and "gross calcifications in the pelvic excavation – calcified myoma?".

The other anatomical details were considered as a whole for establishing a positive identification. Correct pairing of radiographs of the whole sample was achieved by both observers, who presented countless coincidence points in their analyses, and the statistical analysis demonstrated a good-to-perfect interobserver agreement (Table 3).

Signs of traumatisms and/or bone surgeries or congenital malformations, considered as a comparison criterion, have not been found among the radiographic images included in the sample.

Figure 1 shows a pair of images corresponding to the case with the longest interval between the two radiographs (30 years).

DISCUSSION

The 60 pairs of radiographic images were correctly identified by both observers, with a concordance index specifically calculated for each anatomical detail or pathological alteration analyzed. These indices ranged between 0.74 and 1.00, with the statistical analysis demonstrating a good-to-perfect interobserver agreement.

The observers' confidence to define the images pairing was due to the finding of similarly shaped anatomical details — investigated and evaluated separately or in conjunction — and the absence of discrepancies amongst images. Findings of either pathological alteration on the very spinal column, such as osteophytes and other evidences of arthrosis, or occasional abnormal findings, such as "gross calcification in the pelvic excavation – calcified myoma?", or atypical anatomical details, such as "upward transverse process", have allowed some pairings. Essentially, the perfect pairing was based on morphological parameters.

Table 3 Interobserver findings of anatomical variations or details considered abnormalities or similarities between both radiographic images.

Anatomical variations or details	Observer 1	Observer 2	Kappa concordance index*
Pedicles shape	*n* = 87	*n* = 63	0.80
Spinous process shape	*n* = 52	*n* = 40	0.85
Vertebral bodies shape	*n* = 51	*n* = 34	0.77
Transverse process shape	*n* = 45	*n* = 28	0.74
Osteophytes	*n* = 30	*n* = 30	1.00
Osteopenia	*n* = 29	*n* = 29	1.00
Manifest arthrosis	*n* = 25	*n* = 25	1.00
Posterior arches shape	*n* = 20	*n* = 20	1.00
Scoliosis	*n* = 15	*n* = 15	1.00
Other details	*n* = 32	*n* = 32	1.00

* Kappa standard error = 0,05; $p < 0.000$.

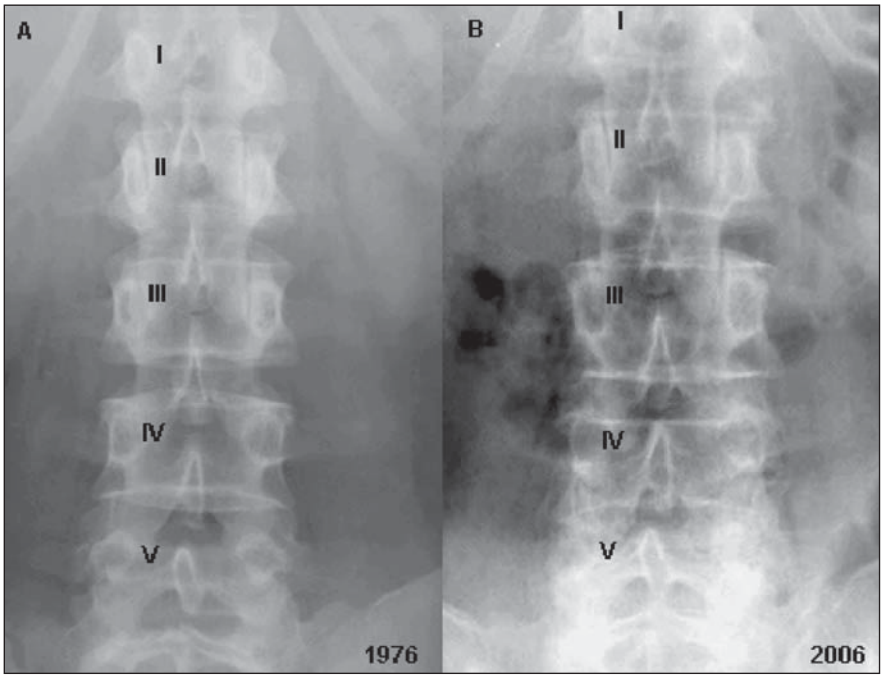

Figure 1. Woman at 50 years (**A**) and at 72 years of age (**B**). Note the similarity between spinous processes of the fourth and fifth lumbar vertebrae, and posterior arch of the first sacral vertebra

The large number of degenerative features found on the majority of radiographic images is attributed to the high age range of the patients included in the present study; however, osteopenia and osteophytes were pointed out as contributory factors in the pairing process. Manifest arthrosis does represent a relevant factor, as well as do alterations capable of considerably affecting anatomical patterns.

Some anthropologists have been insisting that the interval between *ante-* and *post-mortem* radiographies should be no longer than few years, in cases where such radiographic images are suggested as a support to human remains identification[5]. However, the results of the present study go against this idea: among the 60 cases included in the present study, six corresponded to individuals with intervals of more than tem years between studies. It is important to mention a case described in the literature where the *ante-mortem* radiograph had been acquired 13 years before the disappearance of an individual whose cadaver could be identified[6].

The trabecular pattern can be utilized in comparative studies[7], but only in cases where the images are concerned with studies performed in not very distant times, considering that the trabecular structure is susceptible to reabsorption, even in early stages of osteoporosis, particularly in women, and may lead to erroneous interpretation[4].

Reference to forensic authors demonstrates that anatomical details should be meticulously observed despite the absence of a mandatory minimum number of items to be compared for determining the identification of human remains. Usually, one to four coincidental characteristics and no discordance are considered as sufficient parameters[8].

Detailed anatomical structures with natural variations, especially the skull, lumbar-sacral column and chondrosternal joints, constitute the best elements for human remains identification[9]. However, not only these structures can be of help in comparative studies. The literature suggests the mastoid apophysis[10], sella turcica of the sphenoid bone[10], hand and wrist[11], and clavicle[12].

At global level, comparative analysis of *ante-* and *post-mortem* radiographs has represented a potential resource both in necroscopic studies of bone specimens and analyses of carbonized or putrefied cadavers, or even recent cadavers whose physiognomic lines individualization is still feasible[13].

It is evident that the major contribution of this method is associated with recent cadavers, considering that, nearly always in such cases, relatives show up to claim the cadaver

The procedure could be routinely adopted in forensic identification processes, and it is a responsibility of coroners providing the family relatives with guidance in the search of ante mortem radiographs of the deceased.

Considering that the comparison between radiographic images of lumbar spine can determine a correct identification of individuals, despite changes associated with aging, it may be concluded that radiography represents a potential tool to be utilized in forensic identification studies, comparable in utility to fingerprints and dental evidences.

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