

## Sesamoid bones in the ligamentum nuchae of man

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### INTRODUCTION

Radio-opaque formations in the soft tissues behind the spinous processes of the human cervical spine has been known to radiologists since Bársony's description in 1929.

They have been variously interpreted as calcareous bursitis (Bársony, 1929), calcinosis circumscripta ligamenti nuchae (Köhler, 1931; Shoen, 1935; Bársony & Winkler, 1936; Hadley, 1956), heterotopic development of the secondary nucleus of the spinous process of C6 (Fiandesio & Quaglia, 1955*a, b*) and myositis ossificans circumscripta (Yokokura, 1933; Thomson, 1934). The possibility that these entities could be sesamoid bones was discussed by Bársony & Winkler (1936), but histological confirmation was not obtained. Jutras (1938) histologically examined two nodules removed surgically, but he attributed a pathological significance to his findings, thinking them to be osteomas.

The purpose of this paper is to give data on the occurrence of these peculiar nodules in the neck of man (Pl. 1, figs. 1-7), and to eliminate the existing misconceptions, demonstrating that, on the anatomical grounds, they are true sesamoid bones.

### MATERIAL AND METHODS

The material consisted of 760 cervical spine radiographs examined at the Institute of Orthopaedic Surgery of Padua University, the Nuffield Orthopaedic Centre and the Accident Service of the Radcliffe Infirmary, Oxford. Many of the subjects radiographed in Padua were clinically examined. Lateral and antero-posterior views were always available. The opacities behind the cervical spinous processes were often difficult to demonstrate in the antero-posterior view, particularly in obese and short-necked patients; in three cases seen at Padua tomography was used to determine their exact location in the sagittal plane and their internal bony architecture.

Nuchal ligaments from fourteen subjects were collected post mortem in an attempt to localize the nodules both by gross and radiological examination. The attachments of the nuchal ligament to the spinous processes were preserved as reference points. Of these fourteen specimens, six subsequently underwent histological examination. Most of the sections were stained by haematoxylin and eosin, some with orcein, and others were viewed by polarized light.

## OBSERVATIONS

*(a) Clinical and radiographic findings*

A history of past trauma or local tenderness was absent in every case. Usually it was impossible to feel anything on palpation; but in rare cases one could appreciate a 'creaking' under the fingers.

All the patients were radiographed for clinical reasons, mostly for osteoarthritis of the spine, radiating pain in the upper arms or acute injuries involving the neck, and the presence of radio-opaque bodies in the posterior margin of the nuchal ligament was usually a chance discovery. No relation appeared to exist with any particular occupation.

These formations were not observed among the 65 radiographs of young people under consideration. The youngest with positive findings was a man aged 27. On addition of the Oxford material, the percentage occurrence in adults over 20 years of age changed a little from that previously published by myself (Scapinelli, 1960*a, b*). Nodules were seen 13 times in 368 adult women, and 37 times in 327 men, i.e. an incidence of 3.5 and 11.3% respectively.

These small bodies were mainly seen after the third decade of life, with a maximum frequency in the sixth decade. However, this is probably a reflexion of case selection in that patients of the older age-groups are subject more frequently to locomotor disorders of the cervical spine.

The ossicles were always found to lie at the posterior margin of the shadow of the nuchal ligament, at a variable distance from the apices of the spinous processes, most frequently at C5-C6 level (80% of cases) (Pl. 1, figs. 1-7). In a few instances the level was C3-C4 or C6-C7. Their situation in the mid-sagittal plane, visible in a good antero-posterior projection, was confirmed in three cases by tomography.

Their shape was very variable (Pl. 1, figs. 1-7), mostly ovoid or round, with regular contours, sometimes slightly concave on the anterior surface. The long axis was parallel to that of the cervical spine, but could change with movements. Sometimes they were very small and grain-like, at other times bigger (like a pea). Controls were done after several years in many cases; the majority of them showed no alteration; in a man 38 years old a small nodule became slightly bigger after 7 years, maintaining a rounded shape and regular contours; in two other men, 43 and 48 years old, slightly radio-opaque formations reached the usual osseous density in a period of three years.

Usually the nodule was single; in nine cases two nodules occurred, one overlying the other, with a small intervening space (Pl. 1, figs. 2, 7).

In relation to all anatomical developmental variations, racial differences are of interest. The sesamoid bone under discussion appeared in the X-rays of West African natives twice in forty cases examined by Cockshott (personal communication). The 'fabella genus', however, has been reported to be constant in the adult negro (Köhler, 1931).

*(b) Histology*

In two of the six specimens histologically studied (removed from cadavers aged 65 and 79), the previous X-ray control showed the presence of a small ovoid spongy

bone behind the spinous processes of C5 and C6 respectively, at a distance of 1.5 and 2 cm. from their tips (Pl. 2, fig. 8). The first measured 10 mm. in length and 4 mm. in the sagittal plane, the second 10 mm. by 5 mm. Dissection confirmed that both lay in the thick posterior margin of the ligamentum nuchae.

Histological sections (Pl. 2, figs. 9, 10) showed, in each case, an ossicle, firmly fixed at its periphery to the surrounding dense collagenous tissue. It consisted of trabeculae having lamellar structure. Between the trabeculae fatty marrow containing scattered blood vessels was found. Numerous Haversian systems were observed, chiefly at the periphery, their usual organization being confirmed by polarized light examination (Pl. 3, figs. 15, 16). At the junction of bone and the tendo-ligamentous tissue the structural changes seen at tendinous and ligamentous attachments were present (Pl. 2, figs. 11-14). Thus the cortical lamellae were outlined by a thin, irregular, continuous layer of strongly basophilic fibrocalcareous tissue, in which spheroidal cells lie singly, in pairs and often in small groups. Erosion of the fibrocalcareous layer by vascular connective tissue gave origin to new osteons (Pl. 2, fig. 12). The terminal bundles of the ligamentum nuchae and the regional tendons, before entering the calcified zone covering the bone, showed a clear fibrocartilaginous modification with turgid cells surrounded by a halo of ground substance and arranged singly or in short rows (Pl. 2, figs. 13, 14).

The other four cases here considered were chosen by chance from those in which radiographs were negative. In two of them histology showed the presence, at the posterior margin of the nuchal ligament, at C5-C6 level, of a delineated area in which differentiation towards fibrocartilage had occurred (Pl. 3, figs. 17-19). This fibrocartilaginous area was fusiform and about 1.5 cm. long in the former case (female, aged 47), round and about 0.7 cm. in diameter in the latter case (male, aged 62), with a smaller nucleus of the same structure in its proximity.

In neither osseous nor fibrocartilaginous nodules was any histological evidence of neoplasm or inflammation found.

#### DISCUSSION

On clinical, radiographical and histological grounds the nodules detectable in the ligamentum nuchae of man appear to be true sesamoid bones, similar to those commonly found in some tendons of the lower limbs (e.g. gastrocnemius, tibialis posterior and peroneus longus). To them the denomination of 'Ossicula sesamoidea ligamenti nuchae' could be given. In harmony with the characteristics of intra-tendinous sesamoids stated by Gillette (1872), Lunghetti (1909) and others, they are painless, inconstant and vary in shape and size. They are occasionally multiple, show a greater incidence in males and, as a consequence of their delayed ossification, become radiologically visible in adults.

The present findings strongly suggest that the genesis of these ossicles in the ligamentum nuchae is a slow, gradual osseous substitution of a calcified fibrocartilaginous tissue, from the centre towards the periphery. Such calcified fibrocartilage is preceded by a stage of simple fibrocartilage ('fibro-sesamoid'), arising from metaplastic modification of a localized area of the posterior margin of the nuchal ligament. Only in some subjects does calcification and subsequent ossification occur. The

existence of nodules of fibrocartilage in the posterior margin of the septum nuchae is strongly suggested also by the frequent presence in the radiograph of ovoid or round images of slightly differing density from that of the surrounding soft tissues.

As with other intratendinous sesamoids (Lunghetti, 1909; Toni, 1949; Barnett & Lewis, 1958) it is likely that, in their development, mechanical factors acting throughout life play a part, for they appear at the level of the cervical spine where mobility is greatest. In forward flexion of the neck (Pl. 1, fig. 7) the thick, less elastic posterior margin of the ligamentum nuchae is subjected to pressure against the apex of the spinous processes. The same ligament is also concomitantly stretched in forward flexion due to separation of its osseous attachments (pro-tuberantia occipitalis externa and seventh cervical spinous process).

#### SUMMARY

A radiological and anatomical investigation has been carried out on radio-opaque formations seen in the soft tissues behind the spinous processes of the cervical spine in man.

These nodules lie at the posterior margin of the nuchal ligament, usually at the level of the fifth and sixth cervical vertebrae, have variable size and shape, and are more frequent in males than in females after the third decade of life (11.3 and 3.5% respectively in the author's survey). Sometimes two occur near each other.

Post-mortem histology has shown that they are true sesamoid bones, similar to those commonly found in some tendons of the lower limbs. They are preceded by a metaplastic modification of a localized area of the nuchal ligament, which changes into fibrocartilage and in some subjects becomes calcified. Such calcified fibrocartilage is gradually and centrifugally replaced by Haversian bone.

The possible influence of mechanical factors in their formation is mentioned.

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## EXPLANATION OF PLATES

## PLATE 1

Figs. 1-5. Lateral radiographs of the cervical spine. Radio-opaque bodies differing in size, shape and number lie in the soft tissues behind the spinous processes of C5-C6. These were occasional findings in male patients aged respectively 64, 45, 49, 50 and 38. No history of past trauma or local tenderness was obtained.

Fig. 6. Cervical spine radiograph (lateral view) of a female patient 42 years old, showing the presence at the posterior margin of the ligamentum nuchae of a rather large radio-opaque formation, with a smaller one above its upper pole.

Fig. 7. Same subject as in fig. 6. The radiograph demonstrates the change in the position of the radio-opaque bodies in forward flexion of the neck.

## PLATE 2

Fig. 8. Radiographic appearance of an ossicle found at the posterior margin of the ligamentum nuchae at C5 level of a cadaver 65 years old. Note the presence, just behind the spinous process of C7, of a small area of ossification, probably of the same nature.

Figs. 9, 10. Histological sections of two nodules situated in the posterior margin of the ligamentum nuchae (post-mortem specimens from subjects respectively 65 and 79 years old), demonstrating their bony architecture. The trabeculae enclose fatty marrow and scattered blood vessels. Sagittal sections. Haematoxylin and eosin.  $\times 7$  and  $\times 10$  respectively.

Fig. 11. Upper pole of the nodule illustrated in fig. 10. A narrow and irregular layer of calcified fibrocartilage surrounds the cortex. Its presence, allowing bone formation, can explain irregularities of contours occurring in some of the older subjects. Haematoxylin and eosin.  $\times 72$ .

Fig. 12. Focal magnification of the area surrounding the cortex to show the formation of new Haversian systems in the site previously occupied by calcified fibrocartilage. These changes are

strictly analogous to those observed in the calcified layers of many cartilages and at the attachments of tendons and ligaments to bone. Haematoxylin and eosin.  $\times 180$ .

Figs. 13, 14. Cartilaginous cells, isolated or in groups, are shown near the attachment of the terminal bundles of the ligamentum nuchae and regional tendons to the periphery of the sesamoid. Haematoxylin and eosin.  $\times 180$  and  $320$  respectively.

#### PLATE 3

Figs. 15, 16. Unstained specimen from the periphery of the ossicle illustrated in fig. 10 (left) viewed by polarized light (right). The normal lamellar structure of the bone is confirmed by the appearance of typical Maltese crosses. Note the high birefringence of some of the collagen bundles of the ligament near their attachment.

Fig. 17. Post-mortem section of the posterior margin of the ligamentum nuchae at level C5-C6, from a subject (woman aged 47) devoid of any radio-opaque formation in her neck. It shows that in a localized fusiform area—a part of which is seen at the centre of the figure—the fibrous tissue has undergone metaplasia, with formation of fibrocartilage. It is known that the intra-tendinous sesamoids, contrary to the periarticular ones in the hand and foot, are chronologically preceded by a fibrocartilaginous model. Haematoxylin and eosin.  $\times 18$ .

Fig. 18. A similar nodule of fibrocartilage (arrowed), smaller than the previous one, in the posterior part of the ligamentum nuchae from a cadaver 62 years old, at the level of C5. The elastic fibres of this ligament correspond to the lower part of the field. Haematoxylin and eosin.  $\times 25$ .

Fig. 19. A high magnification of the central area shown in fig. 17, to demonstrate the cartilaginous nature of the cells lying in the dense fibrous tissue of the posterior margin of the septum nuchae, which is poorly furnished with elastic fibres. Haematoxylin and eosin.  $\times 615$ .







