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View from within — Radiology in Focus

Radio-opacity of fishbones

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Abstract
Bones are the largest group of foreign bodies found in the air and food passages. Fishbones which lodge in the tonsil can be easily seen and removed relatively easily. Those lodging in the pyriform fossa are well localized by the patient and can usually be seen on mirror examination.

It would be useful to know which types of fishbones are radio-opaque and therefore likely to be shown by radiographs when mirror examination is difficult or fails to reveal a foreign body. Therefore a study was undertaken to ascertain the radio-opacity of the bones of ten different species of fish eaten in the British Isles.

Introduction

Bones are the largest group of foreign bodies found in the air and food passages (Jackson, 1936; Norris, 1948; Hung and Lin, 1953; Zoller and Bowie, 1957). Chevalier Jackson (1948) noted that small spicules of bone lodge mostly in the lower pole of the tonsil, the tongue base, or in a vallecula; whereas larger bones lodge in the cervical oesophagus. Fishbones which lodge in the tonsil can be easily seen and removed relatively easily. Those lodging in the pyriform fossa are well localized by the patient and can usually be seen on mirror examination.

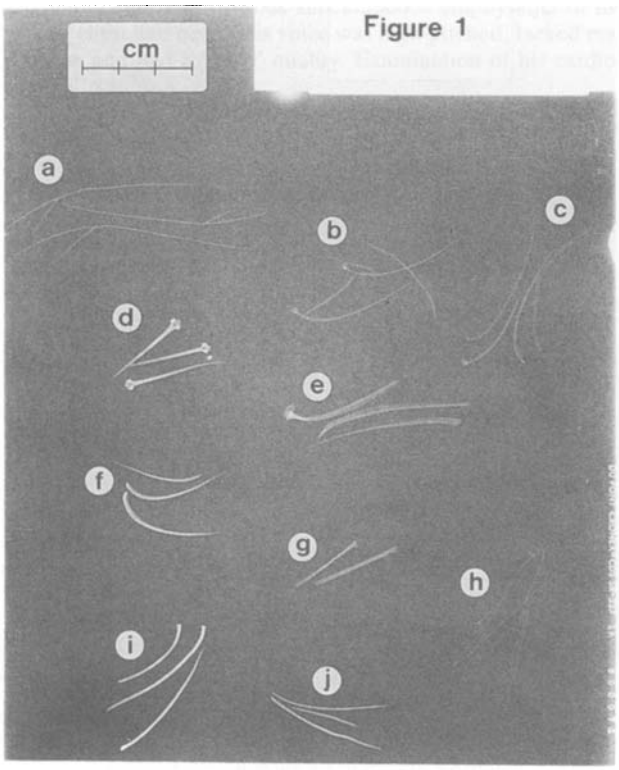


FIG. 1

Comparative X-ray of the different species of fishbone. Bones are: (a) pike, (b) trout, (c) mackerel, (d) gurnard, (e) salmon, (f) haddock, (g) plaice, (h) herring, (i) cod and (j) coley.

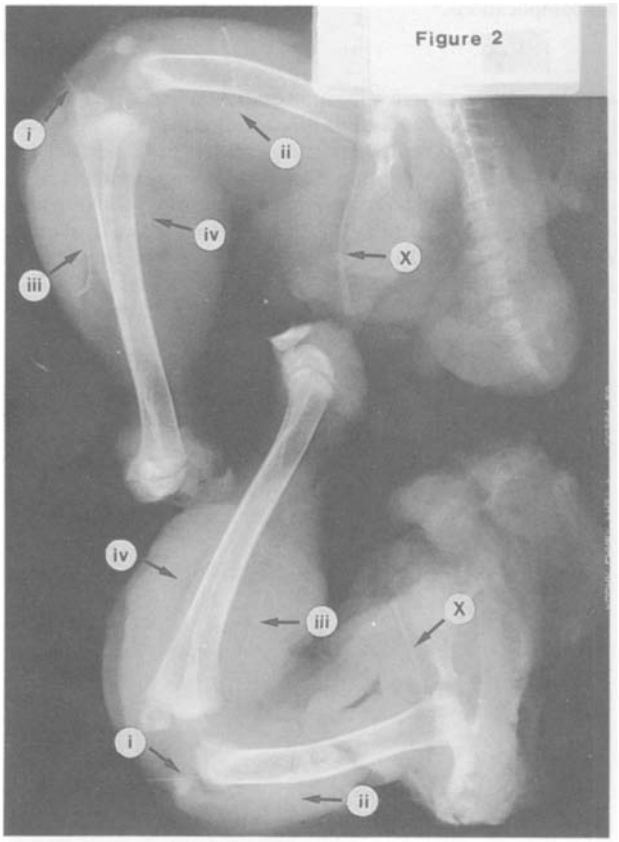


FIG. 2

X-ray visibility of haddock fishbones, seen above, and coley fishbones, seen below, at four different sites in chicken legs:-
(i) within the joint space with one end adjacent to the cartilage of the joint, the other projecting into the air at right angles to the X-ray beam:
(ii) within the flesh and lying across the chicken bone;
(iii) within the flesh and adjacent (parallel) to the bone of the chicken leg;
(iv) within the flesh of chicken leg away from the chicken bone.
An artefact due to a fold in the flesh of the chicken leg is shown by (X).

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TABLE I
X-RAY VISIBILITY OF BONES OF 10 SPECIES AT 4 DIFFERENT SITES WITHIN A SOFT TISSUE MASS

Species	Site (i)	(ii)	(iii)	(iv)
Cod	visible	visible	visible	visible
Salmon	visible	visible	visible	visible
Gurnard	visible	visible	visible	visible
Haddock	visible	visible	visible	visible
Coley (Saithe)	visible	visible	visible	visible
Plaice	visible	visible	visible	visible
Trout	visible	visible	visible	visible
Pike	visible	visible	visible	visible
Mackerel	not seen	not seen	not seen	not seen
Herring (kipper)	not seen	not seen	not seen	not seen

Key to sites:
(i) within the joint space, one end adjacent to the cartilage of the joint, the other projecting into the air right angles to the X-ray beam—
(ii) within the flesh and lying across the chicken bone;
(iii) within the flesh and adjacent (parallel) to the bone of the chicken leg;
(iv) within the flesh of the chicken leg away from the chicken bone.

Plain X-rays of the neck are said to be seldom helpful in the location of fishbones in the air and food passages (Maran and Stell, 1979). A recent study on the use of plain X-ray films in the diagnosis of foreign bodies with debatable radio-opacity in children showed that 55 per cent of 453 children could have been managed without the need for X-rays (Boothroid 1988). However, X-rays are often taken to locate a bone not visible on examination, and if seen, the bone can be removed by endoscopy.

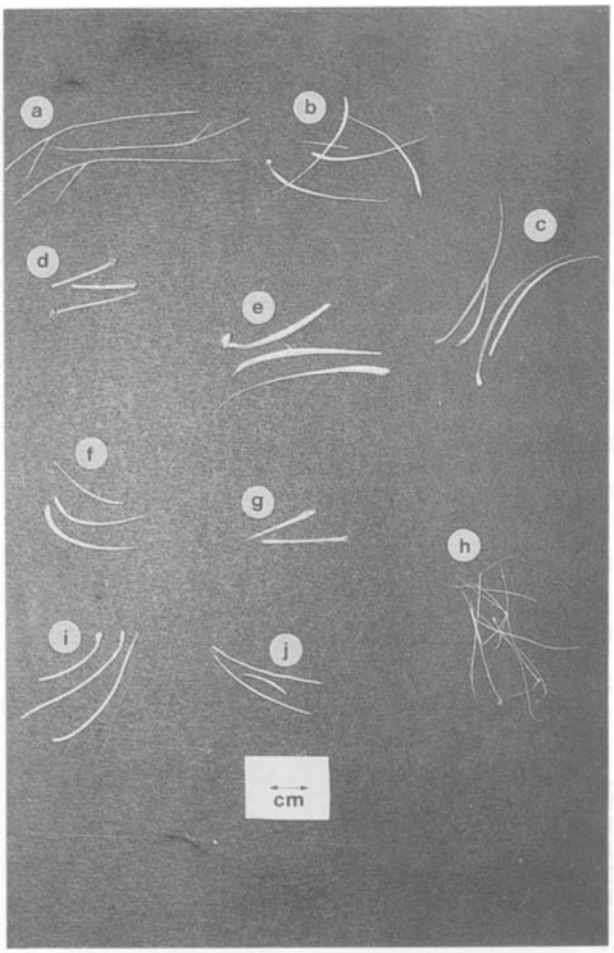


FIG. 3
Photograph of the fishbones orientated in the same way as in Fig. 1.

It would be useful to know which types of fishbone are radio-opaque and therefore likely to be localized on X-ray when mirror examination is difficult or fails to reveal a foreign body. A study was therefore undertaken to ascertain the radio-opacity of the bones of ten different species of fish eaten in the British Isles.

Materials and methods

Bones from ten different species of fish were used, nine from a fishmonger's shop and one (pike) from a fishing enthusiast.

The bones from the fishmonger were from prepared fillets of fish which were on display for sale to the public. The fillets were largely free of bones except for some ribs remaining in the proximal end of the fillet. These bones were removed from the fillet and cleaned of adherent flesh by boiling in water.

The clean fishbones were photographed, and were then X-rayed to compare the relative radio-opacities of the bones using an exposure of 2mA at 40 KV. A chicken leg was then used as a soft tissue mass in which the bones could be embedded. The bones were placed at the following four different sites in the uncooked chicken leg to compare their radio-density with soft tissue, bone, cartilage and air:

(i) Within the joint space with one end adjacent to the cartilage of the joint, the other projecting into the air at right angles to the X-ray beam;
(ii) within the flesh and lying across the chicken bone;
(iii) within the flesh and adjacent (parallel) to the bone of the chicken leg;
(iv) within the flesh of the chicken leg away from the chicken bone.

The chicken legs were then X-rayed using a standard tube made by Siemans Aktienggesellschaft, Bereich Medizinishe Technik—Erlangen. An exposure of 2.5 mA at 46 KV was used on standard 10x8 X-ray plates producing an exposure comparable to clinical soft tissue X-rays.

Results

A plate of the X-ray of the fishbones is shown in Figure 1. The fishbones show a decrease in the radio-opacity; cod and haddock were the most radio-opaque and mackerel and herring the least. A consultant radiologist checked the soft tissue X-rays to confirm the correct exposure and visibility of the fishbones at the various sites, an example is shown in Figure 2.

The bones from cod, haddock, coley (coalfish or saithe), gurnard, plaice and salmon were radio-opaque and could be easily seen in all positions in the chicken leg. Cod bones were the most easily seen. The bones from trout and pike were less radio-opaque but could still be seen in all positions. The bones from mackerel and herring could not be easily seen on the soft tissue X-rays, even though the exact position of the bone was known. The position of the bones was betrayed, not only by their radio-opacity, but by the line of their shadow extending across the differing densities of bone, cartilage and soft tissue of the chicken leg. The findings are summarized by the Table I.

Discussion

Many factors contribute to the density, and hence radio-opacity, of these fishbones; factors best illustrated by considering the nature of fish.

In the classification of fish, Osteichthyes (the Bony Fishes) are divided into Subclasses, one of which is Actinopterygii (Ray-finned fishes). This, in turn, contains: the Infraclass

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Chondrostei ('catilaginous bony fishes'), the Infraclass Holostei ('entirely bony fishes') and the Infraclass Teleostei ('final bony fishes'). These subgroups, which were described from living and often degenerate forms, imply an evolutionary trend of increasing ossification from cartilage to bone in the Actinopterygii. The fossil record, however, indicates the opposite is true, and this working classification remains unaltered (McFarland *et al.*, 1979).

The density of a fish's bones can be inferred from its functional design and habitat. Plaice is a bottom dwelling fish living in shallow waters; it has dense bones, allowing it to sink to the bottom. However it has no swim bladder, a modified lung which contains gas, which in turn allows the fish to change its specific gravity enabling it to maintain a certain depth in the water (Romer and Parsons 1986). The deep sea or bathypelagic fishes have greatly reduced ossification of the axial skeleton and tend to be smaller than the surface dwelling fish. This is related to the increased scarcity of food and the need to prevent sinking. Reduced size increases the relative surface area of a fish per unit of volume (or weight). This would in turn increase its friction and slow the rate of sinking. Also because bone is very dense (specific gravity about 2.0), its reduction in deep sea fishes decreases their overall density and rate of sinking. Surface dwelling, or epipelagic fishes, such as cod, show little bone reduction as they are active swimmers and their muscle requires a strong framework, that is the vertebral column, to be able to act efficiently (McFarland *et al.*, 1979). Such fishes often contain some oil, for example: cod liver oil, which aids bouyancy. The size of the surface dwelling fishes is also important. Small fish, such as pilchard and sardines, have bones which crumble after cooking, but it can be assumed that if a pilchard were ten times larger its bones would need to be stronger, and so more dense, and consequently more radio-opaque.

This does not explain the decreased density, and decreased radio-lucency, of the mackerel ribs. Mackerels have no swim bladder and have to swim continuously to maintain the flow of water over their gills (Alexander, 1967). To prevent sinking, a less dense skeleton would be advantageous, though this must be balanced against the then loss of skeletal strength. For comparison, a similar case exists in the shark *Lamna*, a member of the chondricthyes, which also has no swim bladder and needs to swim continuously to maintain the flow of water over its gills. The cartilaginous vertebral column of the shark is strengthened by calcified bars within the centre of the vertebrae (Romer and Parsons 1986). The vertebral column is necessarily strong, and therefore dense, for muscle attachment, allowing the cartilaginous ribs to economize on weight. This, in turn, may explain why the mackerel ribs are radio-lucent.

The cod bone looks white and dense, and is markedly radio-opaque, whereas mackerel and herring bones are transparent to the naked eye and are radio-lucent. The study indicates that mackerel and herring bones are more likely missed on X-ray than cod bones because they are less radio-opaque. It follows that because the mackerel bone is almost transparent to the naked eye it may also be more difficult to see at endoscopy.

Even though it has been shown that when bones from cod, haddock, coley, gurnard, plaice, salmon, trout and pike were X-rayed within a soft tissue mass they were radio-opaque, the location of a such bones in a soft tissue lateral neck X-ray is not a simple matter. The diagnosis of foreign bodies, especially of bones, is fraught with confusion as the vertical plate of the cricoid cartilage, which is the first to calcify, may be confused with a foreign body (Chamberlain and Young 1935; Richardson, 1955; Zoller and Bowie, 1957; Hately *et al.*, 1965). Further, Chamberlain and Young (1935) showed that ossification occurs in the hyaline cartilage portion of the larynx, including the thyroid and cricoid cartilages and a major portion of the arytenoids. They drew attention to the radiographic problem of mistaking an ossified laryngeal cartilage for a bony foreign body, especially isolated curvi-linear ossification located posteriorly in the cricoid cartilage. This was later illustrated by Richardson (1955) who reported a case in which a patient underwent two negative oesophagoscopies for a radiographically demonstrated calcific density that was felt by the consulting radiologist to indicate a foreign body. This density represented the normal linear ossification of the posterior border of the cricoid cartilage.

It is now known that laryngeal ossification is common not only in the older population but also in older teenagers. Hately *et al.*, (1965) found that 14 of 34 subjects between the ages of 15–20 years showed laryngeal calcification.

The above study raises questions as to the radio-opacity of fishbones from other species of fish less commonly consumed by the general public, but consumed by those who engage in the sport of fishing, or who have different cultural backgrounds with more exotic palates. It may be that bones from various sizes of the same species show differing radio-opacities, so that larger fish have bones which are more radio-opaque.

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