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COMPARATIVE RADIO-OPACITY OF BONES OF COMMONLY CONSUMED FISH SPECIES IN WESTERN KENYA REGION ON DIGITALISED LATERAL NECK X-RAY FILMS
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# COMPARATIVE RADIO-OPACITY OF BONES OF COMMONLY CONSUMED FISH SPECIES IN WESTERN KENYA REGION ON DIGITALISED LATERAL NECK X-RAY FILMS

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## ABSTRACT

***Objective*: To determine the comparative radio-opacity on digital plain radiographs of bones of 10 fish species commonly consumed in Western Kenya Region.**
***Design*: Descriptive cross sectional study.**
***Setting*: Jaramogi Oginga Teaching and Referral Hospital, Kisumu Kenya.**
***Results*: There was excellent interobserver agreement on the rating of 21out of 25 films evaluated. The overall sensitivity of plain radiographs in detection of raw and cooked fish bones was 72% and 69% respectively but varied significantly between fish species. The specificity of the technique was 100% overall.**
***Conclusion*: Lateral soft tissue neck radiograph is an appropriate screening tool in cases of a suspected impacted fishbone. If a fishbone is identified on a radiograph, the patient should be referred for endoscopy without further imaging. If the radiograph is normal, then there should be no further imaging or endoscopy. An observation policy can be adopted. Radiographs may be of limited value in cases of Butter fish (*Schilbe intermedius*) and Elephant snout fish (*Momuruscarnume*) bone impaction as these bones are radiolucent. In such cases, further imaging by CT scan or endoscopy without further imaging may be recommended when clinically indicated.**

## INTRODUCTION

Ingested foreign bodies are among the commonest ENT emergencies reviewed in the accident and emergency (A & E) department atJaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), Kisumu (1). Children usually swallow coins while at play but both children and adults may accidentally swallow fish bones during a meal. Lodging of fish bones in the upper aerodigestive tract and proximal cervical oesophagus is said to be a common occurrence in communities that consume fish (2, 3).

Most impacted fish bones can readily be identified and retrieved under direct vision. It is when impaction occurs at less visible sites, such as at the cricopharyngeus or cervical oesophagus that radiological investigation has a role to play (2). Failure to identify a lodged fish bone at radiography is disappointing to the health worker because the patient may subsequently undergo unnecessary, expensive and invasive procedures in search of a non-existent foreign body. On the other hand a patient with an impacted but undetected foreign body may turn-up with life threatening complications. This dilemma is made worse by the fact that fish bones are usually not present in the majority (79%) of patients who have sharp pain in the throat. The pain is attributed to mucosal abrasions caused by an already passed fish bone (3, 4, 5).

A lateral soft tissue neck radiograph remains the first line imaginginvestigation to aid localization of an impacted foreign body in the upper aerodigestive tract. Prompt localization of the impacted fish bone is importantas it allows for prompt intervention to avert potentially grave complications such as oesophageal perforation, retropharyngeal abscess formation, peri-oesophagitis, mediastinitis or vascular fistula formation (5,6,7,8) .The sensitivity of the lateral neck radiograph in identifying fish bones has been thought to be low. Quite often, indirect signs such as prevertebral soft tissue swelling are relied upon to indicate the possibility of a lodged fish bone (5, 8, 9, 10).

Past studies concluded that lateral radiographs of the neck were unhelpful in demonstrating impacted fish bones from a number of fish species due to their relative radiolucency. However, these studies were done using analogue radiography techniques which lacked the flexibilityof image manipulation (2, 3, 9). Later studies showed that digital radiography could identify fish bones from virtually all species (2, 3). Another study (3) reported a significant increase in sensitivity (79%) but showed variations in the visibility of different species. Subsequently, it has been proven that it is possible to adequately identify bones from different fish species using digitalised radiography (2, 6, 11). While it is clear that computed tomography (CT) is far superior to plain film radiography in both the detection and accurate localisation of a fish bone as well as the recognition of any complications (5,8), radiography was also found reliable in identifying patients who need intervention procedures such as esophagoscopy to retrieve impacted fish bones (3, 8,9). Given that most patients who present to the hospital do not usually have a lodged fish bone; radiography remain the first line imaging modality in clinically indicated cases due to cost effectiveness, easy availability/accessibility and simplicity.

## MATERIALS AND METHODS

*Study design and setting:* A cross-sectional survey was conducted in Kisumu County of Western Kenya between June and December 2015. Kisumu County, a cosmopolitan area, is located in Western Kenya in the former Nyanza province. The County borders the shores of Lake Victoria and majority of the populace consume fish of different species drawn from the lake. There are approximately 37 fish species in the region (12).

*Fish bone selection:* The bones of commonly consumed fish species (10 in number) in the western Kenya region Tilapia(Ngege),Nileperch(Mbuta),Cat fish (Mumi),Lung fish (Kamongo),Butter fish (Sire), Marbled victoria squeaker(Okoko), *LABEO victirianus* (Ningu), Nile tilapia(Nyamami), Elephant snout fish (Suma) andSemutandu (Sewu ) were selected for inclusion in this study based on a studies that showed that by mass, >90% of fish commonly available in markets are constituted by 10 fish species [12,13,14]. The fish weresourced from Jubilee fish market and Dunga beach in Kisumu town.

*Specimen preparationand bone placement:* Fish bones were extracted from raw and stewed fish using forceps and scapel. Whole fish was stewed for 25 minutes in plain water.

A goat neck was used as a soft tissue modelbased on its circumference, (34 cm) which is comparable to that of an adult male human neck (3). Our specimen was sourced locally from a Kisumu Abattoir. Other cadaveric studies have used a sheep, swineand a human cadaver model (2, 3, 9). Bones from cooked and raw fillet from each species were subsequentlyinserted endoscopically in the hypopharynx. (Figure 1)

*Radiography*: Twenty five Digital radiographs of implanted raw fish bones (10), cooked fish bones (10) and controls without fish bones (5) were taken usingEcoRay X-ray machine serial no: COL-1410401 manufactured in October 2014by EcoRay company limited- South Korea. We employed exposure factors of KV80 and 4.0 mAs the standard exposure factor for lateral neck soft tissue radiography in the radiology department at Jaramogi Oginga Odinga teaching and referral hospital (JOOTRH).

Five copies of each the 25 radiographs (a total of 125 films) were printed on films.

*X-ray film reading:* Five radiologists who were blinded to the identity of the films were sent copies of each of the films and asked to separately review each radiograph. The radiologists were asked to rate the bones in each of the lateral neck radiographas either'visible' or 'not visible'.

*Statistical analysis:* For each and all fish species, Sensitivity was described as the proportion of observers who could identify a fish bone on a radiograph in which fish bones were impacted. Specificity was described as the proportion of observers who did not identify a fish bone in radiographs where fish bones were not impacted(16). 95% CI of sensitivities and specificities were also computed as follows:

$$\hat{p} \pm z^{*}\left(\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}\right)$$

where $\hat{p}$ is the sample proportion and $\hat{z}$ is the 95% variate from the normal deviate and n is the sample size (25).

Chi square statistics (exact chi-square) were used to compare the differences in sensitivities of digital radiographs in identifying impacted bones from different fish species.

The test for agreement in observation of presence/absence of bones in fish species among the rates was computed using the *modified Kappa* coefficient ($k^*$) method by Polit *et al.* The method utilises the probability of chance agreement, denoted as $P_c$ and computed as a binomial random variable; and the proportion of agreement by relevance i.e., the species-level content validity index (CVI). The species-level CVI was computed as the proportion of number of raters agreeing on good relevance among all the raters. The probability of chance agreement is computed as,

$$P_c = \left[\frac{N}{A!(N-A)!}\right] 0.5^N$$

Where N= number of raters and A=number agreeing on relevance.
The Kappa coefficient is then computed as,

$$K^* = \frac{\text{Proportion agreement on relevance (CVI) - proportion chance agreement (PC)}}{\text{1 - Proportion chance agreement (PC)}}$$

The CVI for computation of the overall Kappa coefficient was computed as a proportion of the sum of all the raters agreeing on relevance in all the fish species divided by the number of all the raters for all the fish species.

Guidelines described in Cicchetti and Sparrow (1981) and Fleiss (1981), were used to evaluate for strength of agreement for the kappa co-efficient for all the 25 films: 0.4-0.59=fair agreement, .60–.74=good agreement, > .74=excellent.

## RESULTS

*Fish species:* The most common fish species consumed in Western Kenya are shown in Table 1.
*Sensitivities of digital radiographs in detection of raw and cooked fish bones:* The overall sensitivity of digital radiographs detection of raw and cooked fish bones was 72% and 69% and the overall specificity was 100%. The highest sensitivities were observed with the Nile Tilapia (*Oreochromisniloticus*), Lung fish (*Protopterusaethiopicus*), Cat fish (*Clariusgariapinus*), Ningu(*Labeovictirianus*), which all had sensitivities of 100% for both raw and cooked fish bones while the lowest were observed with the Butter fish (*Schilbe intermedius*) which has sensitivities of 20% and 0% respectively. Very low sensitivity(0%) was also recorded for cooked bones of the Elephant Snout fish (*MomurusCarnume*). There was no overlap in the 95% confidence intervals for the sensitivities of both cooked and raw fish. A significant difference between fish species in the sensitivity of bone detection by different observers was observed for both raw and cooked fish (exact $\chi^2$= <0.001, critical value=38.095, *df*=9; p <0.001 and exact $\chi^2$=<0.001, critical value=33.935, *df*=9; p<0.001 respectively).

*Inter-rater reliability:* The exact Fleiss' Kappa, between the five observers on presence or absence of fish bones in 25 films of 10 species of cooked fish, 10 species of raw fish and 5 control X-rays of the cadaveric model was k=0.89. There was excellent agreement on the rating of 23 of the films (including 3 films that had fish bones which were not visualised by all the five experts and 2 films that had bones that were not visualised by four of five experts [k=0.76 and k=1]) and good agreement on 2 of the films [k=0.41](Table 2).

**Table 1**
*Proportion of observers who identified a bone was present (sensitivity) for each type of fish, and population estimates for these proportions, Western Kenya, 2015*

| Fish species Local Name | Common Name | Zoological Name | n/N | Raw Sensitivity (95% CI) | n/N | Cooked Sensitivity (95% CI) |
|---|---|---|---|---|---|---|
| Sire | Butter fish | Schilbeintermidias | 1/5 | 0.20 (-0.58;0.88) | 0/5 | 0.00 (-.088;0.88) |
| Suma | Elephant snout fish | Momuruscarnume | 4/5 | 0.80 (0.41-1.19) | 0/5 | 0.00 (-.088;0.88) |
| Okoko | Marbled victoria squeaker | Synodontisvictoriae | 0/5 | 0.00 (-.088;0.88) | 3/5 | 0.60 (0.05-1.15) |
| Mbuta | Nile perch | Latesniloticus | 5/5 | 1.00 (1.00-1.00) | 3/5 | 0.60 (0.05-1.15) |
| Ngege | Tilapia mario | Oreochromisesculentus | 5/5 | 1.00 (1.00-1.00) | 4/5 | 0.80 (0.41-1.19) |
| Nyamami | Nile tilapia | Oreochromisniloticus | 5/5 | 1.00 (1.00-1.00) | 5/5 | 1.00 (1.00-1.00) |
| Ningu | Ningu | Labeovictirianus | 1/5 | 0.20 (-0.58;0.88) | 5/5 | 1.00 (1.00-1.00) |
| Mumi | Cat fish | *Clariasgariapinus* | 5/5 | 1.00 (1.00-1.00) | 5/5 | 1.00 (1.00-1.00) |
| Sewu | Semutandu | *Bagrusdockmac* | 5/5 | 1.00 (1.00-1.00) | 5/5 | 1.00 (1.00-1.00) |
| Kamongo | Lung fish | *Protopterusaethiopicus* | 5/5 | 1.00 (1.00-1.00) | 4/4 | 1.00 (1.00-1.00) |
| Overall sensitivity | | | 36/50 | 0.72 (0.57-0.87) | 34/49 | 0.69 (0.53-0.83) |
| Overall specificity | | | 25/25 | 1.00 (1.00-1.00) | | |

**Table 2**
*Evaluations of I-CVIs by different radiologists and agreement*

| Species | R1 | R2 | R3 | R4 | R5 | No. of Experts in Agreement | I_CVI | Probability | Kappa# | Evaluation* |
|---|---|---|---|---|---|---|---|---|---|---|
| Control film‡ | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Control film‡ | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Control film‡ | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Sire cooked ¶ | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Okoko raw¶ | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Suma cooked ¶ | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Control film‡ | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Sire raw¥ | 0 | 1 | 0 | 0 | 0 | 4 | 0.8 | 0.15625 | 0.762963 | Excellent agreement |
| Ningu raw¥ | 0 | 1 | 0 | 0 | 0 | 4 | 0.8 | 0.15625 | 0.762963 | Excellent agreement |
| Okoko cooked | 0 | 1 | 1 | 0 | 1 | 3 | 0.6 | 0.3125 | 0.418182 | Good agreement |
| Mbuta cooked | 1 | 1 | 0 | 0 | 1 | 3 | 0.6 | 0.3125 | 0.418182 | Good agreement |
| Ngege cooked | 1 | 1 | 1 | 0 | 1 | 4 | 0.8 | 0.15625 | 0.762963 | Excellent agreement |
| Suma raw | 0 | 1 | 1 | 1 | 1 | 4 | 0.8 | 0.15625 | 0.762963 | Excellent agreement |
| Mbuta raw | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Nyamami raw | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Ngege raw | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Sewu raw | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Nyamami cooked | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Kamongo raw | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Mumi raw | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Ningu cooked | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Mumi cooked | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Sewu cooked | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 0.03125 | 1 | Excellent agreement |
| Kamongo cooked | 1 | 1 | . | 1 | 1 | 4 | 0.8 | 0.15625 | 0.762963 | Excellent agreement |
| Overall | | | | | | 110 | 0.892 | 1.61E-21 | 0.892308 | Excellent agreement |

[#]ck*¼kappa designating agreement on relevance: k*¼(I-CVIpc)/(1pc).

*Evaluation criteria for kappa, using modified guidelines described in Cicchetti and Sparrow (1981) and Fleiss (1981) have proposed the following as standards for strength of agreement for the kappa coefficient: <0.4=poor agreement, 0.4-0.59=fair agreement, .60–.74=good agreement, > .74=excellent agreement

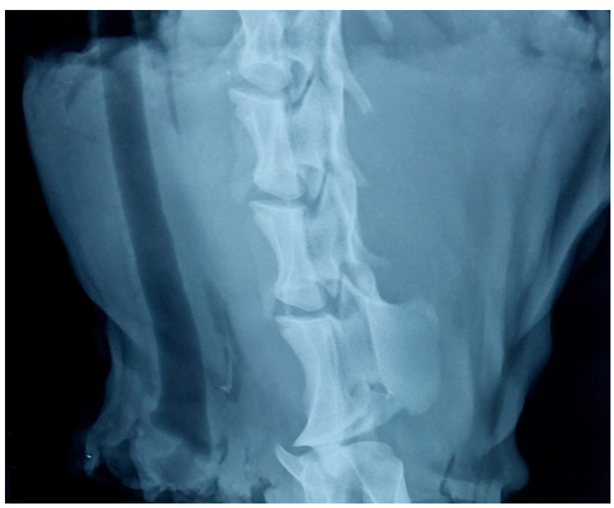
[‡]The cadaveric models x-rayed had no fish bones

[¶] although all the experts did not visualize fish bones on the films, there were fish bones within the cadaveric model

[¥]four experts were in agreement that there were no fishbones visualized in the films although fish bones were present and visualized by one expert

**Figure 1**
*Endoscopic fish bone placement*

**Figure 2**
*Lateral radiograph of the model*



## DISCUSSION

This study was set to determine the comparative radio-opacity on digital plain radiographs of bones of 10 fish species commonly consumed in Western Kenya. Although there are about 37 known species of fish in Western Kenya, the 10 commonest species account for >90% of these fish by weight (12) and can be assumed to be representative of the species consumed in the region. In this study a goat neck specimen was used to simulate a human neck. The neck of the specimen was comparable in circumference to that of the human neck, and the X-ray exposures used were the same as for an equivalently proportioned human. The bones were placed endoscopically whereas in previous studies neck dissection and direct bone placement was done [2,3,6].

As already observed, imaging is only required in cases where impacted fish bones cannot be detected directly during physical examination of the oropharynx, hypopharynx or larynx [4,19].

The sensitivity of radiographs reported in this study [69.3%] is comparable to that found by William Davies *et al*, (79%, using Bovine soft tissue model equivalent to a human neck) and Akazawa *et al* ( 64%*, in a clinical set up). Earlier studies had recorded much lower sensitivities [(Evans *et al* (25.3%), Sundgren et al (28.6%), Ngan et al(32%), Lue AJ *et al* (39%)] probably because they used analogue radiographic systems which were not amenable to image manipulation (3,20,21,22,23).

Our findings concur with other literature which showed that the sensitivity of radiographs in the detection of lodged fish bones greatly varies across the different species of fish. The bones of some species are radio-dense and clearly visible, others are barely visible while a few are completely radiolucent and hence not visible on radiographs (3,6). However, most if not all of these studies were done using salt water fish bones.

In the clinical situation it is, of course, helpful if the patient and or guardian knows what sort of fish has been eaten. It is also important that the patient management team be conversant with the commonly consumed fish species in their region as well as the radio-opacity of the fish bones to avoid unnecessary exposure to radiation or undue delay in decision making. Our findings show that the fish species with radiolucent bones are Butter fish (*Schilbe intermedius/ Sire*) and Elephant snout fish (*Momuruscarnume/ Suma*). In these two species, radiography is of limited value and therefore neck CT scan and/ or esophagoscopy should be recommended on clinical grounds. Radiography is indicated for the rest of the eight fish species since their bones are radio-opaque. In these cases, if the radiograph is normal, then there should be no further imaging or endoscopy. An observation policy can be adopted. If a bone is seen it should then be removed by endoscopy.

The high specificity (100%) of lateral neck radiographs in identifying impacted fish bones is comparable to that reported by Dushyant et al who used a standardised soft tissue phantom and digital radiographic technique. Even earlier studies that showed poor sensitivity still showed a higher specificity of radiographs in bone detection (20, 21, 23, 24).This implies that when fish bones are not visualized, it is unlikely that there is an impaction and the symptoms may be attributed to residual soft tissue injury. Caution should however be exercised when dealing with specific species (*Schilbe intermedius*/Sire and *Momuru*s*carnume* /Suma) where the sensitivity was zero (i.e all observers did not see any fish bones) and inter-rater agreement was high. This further supports the point on knowledge of common fish species.

Previous studies found that stewing fish did not affect visibility of fish bones (2,3).In our study however, there was a marginal decrease in the visibility/radio-opacity of bones when cooked, except for *Synodontisvictoriae* (Okoko) and *Labeo* v*ictirianus* (Ningu) where cooking increased the visibility. The bones of these two species are tiny and fragile. Cooking probably lead to fluid absorption by the bones thereby increasing their sizes to a critical level that render them visible at radiography.

Earlier studies show that only a small proportion of patients who undergo endoscopy actually have lodged bones (22), therefore radiography is still useful in identification and triage of patients for the next course of management.

We are confident that 95% of the times the sample proportion will lie between the upper and the lower confidence limit. Lower and upper limits of the confidence interval may be less than one or more than one respectively when the sample size is small ( like on our analyses where the sample size for individual fish species was 5) to get robust estimates. This is further evidenced when computing sensitivities for all fish species (25).

In conclusion, our study show that lateral soft tissue radiograph is an appropriate screening tool in cases of a suspected impacted fishbone. If a fishbone is identified on a radiograph, the patient should be referred for endoscopy without further imaging. If the radiograph is normal, then there should be no further imaging or endoscopy. An observation policy can be adopted. Radiographs are of limited value in cases of Butter fish (*Schilbe intermedius*) and Elephant snout fish (*Momuruscarnume*) bone impaction as these bones are radiolucent. In such cases, further imaging by CT scan or endoscopy without further imaging may be recommended on clinical grounds.

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