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CASE REPORT

Skeletal fluorosis due to excessive tea and toothpaste consumption

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Abstract We describe the case of a 53-year-old woman who presented with a metatarsal fracture and was found to have a bone mineral density (BMD) T-score of +11 in the lumbar spine and +7.6 in the hip. Subsequent investigation revealed very high serum, urine and tissue fluoride levels, associated with excessive tea and toothpaste consumption. The case emphasises the need to exclude fluorosis in individuals with unexpectedly high BMD levels.

Keyword Fluorosis

Introduction

Skeletal fluorosis is caused by chronic, excessive exposure to fluoride through ingestion or inhalation and most commonly occurs as a result of high fluoride levels in drinking water or industrial exposure from fumes or dust [1, 2]. Other potential sources of significant exposure include some forms of tea and wines, fluoride supplements and fluoridated toothpaste or mouthwashes. It is endemic in parts of the world, notably India, Africa and China [3–7] and is characterised by axial osteosclerosis, joint pain, ligamentous ossification and fractures. In advanced cases, the morbidity is high with reduced mobility of the spine, kyphosis and severe pain. The onset is usually gradual and following withdrawal of exposure to fluoride, symptomatic and radiographic improvement over a period of years has been reported [8, 9].

Although worldwide, millions of people are affected by skeletal fluorosis, it is very uncommon in parts of the world such as Europe and North America. In cases that have been reported, excessive consumption of fluoride-containing tea or wine, fluoride-containing mineral water or fluoridated toothpaste has been described [8, 10–14]. We report a woman whose major sources of fluoride exposure were tea and excessive use of fluoridated toothpaste.

History

A 58-year-old woman presented in December 2005 with a fracture of the left third metatarsal having sustained a fall whilst walking her dog. Past medical history included mild cerebral palsy from birth leading to mild right-sided weakness, right club foot, amputation of all her toes in the right foot due to deformities in 1993, and reflux oesophagitis. She was not taking any bone active medications.

Clinical examination

The patient walked with a stick due to her deformities. Examination of the spine was normal. She had poor dentition with severe dental caries but no dental mottling.

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Investigations

Bone densitometry

Bone mineral density measured by dual energy X-ray absorptiometry in April 2006 revealed a T score of +11 in the lumbar spine and +7.6 in the total hip. These values had increased markedly since 1999, when she had undergone bone densitometry as a volunteer for a population-based study. Subsequent measurements in 2007 and 2008 showed smaller increases (Table 1).

Radiology

Plain radiographs showed marked osteosclerosis of the spine and pelvis. There was bilateral ossification of the sacrospinous ligament and of the anterior and posterior longitudinal ligaments at some locations in the spine. The skull and mandible were spared (Fig. 1). X-rays of the feet showed a stress fracture with florid callus formation involving the neck of the third metatarsal.

Biochemistry

Laboratory investigations revealed normal serum levels of calcium, inorganic phosphate, parathyroid hormone, 25-hydroxyvitamin D, alkaline phosphatase and tryptase. Serum protein electrophoresis, full blood count and erythrocyte sedimentation rate were normal. Serum total creatine kinase (CK) and isoenzymes, including CK-BB, were normal.

Fluoride analyses, including appropriate standards, were done using the ion-specific electrode. Water and urine were analysed using the "direct method", which requires only the addition of a buffer to the standards and samples. Brewed tea, serum, fingernail clippings, bone ash and toothpaste were analysed in triplicate after overnight HMDS- facilitated diffusion [6, 15].

Serum fluoride was first measured on May 8, 2008 and was significantly elevated at 839 μg/l (normal 10–50 μg/l). Urinary fluoride excretion was also increased at 16.9 mg/24 h (normal <1.64 mg/24 h). Fluoride renal clearance was 23 ml/min (normal 30–40 ml/min). Fluoride content in her fingernails was elevated at 9.14 mg/kg (control subject 2.39 mg/kg). Subsequent measurements showed serum fluoride levels of 881 (18/9/08), 1,200 (21/7/09) and 1,120 μg/l (27/7/10).

Analysis of an iliac crest biopsy performed by an orthopaedic surgeon at the beginning of 2008 showed markedly sclerotic bone. The bone was described as compact and mixed lamellar/woven in nature. The biopsy was inadequate for histomorphometric analysis and the patient refused to undergo further bone biopsy. The fluoride content in the bone sample was greatly elevated at 15,144 mg/kg bone ash (normal 700–1,500 mg/kg).

Table 1 Bone mineral density T-scores

Date	Lumbar spine	Total hip	Radius
Jan 1999	4.3	5.6	Not assessed
April 2006	11	7.6	−2.3
July 2007	11.6	8.5	Not assessed
Aug 2008	12	8.7	−1.8
Nov 2009	13.1	9.4	Not assessed

Estimation of fluoride exposure

Analysis of her brewed tea revealed a total fluoride content of 7.6 mg/L. The patient had consumed six 8-ounce (240 ml) cups of standard breakfast tea daily, which would have provided 10.9 mg of fluoride/day, for the last 5–10 years. She denied drinking wine. She had lived in the same house for 40 years and used tap water for drinking. Analysis of the tap water showed a fluoride level of 0.3 ppm. There was no history of exposure to mining, welding or any other industrial source of fluoride.

When initially questioned about her use of toothpaste, the patient admitted to brushing her teeth three times a day and to using one large tube of toothpaste (100 g) each week. In January 2010, we analysed her toothpaste and found a fluoride content of 1,691 mg/kg, similar to the fluoride content of other fluoridated toothpastes.

In subsequent discussions, the patient admitted to brushing her teeth eight to ten times per day for the last 30 years. She had suffered from dental caries since childhood and this led to a strong fear of dental problems and obsessive brushing habits to prevent any further dental caries. Although she denied swallowing toothpaste, it is not uncommon to swallow about 25% of the toothpaste applied to the brush. If she covered the bristles with toothpaste (~1.0 g), brushed ten times daily and swallowed 25%, the daily fluoride dose would have been 4.2 mg. Daily fluoride intake from tea and toothpaste would have been 15.1 mg. Another 2–3 mg from dietary sources would have provided a chronic daily dose of 17–18 mg, an amount sufficient to cause the skeletal changes described above.

Discussion

Fluoride is rapidly absorbed from the gastrointestinal tract, following which around 50% becomes incorporated into bone mainly as hydroxyfluorapatite and the remain-

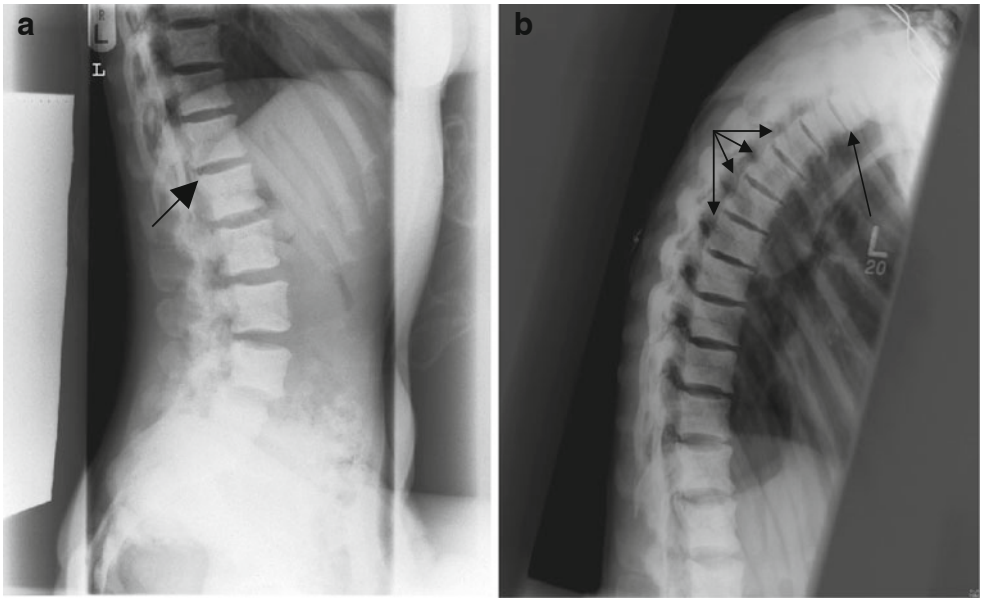

Fig. 1 Lateral radiograph of the lumbosacral spine **a** and thoracic spine **b** showing ossification of the anterior and posterior spinous intervertebral ligaments (*arrows*)

ing 50% is excreted in the urine [16, 17]. Although fluoride stimulates osteoblastic proliferation and increases bone formation, the bone formed may be abnormal and inferior in quality [18–20]. Once in the skeleton, fluoride has a long half-life of around 7 years.

In many reported cases of fluorosis, joint pains and fracture have been prominent symptoms. Our patient presented with a fragility fracture affecting the appendicular skeleton but to date she has not suffered fractures in the osteosclerotic axial skeleton or had joint pains or stiffness. The cause of her fluorosis was difficult to establish, as initially she denied exposure to all known sources of high fluoride intake. Industrial exposure, tap water and wine were excluded but she drank significant amounts of tea. In addition, excessive use of toothpaste was suspected and she later admitted to this. A similar case was reported by Roos et al. [12] of a woman who brushed her teeth 18 times daily, consuming a large tube of toothpaste once every 2 days and swallowing the toothpaste. Kurland et al. [8] also recently described a man with fluorosis in whom excessive toothpaste use was believed to be the cause, although the patient never admitted to this.

Even though our patient did not have symptoms attributable to fluorosis, advice to change her dental regimen and drink less tea seemed appropriate in view of the known skeletal complications of the condition. The case reported by Kurland et al [8] demonstrated that a long time period is required for serum and urine fluoride levels to return to normal; although in the first 2 years of recovery, bone mineral density decreased rapidly; thereafter, it declined at a slower rate and was still markedly elevated after 9 years. Kurland et al. also observed that withdrawal of the source of fluoride was associated with an increase in urinary calcium resulting in nephrocalcinosis and an increase (within the normal range) of serum creatinine [8]. This was associated with increases in biochemical markers of bone turnover and was therefore presumably due to increased bone resorption, although the trigger for this after fluoride withdrawal is unclear.

A striking feature of our case was the very high serum, urine, nail and bone fluoride levels, to our knowledge the highest ever reported in a patient with fluorosis. These high levels were associated with a rapid increase in lumbar spine T-score, from +4.5 to +11 in a period of just over 7 years. Interestingly, her serum alkaline phosphatase level was normal at multiple time points, whereas elevated serum alkaline phosphatase levels have often been reported in other patients with skeletal fluorosis. A possible explanation for this may be the normal vitamin D status in our patient; osteomalacia has been described in other cases, particularly in association with vitamin D deficiency.

High bone mineral density is not an uncommon finding in patients undergoing screening for osteoporosis following a fracture or identification of risk factors for fracture. This case report emphasises the need to consider fluorosis as a possible diagnosis in such individuals. In pursuing this diagnosis, urinary, serum and nail fluoride concentrations are good indicators of current and prior fluoride exposure. Bone is the "gold standard" but biopsies are often not available.

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Conflicts of interest None.

References

1. Public Health Service, Department of Health and Human Services. Review of fluoride: benefits and risks. Report of the Ad Hoc Subcommittee on fluoride of the Committee to Coordinate Environmental Health and Related Programs. US Department of Health and Human Services, Washington DC, USA 1991.
2. Krishnamachari KA (1986) Skeletal fluorosis in humans: a review of recent progress in the understanding of the disease. Prog Food Nutr Sci 10:279–314
3. Malde MK, Zerihun L, Julshamn K, Bjorvatn K (2003) Fluoride intake in children living in a high-fluoride area in Ethiopia—intake through beverages. Int J Paediatr Dent 13:27–34
4. Choubisa SL, Choubisa L, Choubisa DK (2001) Endemic fluorosis in Rajasthan. Indian J Environ Health 43:177–189
5. Yang L, Peterson PJ, Williams WP, Wang W, Li R, Tan J (2003) Developing environmental health indicators as policy tools for endemic fluorosis management in the People's Republic of China. Environ Geochem Health 25:281–295
6. Harinarayan CV, Kochupillai N, Madhu SV, Gupta N, Meunier PJ (2006) Fluorotoxic metabolic bone disease: an osteo-renal syndrome caused by excessive fluoride ingestion in the tropics. Bone 39:907–914
7. Yildiz M, Akdogan M, Tamer N, Oral B (2003) Bone mineral density of the spine and femur in early postmenopausal Turkish women with endemic skeletal fluorosis. Calcif Tissue Int 72:689–693
8. Kurland ES, Schulman RC, Zerwekh JE, Reinus WR, Dempster DD, Whyte MP (2007) Case report. Recovery from skeletal fluorosis (an enigmatic American case). J Bone Miner Res 22:163–170
9. Cundy T (2007) Recovery from skeletal fluorosis. J Bone Miner Res 22:1475
10. Whyte MP, Essmyer K, Gannon FH, Reinus WR (2005) Skeletal fluorosis and instant tea. Am J Med 118:78–82
11. Cao J, Zhao Y, Liu J, Xirao R, Danzeng S, Daji D, Yan Y (2003) Brick tea fluoride as a main source of adult fluorosis. Food Chem Toxicol 41:535–542
12. Roos J, Dumolard A, Bourget S, Grange L, Rousseau A, Gaudin P, Calop J, Juvin R (2005) Osteofluorosis caused by excess use of toothpaste. Presse Méd 34:1518–1520
13. Whyte MP, Totty WG, Lim VT, Whitford GM (2008) Skeletal fluorosis from instant tea. J Bone Miner Res 23:759–769
14. Boivin G, Chavassieux P, Chapuy MC, Baud CA, Meunier PJ (1986) Histomorphometric profile of bone fluorosis induced by prolonged ingestion of Vichy Saint-Yorre water. Comparison with bone fluorine levels. Pathol Biol (Paris) 34:33–39
15. Taves DR (1968) Determination of submicromolar concentrations of fluoride in biological samples. Talanta 15:1015–1023
16. Whitford GM (1996) The metabolism and toxicity of fluoride. Monographs in Oral Science. Volume 16, 2nd edn. Karger, Basel, Switzerland, pp 24–29
17. Whitford GM (1994) Intake and metabolism of fluoride. Adv Dent Res 8:5–14
18. Gruber HE, Baylink DJ (1991) The effects of fluoride on bone. Clin Orthop Relat Res 267:264–277
19. Riggs BL, O'Fallon WM, Lane A, Hodgson SF, Wahner HW, Muhs J, Chao E, Melton LJ III (1994) Clinical trial of fluoride therapy in postmenopausal osteoporotic women: extended observations and additional analysis. J Bone Miner Res 9:265–275
20. Balena R, Kleerekoper M, Foldes JA, Shih MS, Rao DS, Schober HC, Parfitt AM (1998) Effects of different regimens of sodium fluoride treatment for osteoporosis on the structure, remodeling and mineralization of bone. Osteoporos Int 8:428–435