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Original Article

Quantitative Ultrasound of the Mandible as a Novel Screening Approach for Osteoporosis

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Abstract

This study used an axial transmission quantitative ultrasound (QUS) device to assess mandibular bone strength. The aim of the study was first to establish the precision and repeatability of the axial transmission QUS measurement for a range of mandibular anatomic sites, and second to investigate the ability of the modality to differentiate between osteoporotic subjects and a control group. Three groups of adult Caucasian women were recruited: (1) healthy premenopausal women (n = 26), (2) healthy postmenopausal women (n = 48), and (3) women with osteoporosis (n = 53). Subjects were excluded from groups 1 and 2 if they had any pre-existing bone conditions. Speed of sound (SOS) measurements were taken from the mandible using an OmniSense multisite QUS device. Group 3 had dual-energy X-ray absorptiometry scans of the lumbar spine and femur. The most suitable site on the mandible was determined by repeat SOS measurements in 10 healthy premenopausal subjects, at 5 different sites. The parasymphysis site had the lowest root mean squared coefficient of variation at 0.74%, and was chosen as the most suitable site for mandibular SOS measurements. Group 1 and group 2 had significantly higher mean SOS measurements than the osteoporotic subjects (group 3), with means of 3683 m/s (210), 3514 m/s (221), and 3312 m/s (264), respectively. A 1-way analysis of variance confirmed a statistically significant difference between mean SOS measurements from the 3 groups ($p < 0.0001$). Axial transmission QUS of the mandible can differentiate between subjects with osteoporosis and a healthy control group, and shows potential for use as a screening tool for osteoporosis.

Key Words: Axial transmission quantitative ultrasound; dentistry; mandible; osteoporosis.

Introduction

Osteoporosis is well recognized as a largely silent disease, with many patients diagnosed only when presenting with fragility fractures *(1)*. There is, thus, an argument for involving a broader spectrum of health-care professionals in screening for low bone density. A previous systematic review has supported the potential role of pharmacists in improving identification of osteoporotic patients *(2)*, whereas the involvement of dentists in screening for osteoporosis, through dental radiography, has also been put forward *(3)*. Although it has been suggested that osteoporosis may increase the risk of tooth loss *(4)*, there is limited literature on the effect osteoporosis may have on the facial skeleton.

Dual-energy X-ray absorptiometry (DXA) remains the gold standard for osteoporosis assessment. However, there is an increasing body of research examining the use of quantitative ultrasound (QUS) for assessing bone strength. QUS

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avoids the high capital cost and any ionizing radiation-related risks, which, although low, are associated with DXA scans. QUS devices are portable, relatively easy to use, and, reportedly, provide complementary information on bone strength independent of bone density *(5)*. Multisite axial transmission QUS studies of the radius, metatarsals, and phalanx have demonstrated that speed of sound (SOS) measurements offer the ability to discriminate fragility fracture patients from controls, in cases of hip, vertebral, and nonspine fractures *(6–8)*. QUS of the calcaneus, measured with transverse transmission ultrasound, has been successfully shown to predict both total fracture risk and hip fracture risk in both men and women *(9)*. The strength of association between calcaneal broadband ultrasound attenuation and fracture risk in older women has been demonstrated to be similar to that observed with bone mineral density (BMD) measured by DXA *(10)*.

The published data to date, using QUS, for evaluation of mandibular bone strength have been measured using transverse transmission ultrasound *(11,12)*. Transverse transmission QUS utilization necessitates access to both sides of a bone target which, in the case of the mandible, requires intraoral positioning of both transmitter and receiver transducers *(13)*. Conversely, axial transmission QUS allows both transmitter and receiver transducer positioning on the same side of the target bone, acquiring SOS measures along the cortical bone parallel to the bone long axis. The method has been extolled, given its ability to reflect both structural and intrinsic material properties of cortical bone *(14)*. Studies have shown a correlation between DXA-measured mandible BMD and BMD of the rest of the skeleton *(15–17)*; however, to date, no studies have reported the use of axial transmission QUS for the assessment of the bone strength of the facial skeleton.

This work sought to employ an axial transmission QUS device to assess mandibular bone strength, using SOS measurements. Given that the mandible is a very accessible bone and its anatomy is very familiar to the dental profession, the site was chosen for investigation. The work aimed to first establish the precision and the repeatability of the axial transmission QUS measurement for a range of mandibular anatomic sites and, second, to investigate the ability of the modality to differentiate between osteoporotic subjects and a control group. The relationship between mandible SOS measurements, patient age, and tooth loss was also examined.

Materials and Methods

Subjects

The study population consisted of 3 groups of adult Caucasian females aged >18 years: (1) healthy premenopausal women (n = 26), (2) healthy postmenopausal women (n = 48), and (3) women with osteoporosis (n = 53).

Subjects were excluded from groups 1 and 2 if they had a medical history of low impact fracture; menopause before age 45; diseases known to affect bone metabolism such as untreated hyperthyroidism; and drugs known to affect bone metabolism such as long-term steroids, hormone replacement therapy, and bisphosphonates. Subjects for groups 1 and 2 were a convenience sample recruited from among the students, staff, and patients of the Dublin Dental University Hospital.

Group 3 was recruited from the patients of the Bone Health and Osteoporosis Clinic in St James's Hospital. These patients had DXA scans performed within the previous year using a GE Lunar Prodigy, confirming an osteoporosis diagnosis. DXA scans were acquired by a trained radiographer consisting of a lumbar spine, left neck of femur, and total hip measurement; the National Health and Nutrition Examination Survey III reference database was used to calculate T scores *(18)*. Ethical approval was received from the Trinity College Dublin/Tallaght Hospital/St James's Hospital Joint Research Ethics Committee. Informed consent was obtained from all individual participants included in the study.

Axial Transmission QUS Measurement

The study employed an OmniSense multisite QUS device (Sunlight BeamMed, Petah Tikva, Israel) with 3 different probes allowing for SOS measurements to be recorded at the tibia, radius, phalanx, and metatarsal bones. The SOS measurements in this study were acquired using the CRB probe, operating at a central frequency of 1.25 MHz, designed for use on the metatarsals (Fig. 1). This probe was chosen as it had the most suitable size profile. The CRB probe houses a number of ultrasonic transducers, acting as transmitters and receivers, which propagate ultrasonic waves along the long axis of the bone. Once the ultrasound wave reaches the receiver transducer, the arrival time is measured, and the SOS of the bone determined. The OmniSense uses an internal algorithm to check for SOS consistency by examining the coefficient of variation (CV) of 3 scan

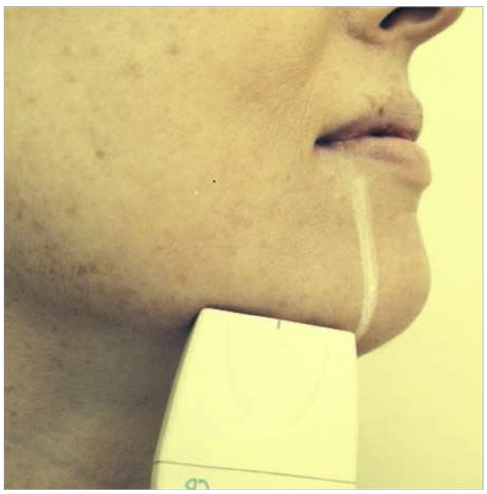

Fig. 1. Measurement sites on mandible. The CRB probe in position at parasymphysis site.