Journal of Clinical Densitometry: Assessment & Management of Musculoskeletal Health, vol. ■, no. ■, 1–7, 2016

1094-6950/■:1–7/$36.00
http://dx.doi.org/10.1016/j.jocd.2016.03.006

**Original Article**

# A Qualitative Examination of the Ward Region of Interest as Imaged on Dual-Energy X-ray Absorptiometry Examinations: The "Wandering Ward Sign"

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## Abstract

While analyzing dual-energy X-ray absorptiometry (DXA) examinations, we observed that, on occasion, the Ward region of interest (ROI) was positioned either unexpectedly or differently between successive examinations. When this occurred, it appeared to be either a marker of a compromised examination or of incident disease. This prompted a systematic inquiry. It became apparent that, while in general seeking the region of least areal density, the Ward ROI is positioned differently by the machines available to us from 2 particular manufacturers (General Electric Co. and Hologic Inc.). Three reviews were thus undertaken: (1) a prospective systematic examination of 200 unselected consecutive DXA examinations made with a General Electric Co. machine, 80 having had follow-up examinations and 245 made with a Hologic Inc. device; (2) a prospective systematic examination of 625 consecutive, unselected DXA examinations that were repeat examinations; and (3) a retrospective examination of a file of 86 cases collected for pedagogical purposes, predominantly made with a Hologic Inc. device. The commonest cause of an unusual position of the Ward area was compromised patient positioning or change in body habitus. Changes between examinations were, in addition if less often, apt to reflect physiological change or disease. Unusual positioning or a change in position of the Ward ROI is easily observed. It does not occur frequently, but, when it does, it may be useful in directing attention to either technical factors or incidental diseases. Observation of the position of the Ward ROI may thus be a quality assurance, and occasionally a diagnostic, tool.

**Key Words:** Densitometry; osteoporosis diagnosis; quality assurance; Ward's area; Ward's triangle.

## Introduction

Ward's triangle was described in 1838 as that part of the femoral neck, of a roughly triangular shape (when viewed in the anatomical position), subtended by the primary compressive, primary tensile and secondary compressive trabecular bundles *(1)*. It was noted that this triangle increases in size and becomes indistinct as a result of the bone loss in osteoporosis. Like the related radiographic Singh index *(2)*, it was hoped that such observations in tissue specimens and, later, from radiographs might provide an analog scale for the diagnosis of bone loss. In practice the radiographic Singh index has been found to suffer from high levels of inter- and intraobserver error, even with the use of quantitative digital radiography *(3)*. The advent of single-photon, dual-photon and, later, dual-energy X-ray

Received 12/11/15; Revised 03/14/16; Accepted 03/21/16.
Disclosure: BCL received 2 teaching honoraria from Amgen.
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absorptiometry (DXA) and subsequent techniques providing for the measurement of bone mineral in life has superseded such subjective tools (4–7).

In DXA practice, Ward's area, like other DXA regions of interest (ROIs), has been precisely defined (4–8). There is, however, a consensus that, from a quantitative perspective in diagnosing osteoporosis, the Ward area is of no value. The International Society of Clinical Densitometry (ISCD) recommends the use of only the total proximal femoral and femoral neck ROI bone mineral density (BMD) determinations for diagnosis and follow-up (9), although the contrary opinion has been recorded (10). From first principles, it is evident that the mineral content of the "triangle" will be very small and therefore quantitation and reproducibility will be constrained by a small sample size. The purpose of this note is to suggest that the Ward area can be reimagined as a sensitive indicator of real or apparent change in the mineral distribution in the proximal femur and, as such, reflective of the quality of patient positioning and repositioning, and, on occasion, of incidental disease.

For DXA, Ward's triangle has morphed into a rectangular ROI and, as Bonnick and Lewis have noted, it is now usual to describe the eponymous site as an "area," not as a "triangle" (6,7). It is also positioned differently by the software of different DXA manufacturers. In the case of General Electric (GE) Co. devices, the Ward ROI is dependent on the femoral neck ROI and the region slides along the femoral neck midline seeking the site of lowest density. Whenever the neck ROI box is moved, the "search" feature must be used to look for the narrowest part of the neck as well as the lowest summed bone density. In respect of Hologic Inc. machines, the software searches the total proximal femoral ROI (rather than just along the midline of the neck) for the area with the lowest summed density within the greater ROI. This is designated as the Ward area without reference to anatomical markers. The display of the Ward area may be made inoperational by choice. In general, the Hologic Inc. neck area is of constant size, not true of that applied by GE Co. devices.

When using the "compare" feature on Hologic machines, the Ward area is placed in the identical position along the femoral neck as the baseline scan so there is no new search for the least dense region. When using the "copy" feature with GE, the ROIs are all copied onto the new scan so there is no reason to do a "search" unless the patient's position has changed, when the "copy" operation would be invalid anyway.

We have not had access to, and therefore have not been in a position to look at examinations made with, DXA machines from other manufacturers.

In respect of the positioning of the Ward area—as distinct from mineral measurements within it—Cardadeiro et al. used a sophisticated digital method using DXA to show interindividual differences in the positioning of the Ward region in children (11). Cardadeiro et al. found that proximal femur shape variation in children ages 8 and 9 was related to differences in the position of Ward's area. This was, in part, influenced by body composition in both genders and by both moderate and vigorous physical activities in boys. These variables were positively associated with a central Ward's area and thus, in their words, "a more balanced femoral neck bone mass distribution." Cardadeiro et al appear to be the first to have recognized that the position of Ward's area might reflect either a real or apparent change in distribution of mineral in the femoral neck, if in a different context from this.

We have not found other descriptions of systematic observations of the serial positioning of the Ward ROI. Wahner and Fogelman in their texts do note that the Ward area may move on repeat examinations and recommend using the machine option of placing the Ward area in the same position as on the original scan (4). This would only be important if the quantitative data from the Ward area were to be found to be useful. In the second edition of Blake et al's (5) book, note is again made of changes in the Ward area; in this the authors are more concerned with the impact of such changes in comparing successive BMD measurements of the Ward area.

Although in the majority of adults the Ward ROI is predictably situated and constant between examinations, we have observed that, without any procrustean manipulations, the "triangle" may either be eccentrically situated or shifted in position between successive examinations in the same individual. This shift betrays some real or apparent alteration of the distribution of mineral in the femoral neck typically as a result of changes in patient positioning or the advent of disease. Initially, we were focused on changes in the Ward position as a result of disease. With experience, it became apparent that a more common cause is a change in positioning. The "movement" of the Ward ROI is not specific to any 1 factor or disease but might prompt an observer to look for an underlying cause.

## Patients and Methods

The data we report were acquired in conventional DXA practice in the context of academic medical centers with one serving a specialized osteoporosis clinic. The technologists concerned are required to be certified by the ISCD and all optimal quality measures (areal reproducibility, precision, etc.) are measured, recorded, and monitored. In such contexts, DXA examinations are performed by standard methods. Fortuitously, we have not switched off the placement of the Ward ROI that might have obscured some of the observations we report.

The machines and the software used over the time in question have been a GE Lunar Prodigy 7.51–10.51 (GE Lunar, Madison, WI) and a Hologic Discovery A versions 13.3.3–13.49 (Hologic, Inc., Bedford, MA). One pair of submitted images used was made using a GE iDXA (14.10).

We have conducted 4 separate analyses: one of 245 unselected Hologic Inc. DXA examinations seen consecutively; a second of 625 examinations consecutively made with the same device (this group is distinct because at that stage we were looking for a change between successive examinations due to disease); a third of 271 consecutive GE