Original Article

EFFECT OF IMPLEMENTING A COMPUTERIZED SYSTEM FOR BONE MINERAL DENSITY STORAGE AND REPORT PREPARATION ON RESULT TURNAROUND TIME AND SAVINGS IN COST, TIME, AND SPACE

Latarsha G. Whittaker; Raphael J. Rosen;
Alan O. Malabanan, MD, FACE; Harold N. Rosen, MD, FACE

ABSTRACT

Objective: To evaluate whether introduction of a densitometry workflow, data-storage, and reporting software system would result in streamlined workflow with fewer expenses and quicker result turnaround time.

Methods: BoneStation was implemented March 30, 2009, in a large, urban, tertiary referral center performing more than 6000 bone mineral density studies annually at 3 different geographic sites. The times of scan acquisition, report preparation, and final signature in the online medical record were recorded, and the delays from scan to report and from scan to final signature in the online medical record were calculated for each patient during 2 representative weeks before (n = 274) and 2 weeks after (n = 235) implementation of BoneStation.

Results: Use of BoneStation reduced time from scan to report from 2.11 ± 0.16 days to 0.46 ± 0.05 days (*P*<.001). BoneStation saved our practice $8.94 per scan, while costing only $3 per scan, resulting in net savings. Considering that the total reimbursement from Medicare in 2010 for dual-energy x-ray absorptiometry is projected to be $55.44, this constitutes cost savings of 10.7% of the total reimbursement.

Conclusion: The introduction of a specialized electronic medical system for data storage and reporting reduced costs and improved result turnaround time in a densitometry practice. **(Endocr Pract. 2010;16:30-35)**

Submitted for publication July 22, 2009
Accepted for publication August 12, 2009
From the Charles A. Dana Research Institute and the Harvard-Thorndike Laboratory of the Beth Israel Deaconess Medical Center, Department of Medicine, Division of Endocrinology and Metabolism, Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, Massachusetts.
Address correspondence and reprint requests to Dr. Harold N. Rosen, Division of Endocrinology, GZ-609, Beth Israel Deaconess Medical Center, 330 Brookline Ave, Boston, MA 02215. E-mail: hrosen@bidmc.harvard.edu.
Published as a Rapid Electronic Article in Press at http://www. endocrine practice.org on August 24, 2009. DOI: 10.4158/EP09217.OR

Abbreviations:
BMD = bone mineral density; **WHO** = World Health Organization

INTRODUCTION

The International Society for Clinical Densitometry has many recommendations designed to maximize the accuracy and precision of bone density measurement and to ensure that the report gives the referring physician valid information to use for patient care (1). However, the International Society for Clinical Densitometry has wisely avoided specific recommendations about storing data, preparing reports, and making results available to the referring physician. Wide variation exists in how reports are prepared throughout the world. Some centers provide simple paper reports with boxes for the reader to manually check to choose the World Health Organization (WHO) diagnosis and changes in bone mineral density (BMD). Other centers generate more elaborate reports electronically, including detailed information about T and Z scores and percentage change (and significance of those changes) over time.

Recently, much attention has been focused on the advantages of electronic medical records in the general care of the medical patient (2-6). Advantages of electronic medical records in densitometry might include ease of storage and ease of access to scans and reports by the scanning technician, the reporting physician, and the referring provider. Concerns about the initial outlay of capital required for electronic medical systems are mitigated by the promise of savings and improved patient outcomes in the long-term (2). The amount of initial outlay of capital and the length of time required to recoup it vary from system to system. We recently changed our densitometry storage and reporting system from a mostly manual paper system to a completely electronic system called BoneStation. We aimed to evaluate whether introduction of a densitometry workflow, data-storage, and reporting software would result in streamlined workflow with fewer expenses and quicker result turnaround time.

METHODS

Patients

The included patients had BMD measurements performed in the Osteoporosis Prevention and Treatment Center at Beth Israel Deaconess Medical Center. Our center is a large, urban, tertiary referral center performing more than 6000 BMD studies annually at 3 different geographic sites.

Protocol

BoneStation (Cardea Technology, Inc, Somerville, Massachusetts) is a workflow, storage, and reporting system for densitometry. The version used was 2.2.0b8.

Because this study describes improvements in cost and outcomes when switching to BoneStation for densitometry, we describe in the following text the workflow and reporting system in place until the BoneStation system was implemented.

Until March 30, 2009, workflow started with the technician preparing for the day's schedule of visits by locating and retrieving paper charts containing all previous images and reports and bringing them to the scanning session. The technician inspected the paper medical record to ensure that the current scan was acquired to match the appearance and scan mode of previous images. At the end of a scanning session, the technician transferred all scans to the administrative desktop in a DICOM (Digital Imaging and Communications in Medicine) format, and reports were prepared with Microsoft Word using Report Writer software (Hologic, Waltham, Massachusetts). The software automatically configured a table with scan results including BMD, Z scores, and T scores and a table of BMD results over time. The technician drafted a narrative report according to our protocol, noting the WHO diagnosis and the significance of changes in the spine and total hip BMD compared with previous BMD measurements. This report was then saved and printed. Each day, the reporting physician reviewed the reports, made necessary corrections, and signed the paper copy. A paper copy of the images and report was placed into the paper chart, and the paper chart was filed alphabetically. A paper copy was then sent to the referring physician upon request, and the Microsoft Word report was copied as a note into the patient's online medical record as a transcription from the physician. The reporting physician reviewed the transcription once more for errors and then signed off in the online medical record and electronically forwarded a copy of the report to the referring physician.

Since March 30, 2009, technicians at our institution have not used the paper medical record. Rather, while performing scans, they have a computer in the scanning room open to BoneStation's Web site where electronic copies of all old scans are available for immediate comparison. This facilitates the technician's ability to match the appearance and scan mode to that of previous scans. At the end of a scanning session, the technician transfers all scans using the DICOM standard to BoneStation's server, which then populates a queue of pending reports for the reporting physician. At the BoneStation Web site, the physician inspects each BMD measurement for technical adequacy, in comparison with images from all previously acquired BMD measurements (Figs. 1 and 2). A report is then automatically prepared with the WHO diagnosis on the basis of T scores and statements about changes in BMD over time

Fig. 1. First screen in BoneStation, showing the dates, scan modes, and type of densitometer used for the current study and each of the previous studies.

Fig. 2. Second screen in BoneStation, showing the current and baseline scans. Information is included about scan mode and size of the region of interest. Beneath these images are dates of all previous scans; clicking on these will bring into view each previous image, allowing simultaneous comparison of current, baseline, and other scans to ensure technical adequacy and comparability.

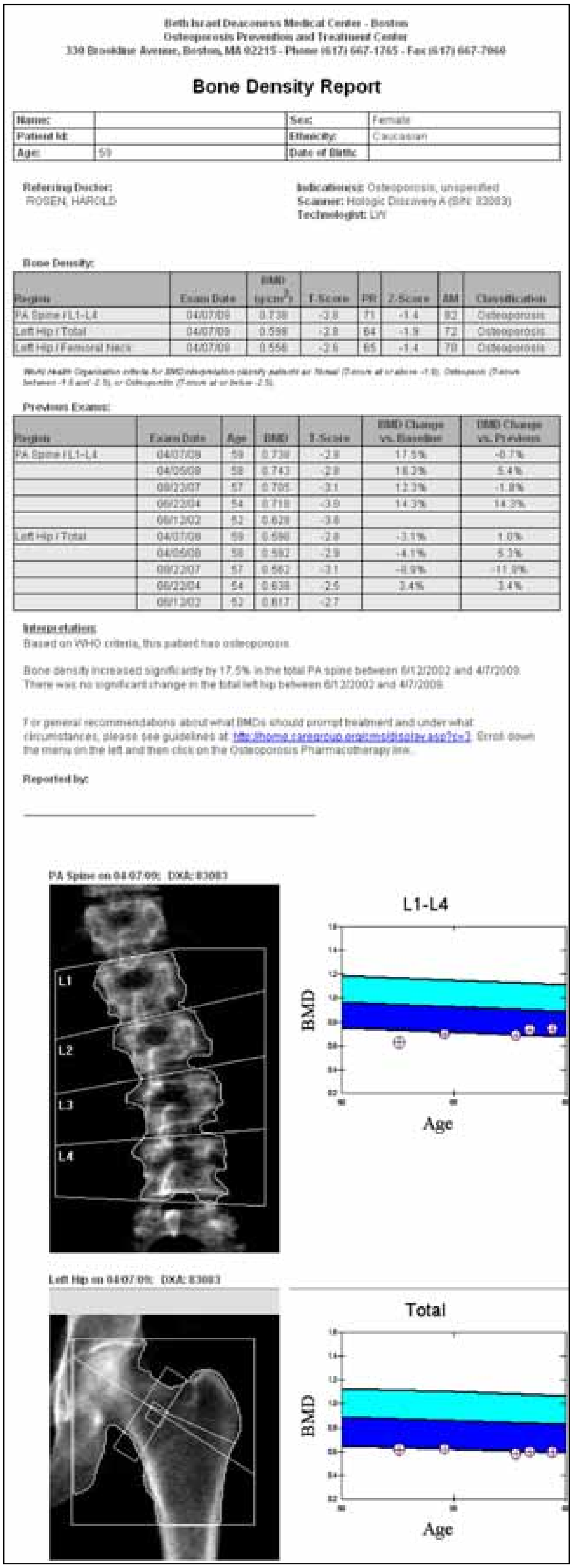
based on our in-house precision data (Fig. 3). Macros (standardized text with frequently used comments) are available in a drop-down menu, as is free-text space for the physician to make comments specific to the patient's case. The physician electronically signs the report on BoneStation, and technicians print out and send a paper report if requested by the referring physician. Technicians then export the BoneStation report into a text document, and paste it into a note in the patient's online medical record as a transcription from the physician. The reporting physician reviews the transcription once more for errors, and then signs off in the online medical record and electronically forwards a copy of the report to the referring physician.

The cost savings with BoneStation were estimated according to savings in employee time and materials.

The times of scan acquisition, report preparation, and final signature in the online medical record were all recorded, and the delays from scan to report and from scan to final signature in the online medical record were calculated for each patient during 2 representative weeks before (n = 274) and 2 weeks after (n = 235) implementation of BoneStation. Patients were scanned on the same days of the week and at the same geographic locations. Our committee on clinical investigation verified our impression that no informed consent or institutional review board approval was required for this study.

Statistics

Mean ± standard error of the mean was calculated for the interval from scan acquisition to report signature and



Beth Israel Deaconess Medical Center - Boston
Osteoporosis Prevention and Treatment Center
330 Brookline Avenue, Boston, MA 02215 - Phone (617) 667-1765 - Fax (617) 667-7060

Bone Density Report

Name:		Sex:	Female
Patient Id:		Ethnicity:	Caucasian
Age:	59	Date of Birth:	

Referring Doctor: ROSEN, HAROLD

Indication(s): Osteoporosis, unspecified
Scanner: Hologic Discovery A (S/N: 83083)
Technologist: LW

Bone Density:

Region	Exam Date	BMD (g/cm²)	T-Score	PR	Z-Score	AM	Classification
PA Spine / L1-L4	04/07/09	0.738	-2.8	71	-1.4	82	Osteoporosis
Left Hip / Total	04/07/09	0.598	-2.8	64	-1.9	72	Osteoporosis
Left Hip / Femoral Neck	04/07/09	0.556	-2.6	65	-1.4	78	Osteoporosis

World Health Organization criteria for BMD interpretation classify patients as Normal (T-score at or above -1.0), Osteopenic (T-score between -1.0 and -2.5), or Osteoporotic (T-score at or below -2.5).

Previous Exams:

Region	Exam Date	Age	BMD	T-Score	BMD Change vs. Baseline	BMD Change vs. Previous
PA Spine / L1-L4	04/07/09	59	0.738	-2.8	17.5%	-0.7%
	04/05/08	58	0.743	-2.8	18.3%	5.4%
	08/22/07	57	0.705	-3.1	12.3%	-1.8%
	06/22/04	54	0.718	-3.0	14.3%	14.3%
	06/13/02	52	0.628	-3.8		
Left Hip / Total	04/07/09	59	0.598	-2.8	-3.1%	1.0%
	04/05/08	58	0.592	-2.9	-4.1%	5.3%
	08/22/07	57	0.562	-3.1	-8.9%	-11.8%
	06/22/04	54	0.638	-2.5	3.4%	3.4%
	06/13/02	52	0.617	-2.7		

Interpretation:
Based on WHO criteria, this patient has osteoporosis.

Bone density increased significantly by 17.5% in the total PA spine between 6/12/2002 and 4/7/2009.
There was no significant change in the total left hip between 6/12/2002 and 4/7/2009.

For general recommendations about what BMDs should prompt treatment and under what circumstances, please see guidelines at [illegible]. Scroll down the menu on the left and then click on the Osteoporosis Pharmacotherapy link.

Reported by:

Fig. 3. Final report in BoneStation.

for the interval from scan acquisition to final signature in the online medical record. The data were not normally distributed, so the significance of the differences before and after the implementation of BoneStation was computed using the Mann-Whitney test. The computations were done with and without excluding outliers greater than 3 standard deviations from the mean, and the results were substantially similar. Thus, results are reported with the outliers omitted. No correction for the 4 comparisons was done because the difference between groups was so significant ($P<.001$) that such correction was unnecessary.

RESULTS

Before BoneStation was implemented, the mean delay from the time of scanning to the time a report was completed was 2.11 ± 0.16 days. After implementing BoneStation, the mean delay decreased to 0.46 ± 0.05 days ($P<.001$) (Fig. 4). Before BoneStation, the mean delay from the time of scanning until the report was available in the online medical record was 5.30 ± 0.16 days. After implementing BoneStation, the mean delay decreased to 2.48 ± 0.10 days ($P<.001$) (Fig. 5).

In addition to the decrease in reporting delay with BoneStation, we also found substantial cost savings, as outlined in Table 1. The main source of cost savings was in support staff time. BoneStation eliminated the need to locate each chart before the scan, place the new report in the paper chart, and return the chart alphabetically to the filing cabinet. Furthermore, the technician no longer needed to create the first draft of the report by typing in WHO criteria and significance of bone loss because those steps were automated in BoneStation. The savings in employee time, space, and materials resulted in an estimated cost reduction of $8.94 per report (Table 1). Of course, these savings are partially offset by the cost of BoneStation, which is $3 per report; however, even with this cost, net savings in the cost of operations was still accrued.

DISCUSSION

Although operating procedures to ensure accuracy and precision of bone densitometry are well standardized, wide variation exists in how scans and reports are produced and stored. It is widely assumed that, in general, electronic medical records can reduce practice expense while improving patient care (5), and an electronic medical record for densitometry might be expected to provide similar benefits. We describe our institution's transition to BoneStation, an electronic solution for workflow, scan storage, and reporting, and summarize the quicker result turnaround time and cost savings in materials, space, and personnel.

While some studies suggest that electronic medical records reduce cost, these findings are not universal. Baron et al (2) found that implementation of an electronic medical

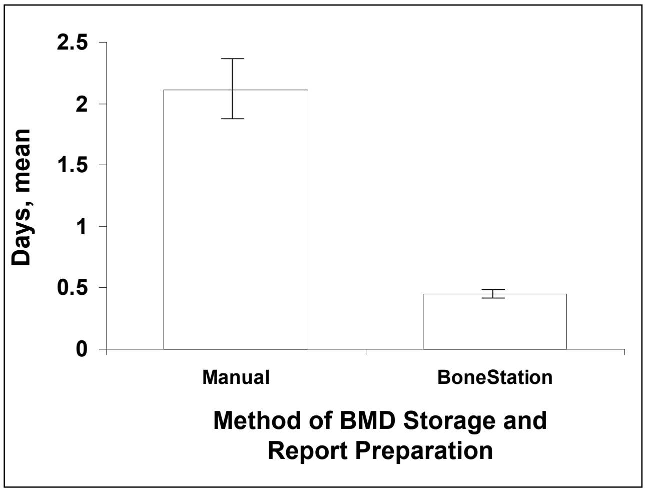


Fig. 4. The time from scan acquisition to completion of the report before and after implementation of BoneStation. Error bars represent standard error of the mean. BMD, bone mineral density.

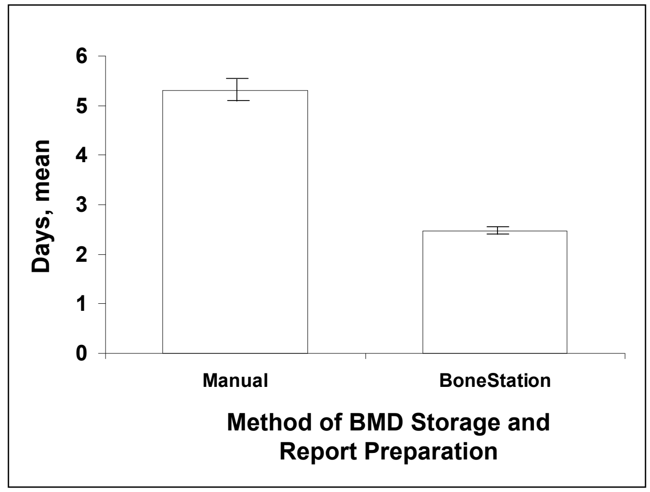


Fig. 5. The time from scan acquisition to the availability of the report in the online medical record before and after the implementation of BoneStation. Error bars represent standard error of the mean. BMD, bone mineral density.

record in their 4-person internal medicine practice accrued no net reduction in cost. However, a cost-benefit study by Wang et al (5) reported substantial savings with implementation of electronic medical records, with the greatest cost reduction achieved by more economic use of drugs and radiology. Additional savings were realized by reduction in personnel expenses from chart retrieval. In our study, we found that most of the cost savings resulted from decreases in personnel time related to chart retrieval. Because of the very specialized nature of our electronic medical record, we did not expect decreases in drug expenses.

In addition to economic advantages, electronic medical records are thought to improve patient outcomes. Jerant and Hill (3) reviewed the literature and concluded that most nonrandomized, uncontrolled observational studies report improvement in indicated health maintenance such as fecal occult blood tests, lipid screening, and immunizations. In our study of the very specialized densitometry electronic medical record, turnaround time is the only patient outcome readily measured, and it clearly improved. We would have liked to report on the incidence of reporting errors and any possible improvement after implementation of BoneStation. However, because the reporting system is redundant, errors were very infrequent both before and after implementation of BoneStation, and we had no way to readily estimate the small number of reporting errors.

It is important to put the estimated cost savings from use of BoneStation into context. We estimated that BoneStation saves $8.94 per study and costs $3 per study, for a net savings of $5.94 per study. Since the total Medicare

Table 1
Estimated Cost Savings per Scan Using BoneStation

Expense	Explanation	Amount saved, $
Personnel salary	Chart retrieval/filing[a]	5.00
	Preliminary report preparation (0.16 h)	3.15[b]
Paper	7 Sheets for the report and images	0.05
Printing	7 Sheets for the report and the images	0.10
Folder	For each new patient	0.58
Storage space	For charts	0.08[c]
		Total = $8.94

[a] $5 per chart pull is derived from reference 5.
[b] Computed on the basis of a salary of $15 per hour plus 26% fringe.
[c] Computed at a price of $20 per square foot per year.

reimbursement for dual-energy x-ray absorptiometry in 2010 is projected to be $55.44, BoneStation savings would constitute a substantial 10.7% of total reimbursement.

The weakness of our study lies mostly in its observational nature. We chose 2 representative weeks of patients both before and after the transition to BoneStation. During these weeks, patients were scanned on the same days of the week and at the same geographic locations. Furthermore, we chose weeks when the usual readers (H.N.R. and A.M.) were reading scans on their usual schedules. Of course, some factor other than the transition to BoneStation possibly accounts for the shortened delay in reporting. Nonetheless, the differences in reporting time were so large and so significant that we doubt that they could be completely accounted for by unintentional differences in the time periods studied. The cost savings that we report are, of course, only estimates. We considered reporting differences in actual expenditures before and after the transition; however, 2 practice assistants resigned and 2 new physicians were hired. Many other variables change expenditures from month to month, so that the reported cost-estimates are more reflective of the changes with BoneStation. Another weakness of our study is the lack of comparison with other products similar to BoneStation. We are unaware of any comparable competing computerized workflow, data-storage, and reporting solution for densitometry.

CONCLUSION

We implemented use of BoneStation, a workflow, data-storage, and reporting system for bone densitometry, with a resultant reduction in cost and improved turnaround time. At a time when reimbursement for densitometry is falling and when the zeitgeist is moving towards electronic medical records, adoption of programs like BoneStation should be considered by densitometry practices.

ACKNOWLEDGMENT

We gratefully acknowledge the bone densitometry technicians of the Osteoporosis Prevention and Treatment Center at Beth Israel Deaconess Medical Center, without whom the transition to BoneStation could never have been accomplished.

DISCLOSURE

The authors have no multiplicity of interest to report. No author has any commercial or financial relationship with BoneStation other than the fact that our densitometry center has purchased this system for use.

REFERENCES

1. **The International Society for Clinical Densitometry**. Official Positions. ISCD Web site. Available at: http://www.iscd.org/Visitors/positions/OfficialPositionsText.cfm. Updated October 2007. Accessed August 11, 2009.
2. **Baron RJ, Fabens EL, Schiffman M, Wolf E**. Electronic health records: Just around the corner? Or over the cliff? *Ann Intern Med*. 2005;143:222-226.
3. **Jerant AF, Hill DB**. Does the use of electronic medical records improve surrogate patient outcomes in outpatient setting? *J Fam Pract*. 2000;49:349-357.
4. **Hartzband P, Groopman J**. Off the record--avoiding the pitfalls of going electronic. *N Engl J Med*. 2008;358:1656-1658.
5. **Wang SJ, Middleton B, Prosser LA, et al**. A cost-benefit analysis of electronic medical records in primary care. *Am J Med*. 2003;114:397-403.
6. **Grieger DL, Cohen SH, Krusch DA**. A pilot study to document the return on investment for implementing an ambulatory electronic health record at an academic medical center. *J Am Coll Surg*. 2007;205:89-96.