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Research Article

Effect of Day Optimizing Throughput (Dot) Knee Software Implementation on Magnetic Resonance Imaging Workflow Efficiency

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ABSTRACT

Purpose: Attempts by magnetic resonance (MR) manufacturers to help imaging centres improve patient throughput has led to the development of more automated acquisition. This software is capable of customizing individual scan alignment; potentially improving imaging efficiency and standardizing protocols. However, substantial investments are required to introduce such systems, potentially deterring their widespread application. This study assessed the implementation costs and reduction in examination durations for automated knee MR imaging (MRI) software.

Materials and Methods: Research activities were performed at a community-based academic centre on a 3-Tesla (3-T) system using Siemens' Day Optimizing Throughput (Dot) knee software. Examination acquisition times were extracted from the system before and after software implementation. Fiscal year 2012/13 finances were used to determine the average hourly cost of MRI utilization. Costs associated with automated software implementation were also calculated. Finally, the number of knee scans required to achieve a positive return on investment using the software was established.

Results and Discussion: The mean (standard deviation, sample size) pre- and post-Dot software scan times were 23.20 (4.18, n = 266) and 21.94 (4.51, n = 59) minutes, respectively, for a routine knee scan and 11.88 (1.60, n = 74) and 11.24 (1.51, n = 27) minutes, respectively, for a fast knee scan. The overall weighted average resulted in a 64-second time savings per automated knee examination. This negligible time savings would be extremely difficult to make use of clinically. Dot simplified 29 unique knee protocols to two, improving the consistency of knee examinations. Current Dot software is not compatible with all patients and therefore has limitations that are a concern among MR technologists.

Conclusion: Adoption of automated knee systems could assist in standardizing protocols; however, the cost of implementation and difficulty in modifying patient scheduling to reflect the minimal time savings would make a financial return unlikely to occur at small- and medium-sized institutions.

RÉSUMÉ

But : Les efforts des fabricants d'équipement d'imagerie par résonance magnétique visant à aider les services d'imagerie à augmenter le nombre de patients traités ont mené à une plus grande automatisation du processus d'acquisition d'image. Ce logiciel est en mesure de personnaliser l'alignement individuel du balayage, ce qui permet potentiellement d'améliorer l'efficacité de la prise d'image et de standardiser les protocoles. Cependant, des investissements substantiels sont nécessaires pour l'acquisition de tels systèmes, ce qui peut nuire à leur application à grande échelle. Cette étude évalue les coûts d'implantation et la réduction de la durée des examens pour trois logiciels d'IRM automatisée du genou.

Matériel et méthodologie : Les travaux de recherche ont été menés dans un centre universitaire communautaire sur un système 3T utilisant le logiciel d'examen du genou Day Optimizing Throughput (Dot) de Siemens. Les durées d'acquisition des images ont été tirées du système avant et après la mise en place du logiciel. Les données budgétaires de l'exercice financier 2012-2013 ont été utilisées pour établir le coût horaire moyen d'utilisation du système IRM. Enfin, le nombre d'images de genoux requis pour obtenir un rendement positif sur l'investissement a été calculé.

Résultats et discussion : La durée moyenne (écart-type, taille de l'échantillon) avant et après la mise en place du logiciel Dot était respectivement de 23,20 (4,18, n=266) et 21,94 (4,51, n=59) minutes pour un scan de routine du genou et de 11,88 (1,60, n=74) et 11,24 (1,51, n=27) minutes pour un scan rapide du genou. Le résultat global moyen pondéré montre une économie de 64 secondes par examen automatisé. Cette économie de temps négligeable serait extrêmement difficile à utiliser dans un contexte clinique. Le logiciel Dot simplifie 29 protocoles uniques pour le genou et les remplace par deux, ce qui permet d'améliorer l'uniformité des examens du genou. Le logiciel Dot actuel

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n'est cependant pas compatible avec tous les patients et présente donc des limitations qui préoccupent les technologues en IRM.

Conclusion : L'adoption des systèmes automatisés d'imagerie du genou pourrait aider à standardiser les protocoles, mais le coût d'implantation et la difficulté de modifier l'ordonnancement des patients pour refléter l'économie de temps minimale font en sorte qu'il serait peu probable d'obtenir un rendement financier positif pour les institutions de petite ou moyenne taille.

Keywords: automation software; image alignment; knee MRI; protocol standardization; scan efficiency

Introduction

Magnetic resonance imaging (MRI) is a dynamic medical imaging modality that enables clinicians to noninvasively diagnose and monitor a wide variety of conditions. MR examination volumes have dramatically increased over time in many jurisdictions. In the United States, MRI volumes increased from an average of 73 to 183 examinations per 1,000 enrollees between 1998 and 2010 [1]. Similarly, the annual volume of examinations performed in Canada more than doubled between 2003/04 and 2011/12, from 0.69 million to 1.7 million [2], with an increase of 0.7 million between 2006/07 and 2011/12 alone [3].

Numerous factors contribute to this increased demand for imaging, including technological advances that have broadened the range of clinical indications for which MR is beneficial [4]. Many jurisdictions have responded to the growth in demand by increasing the number of MR scanners (''magnets'') in operation. For example, the number of magnets increased from 2,990 to 10,815 in the United States and from 30 to 308 in Canada between 1993 and 2012 [2]. However, because of the costs of purchasing and operating MR magnets, focus has increased at many facilities to using existing magnets more efficiently.

Recognizing this, MR manufacturers have sought to improve magnet efficiency, largely through image acquisition and processing time reductions. Yet examination setup and image plane alignment activities are also receiving attention, leading to software advancements that enable images to be acquired with fewer user modifications. These software systems are intended not only to reduce calibration and setup time but also to improve image quality and examination consistency. This has the potential not only to reduce the need to repeat sequences during examinations but also to eliminate the need to reimage some patients entirely, thereby reducing system demand.

Although such automation software is now available for many recently developed MR systems and for most examination types, clinical implementation of such software is not yet widespread. Broad uptake may be inhibited by concerns about the high initial costs, which stem from both the initial purchase price and those associated with system calibration and customization. Such systems can cost tens of thousands of dollars (in CAD) to purchase and require numerous hours of both magnet and technologist time to initially calibrate each individual protocol. Hence, without a strong business case demonstrating the time savings and examination cost reductions achieved by such systems, the high upfront investments may deter their adoption.

Thus far little research into the costs and benefits of automated imaging software has been published, and that which has, typically relies on small sample sizes or does not quantitatively analyze the associated time savings [5–9]. To address these shortcomings, we sought to assess the costs and benefits of implementing automated imaging software in a community-based academic medical centre. We hypothesized that a comprehensive assessment of the implementation of such a system would demonstrate that the initial setup costs would be offset by the reduction in long-term examination costs.

Materials and Methods

This prospective study was supported in kind by Siemens Healthcare, as they temporarily supplied a trained programmer (B. Schraa) and a MR system simulator to our site to assist with sequence development. The authors had complete control of the data and information submitted for publication. The University of Saskatchewan's Research Ethics Board waived the need for research ethics approval.

Study Setting

Our facility, the Royal University Hospital (RUH) in Saskatoon, Saskatchewan, Canada, is one of three MR-equipped hospitals in the Saskatoon Health Region (SHR), housing two Siemens MR systems; a 1.5-T Avanto and a 3-T Skyra, the only 3-T system within the SHR. RUH performed 8,811 MR examinations in fiscal year (FY) 2012/13 on a wide variety of pediatric, adult, and geriatric patients. A recent decision to implement previously acquired automated imaging systems, ''Day Optimizing Throughput (Dot) engines'' in Siemens' parlance, provided an opportunity to study the costs and benefits of implementing such systems. This study focuses specifically on implementation of the Dot knee engine on the 3-T Skyra (syngo MR D13).

Study Design

As we sought to perform a cost–benefit analysis of the Dot engine implementation, this study comprised three phases outlined in Figure 1.

Data relating to examinations performed during phase I were used to establish preimplementation performance and costs providing baseline statistics. Phase II, the Dot engine development stage, initially involved 3 intensive days that included training a subset of the MR technologists as ''super users'' who assisted with the Dot development and the programming of hospital-specific Dot engine protocols. Four standard Dot knee protocols were developed using the