

## A standard universal C-arm language: Assessing its need and its likelihood of acceptance



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### ABSTRACT

Intraoperative fluoroscopy has facilitated improvements in surgical procedures across various subspecialties but has resulted in increased radiation exposure to the patient and surgeon. The results of a survey administered to 447 orthopedic surgeons and radiological technologists show that there is no standard universal c-arm language, that significant confusion and miscommunication exists between surgeons and technologists because of this, that unnecessary radiation exposure occurs as a direct consequence of this miscommunication, and that the vast majority of respondents would accept a standardized language similar to the one proposed in this study. This could potentially lead to less miscommunication and radiation exposure.

### 1. Introduction

The use of intraoperative fluoroscopy has facilitated a dramatic change in surgical technique and patient outcomes over time. Most C-arm fluoroscopes exhibit 6° of freedom allowing for imaging from almost any angle.<sup>1</sup> The advent of the mobile c-arm unit greatly increased its practical use for imaging patients during surgical procedures. Surgeons across a wide variety of specialties have found use for this rapid, versatile imaging modality in the operating theatre, especially within the field of orthopedics. Vertebroplasty, kyphoplasty, and fracture care are just a few of the many procedures where the use of intraoperative fluoroscopy is now common practice.

Increasing use of intraoperative fluoroscopy during orthopedic procedures has resulted in increased radiation exposure to the patient and the surgeon. Estimates of radiation exposure to the orthopedic surgeon during an intramedullary nail locking procedure with an average fluoroscopy time of 5 minutes are as high as 100 mrem to the torso and 150 mrem to the hands per case.<sup>2</sup> Formal education programs on radiation safety and the appropriate use of personal safety equipment such as lead vests are common sense solutions which have been shown to reduce radiation exposure to both patients and physicians.<sup>3</sup> However, a major deficit in the prevention of unnecessary radiation exposure still exists in the lack of an established standardized universal c-arm language which leads to needless images being obtained intraoperatively.

The versatility of movement of the c-arm fluoroscope introduces significant communication barriers between the surgeon and the radiologic technologist. A study by Pally and Kreder surveyed orthopedic surgeons and radiologic technologists revealing that not only is the terminology currently employed for intraoperative direction of C-arm fluoroscopy tremendously diverse, but that in some cases identical language was used by different respondents to describe different C-arm movements.<sup>4</sup> Additional studies in which orthopedic surgeons and radiologic technologists were asked to write descriptors of diagrams illustrating various C-arm maneuvers found that little to no consensus exists within or between these two groups in regards to what terminology should describe which maneuver.<sup>5,6</sup>

Poor communication between orthopedic surgeons and radiologic technologists regarding use of intraoperative fluoroscopy (c-arm) leads

to surgical delays, mutual frustration, and increased exposure to ionizing radiation. Implementation of a standardized universal language for c-arm use has the potential to reduce all of these adverse outcomes by decreasing OR time, improving teamwork and further minimizing unnecessary radiation exposure. Previous studies have already demonstrated such benefits using in vitro simulations of intramedullary nail locking procedures. Yeo et al. found a 45% and 50% reduction in the mean time needed to complete the procedure and the mean number of images required, respectively after the introduction of a default c-arm language.<sup>7</sup> A similar study by Williams et al. found 38% and 39% reductions in mean time and mean number of images required to complete the same simulated procedure.<sup>8</sup>

We hypothesize that there is no standard universal language for c-arm use among orthopedic surgeons and radiologic technologists and that significant unnecessary radiation exposure occurs secondary to poor communication and confusion between these two groups. Additionally, the purpose of this study is to determine the willingness of orthopedic surgeons and radiologic technologists to adopt a universal standard language for c-arm use.

### 2. Methods

An eight-question web-based survey was created consisting of both open-ended and multiple-choice questions to characterize c-arm use and communication in the OR and willingness to adopt a proposed standard universal c-arm language (Fig. 1). This survey was administered to orthopedic surgeons through the Canadian Orthopaedic Association, the American Academy of Orthopaedic Surgeons State List Servers, and [Orthobullets.com](http://Orthobullets.com). The same survey was administered to radiologic technologists through The American Registry of Radiologic Technologists and the Canadian Association of Medical Radiation Technologists. Results were collected through [surveymonkey.com](http://surveymonkey.com) and a descriptive analysis was run.

### 3. Results

A total of 447 participants were surveyed, including 212 orthopedic surgeons (47%) and 235 radiological technicians (53%). Surgeon's

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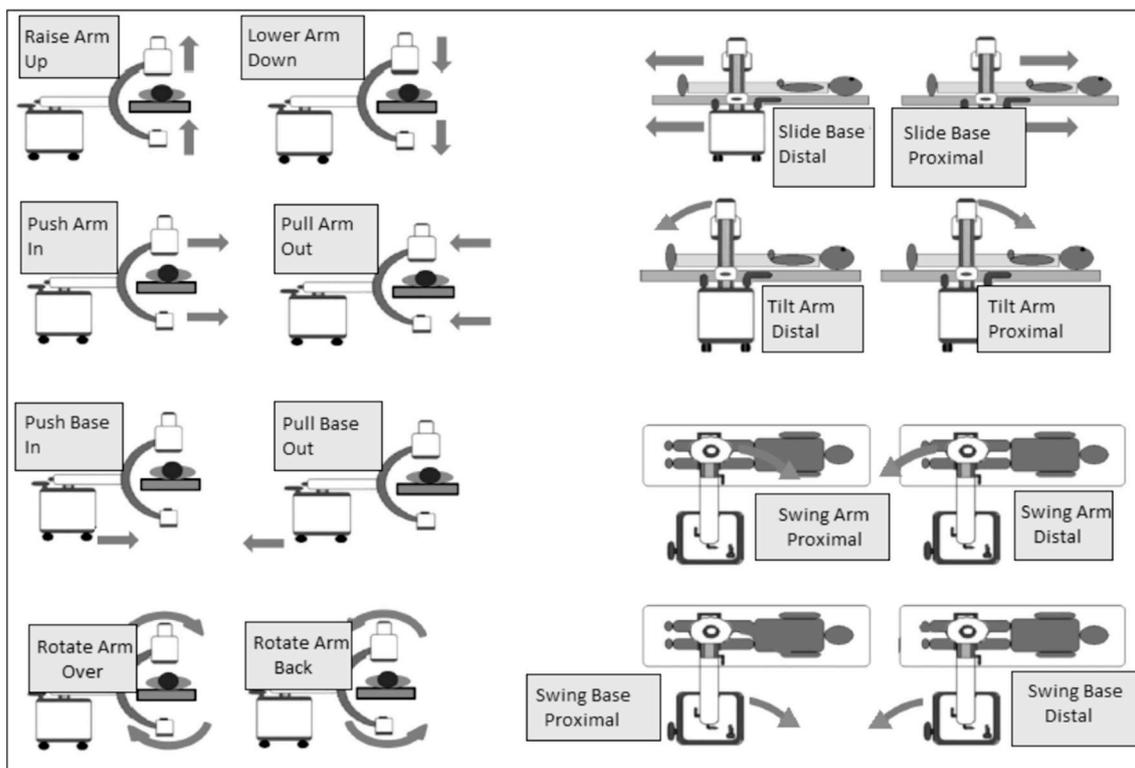


Fig. 1. Proposed Standard Universal C-arm Language (Action, Component, Direction).

The terminology follows an easily repeatable order of directions starting first with the desired action, followed by the component being acted upon, followed by the direction the component is to be moved.

experience included resident/fellow (36%), those in practice ≤ 15 years (33%), and ≥ 16 years (31%).

Routine c-arm was reported as used by 97% and 89% of surgeons and technologists, respectively. Both groups also reported never having been taught a standard language for the use of c-arm (89% and 91% of surgeons and technologists, respectively) and reported having experienced confusion in the OR regarding c-arm use (92% and 96%, respectively). Of surgeons and technologists surveyed, 93% and 89% respectively reported exposure to unnecessary radiation due to confusion. Willingness to accept a standard universal c-arm language was reported for 83% of surgeons and 95% of technologists, respectively (Table 1).

Our proposed universal C-arm language (Fig. 1) would be either unequivocally accepted or accepted with only minor changes by 83% and 91% of surgeons and technologists, respectively.

#### 4. Discussion

Intraoperative fluoroscopy is increasingly being used in the operating theatre and will continue to grow in use with technological and procedural advancements. Most orthopedic surgeons and radiologic technologists in our survey reported routine use of intraoperative c-arm fluoroscopy, yet the vast majority of these two groups denied having

been taught a standard universal language for c-arm use during school or training. In the absence of a predetermined language for c-arm use, the surgeon must rely on his or her personal judgement in assigning terminology to specific c-arm maneuvers. The radiologic technologist must then rely on his or her personal judgement in interpreting the meaning of directions given by the surgeon. As Pally and Kreder have already demonstrated, this lack of standardized communication has resulted in unnecessarily diverse, confusing and sometimes even directly conflicting sets of terminology for c-arm movements from surgeon to surgeon.<sup>3</sup> Findings from our study reveal similarly diverse language used by surgeons and radiologic technologists to indicate that they want an image to be taken with the c-arm (Table 2). One third of both surgeons and radiation technologists reported using multiple different phrases to indicate that an image should be taken with the c-arm while the remainder of both groups showed no consensus on any one regularly used phrase. In the context of such inconsistent language it is not surprising that 93% and 89% of surgeons and technologists, respectively reported exposure to unnecessary radiation (Table 1).

Many radiologic technologists work with multiple surgeons and vice versa, thus further complicating intraoperative communication as radiologic technologists are put in the position of attempting to memorize a different set of c-arm vocabulary for each surgeon with whom

Table 1  
Need for and Willingness to Accept a Standard Universal C-arm Language.  
A summary of survey results from 447 participants.

	Orthopedic Surgeons (n = 212)	Radiological Technologists (n = 235)	All (n = 447)
Routinely use c-arm in OR	97%	89%	93%
Have never been taught a standard c-arm language	89%	91%	90%
Have experienced confusion in OR regarding c-arm use	92%	96%	94%
Have been exposed to unnecessary radiation due to that confusion	93%	89%	91%
Would be willing to adopt a standard c-arm language	83%	95%	89%
Would adopt the proposed language (+ minor changes)	65% (83%)	71% (91%)	68% (88%)

**Table 2**  
Phrases Used to Signify that an Image Should be Taken with the C-armWide variation in terminology used to signify that a c-arm image should be taken.

	Orthopedic Surgeons	Radiologic Technologists
"Image"	7%	4%
"Shot"	24%	6%
"X-ray"	24%	39%
I use more than one term	32%	34%
Other	13%	18%

they work. Surgeons still often experience frustration despite the use of consistent language because technologists new to their room may not be familiar with that particular terminology. Our study found that an overwhelming majority of surgeons and radiologic technologists reported experiencing such confusion in regards to c-arm operation.

Furthermore, 91% of surgeons and radiologic technologists have witnessed unnecessary imaging taken in the OR as a direct consequence of confusion between surgeon and radiologic technologist. Therefore, our study provides evidence that not only is the issue of poor intraoperative c-arm communication widespread, but that in the vast majority of cases where it exists it has resulted in unnecessary radiation exposure to both patient and surgeon. This finding highlights an opportunity for targeted quality improvement which could result in significantly reduced radiation exposure for thousands of patients and their surgeons each year.

The potential for a standard universal c-arm language to reduce unnecessary intraoperative radiation exposure has already been demonstrated by in vitro studies.<sup>6,7</sup> However, even an evidence based solution to the problem of intraoperative c-arm communication is not useful unless surgeons and radiologic technologists are willing to implement it. Therefore, one of the goals of this study was to evaluate the willingness of these two groups to adopt a standard set of c-arm “language” to be used by all English speaking surgeons and radiologic technologists. Over 89% of surgeons and technologists indicated that they would be willing to adopt a standardized language for c-arm use while 68% and 88% indicated that they would be willing to adopt our proposed standard universal c-arm language (Fig. 1) as is or with only minor changes, respectively.

That such a vast majority of surgeons and radiologic technologists in our survey, many of whom have been in practice for over 20 years, would be willing to adopt a new standard universal c-arm language emphasizes the inadequacy of the status quo in intraoperative c-arm communication strategies. Future studies are needed to determine ease of implementation and clinical impact of a universal language in eliminating or reducing intraoperative confusion and unnecessary radiation. If indeed future studies support an in vivo reduction in intraoperative confusion and unnecessary radiation exposure with implementation of a standard c-arm language, our study shows promising evidence that such a solution would meet widespread acceptance among the current population of surgeons and radiologic technologists.

## 5. Conclusion

There is no standard universal c-arm language. Such a terminology

would significantly decrease intraoperative confusion between orthopedic surgeons and radiologic technologists with the potential for significantly reducing unnecessary radiation exposure to both patient and surgeon. A vast majority of surgeons and technologists would accept a language similar to the one proposed in this study. Additional studies need to be done in order to determine the ease with which such a standardized c-arm language could be implemented on a widespread basis.

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## Conflicts of interest

The authors report no conflicts of interest, financial or otherwise.

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