



# Evaluation of Audiovisual Reports to Enhance Traditional Emergency Musculoskeletal Radiology Reports

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## Abstract

Traditional radiology reports are narrative texts that include a description of imaging findings. Recent implementation of advanced reporting software allows for incorporation of annotated key images and hyperlinks directly into text reports, but these tools usually do not substitute in-person consultations with radiologists, especially in challenging cases. Use of on-demand audio/visual reports with screen capture software is an emerging technology, providing a more engaged imaging service. Our study evaluates a video reporting tool that utilizes PACS integrated screen capture software for musculoskeletal imaging studies in the emergency department. Our hypothesis is that referring orthopedic surgeons would find that recorded audio/video reports add value to conventional reports, may increase engagement with radiology staff, and also facilitate understanding of imaging findings from urgent musculoskeletal cases. Seven radiologists prepared a total of 47 audiovisual reports for 9 attending orthopedic surgeons from the emergency department. We applied two surveys to evaluate the experience of the referring physicians using audio/visual reports as a complementary material from the conventional text report. Positive responses were statistically significant in most questions including: if the clinical suspicion was answered in the video; willingness to use such technology in other cases; if the audiovisual report made the imaging findings more understandable than the traditional report; and if the audiovisual report is faster to understand than the traditional text report. Use of audiovisual reports in emergency musculoskeletal cases is a new approach to evaluate potentially challenging cases. These results support the potential of this technology to re-establish the radiologist's role as an essential member of patient care and also provide more engaging, precise, and personalized reports. Further studies could streamline these methods in order to minimize work redundancy with traditional text reporting or even evaluate acceptance of using only audiovisual radiology reports. Additionally, widespread adoption would require integration with the entire radiology workflow including non-urgent cases and other medical specialties.

**Keywords** Video recording · Web technology · Radiology workflow · Radiology report · Software design · Audio/video report · Software · Audiovisual · Musculoskeletal

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**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s10278-019-00261-9>) contains supplementary material, which is available to authorized users.

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## Introduction

The radiology report is the final product of the medical interpretation of imaging studies. Standardized reports are narrative texts, including a detailed description of the findings, and a conclusion. In most cases, electronic access to a text report often provides sufficient communication without the need for an in-person discussion or phone call. Advanced voice recognition software and standardized reports enable rapid dictation and high-volume radiology practices. The disadvantages of text reports include the potential commoditization of radiologist's work, lengthy reports that may distract or inadequately convey findings, and decreased visibility of radiologists in patient care. Inconsistent or imprecise reports may confuse and frustrate referring providers, leading to decreased reliance on the radiologist's work. Until now, these shortcomings have been tolerated in order to generate fast turnaround times.

However, with recent decline in reimbursements and the transition towards value-based care and precision medicine, radiologists need better methods of communication with referring clinicians. This may be a difficult realization because it antagonizes the constant urgency for expedited reporting and high volumes. However, it is paramount to improve communication with ordering physicians and focus on the patient's experience in healthcare, such as recommended by the triple aim [1] and also with the goals of the Affordable Care Act, particularly for inpatient medicine services [2].

Text reports may not express nuances of a case. Findings that deserve emphasis may become buried in reporting details. Radiology reports are important medical-legal documents, therefore all pertinent negatives and important incidental findings should be covered, with a potential of producing a long text with an unclear message for the clinician [3]. Case details may not be clear in a narrative text; therefore, putting findings into context to answer the most important clinical questions could be sub-optimal. Recent structured report guidelines are important tools to create consistent radiology text reports and minimize communication errors with the referrer physician [3, 4]. In-person interactions between referring clinicians and radiologists in the setting of radiology rounds ensure accurate communication of study results and proper patient care [5]. Efforts have been made to rediscover this form of communication in a modern setting [6]. For complex patients, in-person interaction between radiologists and clinicians may still be routine, especially at large academic centers with interdisciplinary case conferences like tumor and sports medicine boards.

New report methods including features such as key images, arrows, and hyperlinks have been explored to reduce limitations of text reports [7]. Clinicians may use report images as footnotes to the text summary. However, the anatomy and pathology of complicated radiology studies may be difficult to convey by a traditional method even if key images and hyperlinks are included. Live video conferencing is a modern technology available to

radiologists for connecting remotely with clinicians, but this is not yet widely used given the inherent time commitment required and elaborated technology.

Providing clinicians with a supplemental audiovisual report could deliver an engaging experience similar to an in-person consult with the radiologist focused on simplification of a complicated case. Those videos contents could be viewed at the convenience of the ordering provider to minimize disruptions in workflow and retain the radiologist's essential role in a multi-disciplinary team. Also, audiovisual reports could be sent or shared to the patients for better understanding of their conditions and re-insert the radiologist as another health provider in clinical care [8].

There is little information on current literature about audio and video capture of radiology studies [9]. However, since video reporting has not been integrated into a PACS, it has not undergone a real workflow evaluation, such as in this study. Modern web technology and screen capture software allow for development of an environment where AV files can be easily created and shared with clinicians using cloud technology.

In this project, an audio/video radiology reporting tool is created using screen capture software integrated with local PACS that stores and serves videos. Our hypothesis is that the audiovisual report adds value to the traditional text report in clinical management of emergency musculoskeletal cases.

## Materials and Methods

This study was approved by the Institutional Review Board and was compliant with HIPAA guidelines. Informed consent was obtained for participants included in the study. After institutional review board approval, all the magnetic resonance (MR) and computed tomography (CT) musculoskeletal studies ordered from the emergency department at our hospital were included during the 2 months of the study, for a total of 47 cases. Exams were anonymized using a built-in PACS hot-key feature in order to prevent release of patient information.

Video reports were created using *Screencast-O-Matic* screen capture software (Seattle, WA) in a personal password protected computer from the hospital. A standard radiology workstation dictaphone was used for audio recording. Videos were saved in MP4 format and uploaded to the institution's PACS using the software's application programming interface (API), following HIPAA guidelines with interoperability via HL7. No Digital Imaging and Communications in Medicine (DICOM) data or patient-protected information was released or stored outside of the hospital's PACS. Seven attending musculoskeletal radiologists with experience ranging from 6 to 15 years and mean ( $\pm$  SD) age of  $41.1 \pm 3.3$  years created the videos from the ordered cases.

The audiovisual report was generated for all musculoskeletal cases from the emergency department during the 2 months of the

study. Both normal and abnormal interpretations were included in the study. Normal anatomy was highlighted with the mouse arrow for cases with high clinical suspicion but no pathology such as: “there is no acetabular fracture, the bone structures of the right hip are unremarkable”. This was intended to reassure referring clinicians that abnormalities had been ruled out, while providing educational value.

The creation of videos occurred after to the dictation of preliminary text reports. The radiologist then opens the screen capture software and generates the video narrating and showing the radiologist’s workstation screen. Audiovisual reports were limited to 2 min in duration and focused on pertinent positives or negatives of a case. For example, while recording the audiovisual report, the radiologist may move the mouse and point to relevant findings of an image while speaking, “this patient has a proximal femur fracture here”, or any other relevant finding. Final text report and audiovisual reports were available almost at the same time, after pressing the “approve” button for the text report and “save” button for the video by the radiologist in any order. Details and incidental findings could be found in the text report. In all cases, the content within the movie remained consistent with findings in the text report. Thus, videos served a supplemental role in the reporting process, similar to telephone or in-person communication of results. Clinicians were encouraged but not obligated to watch the videos uploaded in hospital’s PACS, without specific instructions on which to evaluate first, text or audiovisual report and without disrupting workflow in the emergency department. After viewing the videos, the provider could opt to delete its content by clicking a website button. Alternatively, videos could automatically be expunged from cloud storage within 24 h, as a security measure due to the fact that the audiovisual reports were used as supplemental form of communication between radiology staff and orthopedic surgeons in this work, such as a telephone call. All the cases include were from the emergency department and required fast clinical decision-making. Therefore, the deletion of the video content in 24 h would not affect patient care. Text reports were not deleted and could be accessed by the patients and clinicians at any time.

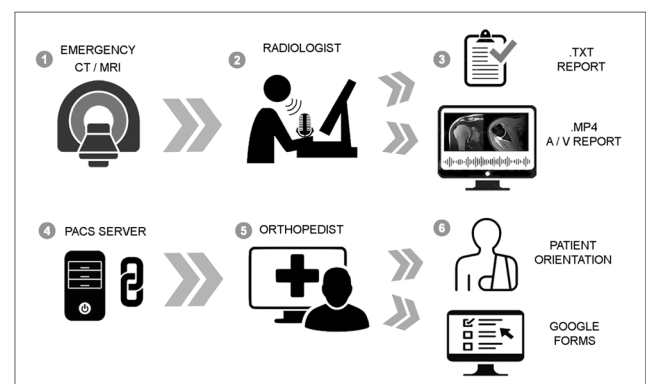
After viewing the videos and reading the text reports, participating clinicians were provided a several question survey via secure email. The cases included in this study were anonymized with continuous numbering bases on the date of the study. Questions were asked using two online questionnaires (Google Forms). The first questionnaire was related to each case that the ordering physician was involved in based on the date and order that the imaging studies were performed. However, any ordering physician of the orthopedic surgery staff could answer this first questionnaire related to any case included in this research. The questions in the first questionnaire were: (1) Did the audiovisual report answer the clinical suspicion? (2) What is the complexity of this case? (3) Did the audiovisual report make the alterations more understandable than the traditional report?(4) Would you like to receive audiovisual reports again?; (5) In comparison to

the traditional one, was the evaluation time of the audiovisual report faster, similar, indifferent, or slower? (6) Would you forward this audio-visual report to the patient and family members? The scoring system was based on a 0–4 scale, being 0: totally disagree, 1: partially disagree, 2: neither agree or disagree, 3: partially agree, 4: totally agree.

The second questionnaire was applied at the end of the 2 months study to assess (from 12 April 2018 to 2 April 2019) the experience of the referring physicians with the audiovisual reports in a broader fashion. The questionnaire included questions and affirmations to measure the concordance in a Likert-type scale, with exception of the question regarding experience time in the orthopedic surgery field. The questions and affirmations of the second questionnaire were: (1) How many years of experience in the orthopedic surgery field do you have? (2) I prefer the text report instead of the audiovisual report.(3) The audiovisual report dispenses face-to-face discussion with the radiologist. (4) The audiovisual report is not needed in usual or low complexity cases. (5) I believe that the audiovisual report may have the same legal value as the text report. (6) The audiovisual report should be restricted to health professionals. (7) I would like to receive the audiovisual report as routine (outpatients). (8) The audiovisual report improves understanding in more complex cases. (9) The audiovisual report is sufficient for decision-making. Clinicians were only asked to evaluate the video reporting system as a supplement to text reports. The workflow is summarized in Fig. 1.

Data were summarized using simple frequencies and relative (percentages) and represented by bar graphs and pie charts. Fisher’s exact test was applied to analyze the associations between the questions and the degree of complexity of the cases.

The graphics were produced using Microsoft Office Excel. Data analysis was performed in the statistical program ‘R’ for Windows using the ‘Rcmdr’ package and the ‘RStudio’ platform.



**Fig. 1** Summarized steps of the workflow. 1: Acquisition of the CT or MRI images. 2: Case evaluation by the radiologist. 3: Creation and saving the text report and the audiovisual report. 4: Files are uploaded to PACS server. 5: Orthopedist reads the radiology text report and the watches the audiovisual report. 6: Clinical decision and patient orientation. After this final step, the orthopedic surgeons answer the questionnaires

## Results

Creation of the audiovisual report took less than 5 min for each case, once each radiologist was familiar with the screen capture software. The purpose of the videos is to reflect the radiologist's point-of-view in each case, including the sequences used to evaluate the findings and pointing to relevant alterations. Each video was less than 2 min in length, ranging in size from 2 to 12 megabytes (MBs), and was automatically uploaded as a new series on PACS in less than 10 s after the radiologist reviewed and finished the report. Videos in MP4 format were accepted by the hospitals PACS and could be replayed on a desktop computer or handheld device such as a tablet or smartphone. Direct inquiries of the cloud database confirmed that videos could be manually deleted after viewing or were automatically expunged from storage 24 h after uploading. In all cases, the corresponding video links sent to providers and web application worked as expected using a modern web browser on a desktop computer or handheld device.

Nine (9) of 11 ordering physicians answered the first questionnaire; however, the number of cases seen by each was variable. While some evaluated only one case, others rated more than one, including one ordering physician who analyzed 29 cases. Overall, the study evaluated 47 cases, of which 35 were seen by only one doctor, ten cases were evaluated by two physicians, and two cases by four physicians, totaling 63 questionnaire responses. This may be due different age, seniority, and schedule of orthopedic surgeons of this study. Consequently, more than one physician could be responsible for each case.

The professionals also classified the exams as high complexity, low complexity, and normal examination (without changes). Over half of the cases were considered to be low complexity (32 responses, 50.8%), 8 were normal (12.7%), and 23 were highly complex (36.5%). In cases evaluated by more than one ordering physician, the complexity of the case was not always agreed upon. In some situations, the same exam was considered to be high and low complexity by different professionals (cases 2, 15, 40, and 59).

In three questions in the questionnaire (1, 3, and 6), the physicians agreed using a Likert scale of 1 to 5 points. The distribution of answers given to these questions is in Figs. 2, 3, and 4.

In all assessed cases, physicians fully agreed that the audiovisual report confirmed the clinical suspicion. In relation to making the changes more comprehensible compared with the traditional report, in most cases, the physician fully agreed (52 observations, 82.5%), in 10 cases, the physician partially agreed (15.9%), and in one case, the physician considered it indifferent (1.6%). Such understanding was similar in cases of high and low complexity (87.0% of total agreement in cases of high complexity, compared with 84.4% in cases of low

complexity). Considering the 8 cases of normal exams (without changes), in 6, there was full agreement regarding comprehension, and in 2 cases, agreement was partial. There was no association between improved understanding of the alterations and case complexity ( $p = 0.7$ ).

In regard to the transmission of the audiovisual report to patients and their families, the variability of responses was greater: 20 totally agreed (31.8%), 13 partially agreed (20.6%), one judged it to be indifferent (1.6%), one partially disagreed (1.6%), and in 28, there was complete disagreement (44.4%). All of the "totally disagree" responses were reported by a single physician. The results of this question and the answers of each physician are available in Fig. 2.

In regard to receiving reports in audiovisual format again, in 60 cases (95.2%) doctors replied that they would certainly like to receive them in this format. Considering the total of 9 physicians, six answered "certainly", two physicians who evaluated only 1 case responded that they would probably like it (4.8%), and one doctor who evaluated 4 cases answered "certainly" in three and "probably" in one case.

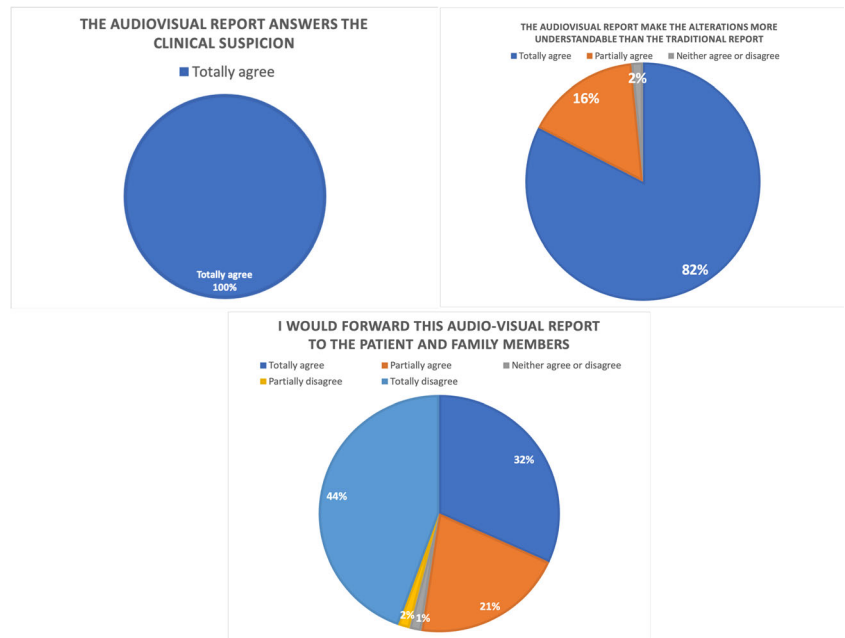
Considering the time of evaluation in this type of report compared with the traditional one, 48 considered it faster (76.2%) and 15 considered it indifferent or similar (23.8%). In 95.8% of cases considered to be "high complexity", the ordering physician believed that the audiovisual report had a faster evaluation time than the traditional one. In cases considered to be "normal", this percentage fell to 87.5%; while cases considered "low complexity" had a faster evaluation time in only 59.4% of cases and indifferent or similar in 40.6% (Fig. 4). This time, therefore, varies according to case complexity and is more optimized for cases of high complexity. This association was statistically significant ( $p = 0.002$ , Fisher's exact test).

Eleven orthopedic surgeons participated in this study. The mean ( $\pm$  SD) age was  $34.5 \pm 2.9$  years. Most of the orthopedic surgeons (73%) had at least 5 years of experience in the field. The aim of the questionnaires was to inquire about the medical experience of an alternative form of radiological report, which could supplement or even replace the evaluation by text-only reports. Due to being answered in urgent care situations, the questionnaire was limited to 6 direct questions.

The response to clinical suspicion was adequate in all cases. The majority of physicians reported better understanding of the audiovisual reports compared with the traditional one. All agreed to receive the reports in audiovisual format in future appointments.

Professionals were asked to rate the cases obtained according to the presenting complexity. Although there was a disparity regarding the classification in some cases, there was a perception of optimization of the evaluation time regarding the audiovisual report in cases classified as "high complexity". This perception was not so evident when the cases were classified as "low complexity"—approximately

**Fig. 2** Distribution of answers given to questions 1, 3, and 6 of the questionnaire

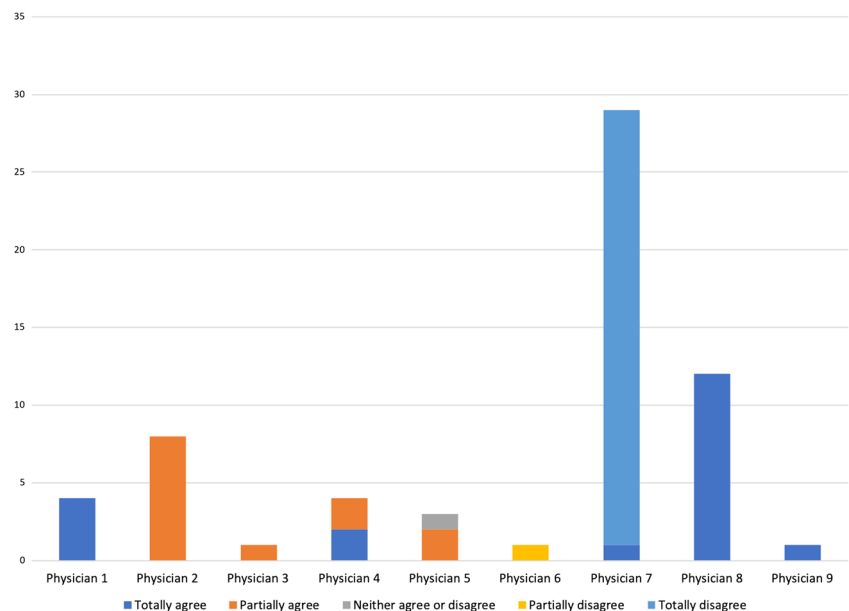


40% of the respondents stated that the assessment time, in these cases, did not differ from the traditional one.

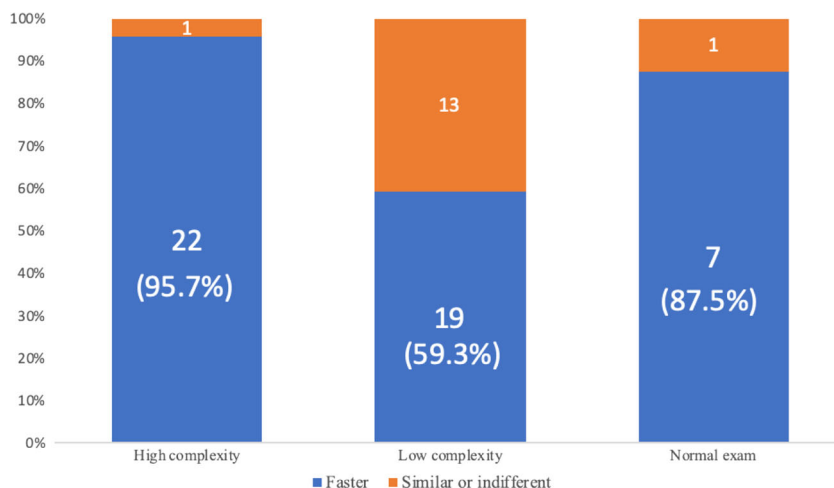
In regard to the last question of the questionnaire—“would you forward this audio-visual report to the patient and family members?”—it is important to note the number of responses of a single physician in the sample and low variability of responses when respondents are observed separately. This data reveals an intense individuality regarding the treatment, communication, and delivery of information between physicians and their patients, and their reasons could be the focus of possible research in future analyses.

The answers of the second questionnaire are outlined in Fig. 4. Only 18.2% of participants reported to prefer the traditional text report over the audiovisual report. We observed that 54.6% of the ordering physicians agreed that the audiovisual report dispenses in-person discussion with the radiologist. One interesting response was that 72.8% of participants agreed that the audiovisual report might not be necessary in low complexity cases. However, all ordering physicians agreed that the audiovisual report improves understanding of complex cases and is sufficient for decision-making in patient care.

**Fig. 3** Physicians’ answers about the transmission of the audiovisual report to patients and their families in relation to number of evaluated cases



**Fig. 4** Evaluation time of the audiovisual report in relation to the traditional one according to complexity of the case



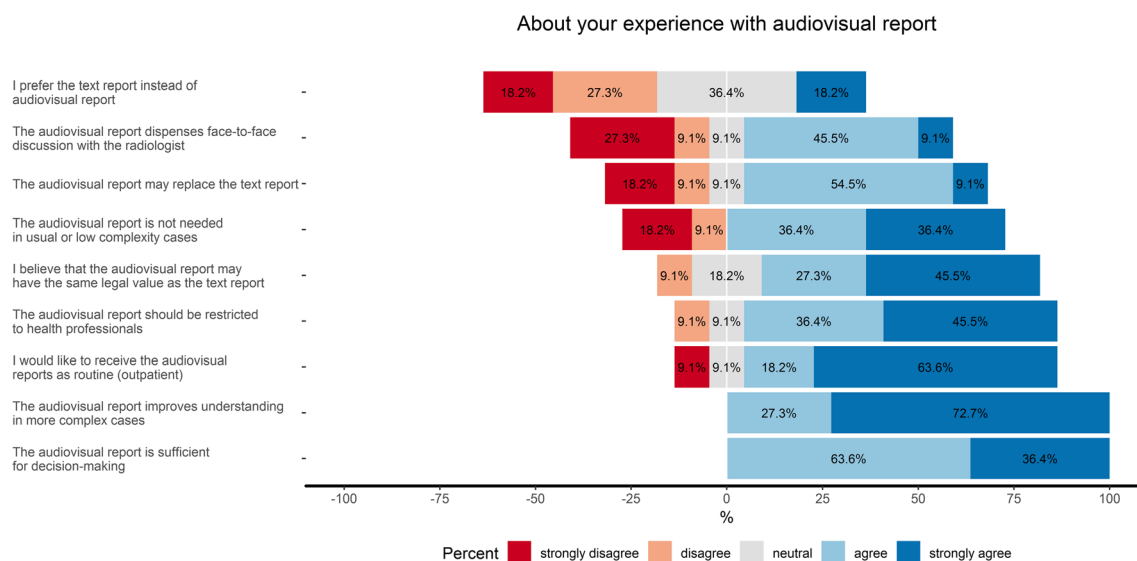
Based on the data obtained in this research, the audiovisual report seems to have potential for application in routine professional practice with a good response in terms of agility of evaluation and quality of information passed on to ordering physicians, helping in decision-making, especially in cases of high complexity (Fig. 5).

### Discussion

Throughout the years, little progress has been made in the format of radiology text reports. There is a growing concern from radiologists to improve communication with clinical providers and patients to regain their position as a crucial part of healthcare [7]. Decentralized reading rooms in hospitals and in radiology practices may increase productivity with high volume of reports, but also reduces participation of radiologists in clinical/surgical rounds and limits accessibility of the radiology team for eventual

in-person consultation. Campaigns such as “Radiology Cares” and “The Face of Radiology” [10, 11] are focused on reducing the distance between the radiology team and other healthcare providers and patients.

Audiovisual reports are a new and promising tool with potential to increase engagement of the ordering physicians and patients with the radiologist’s work. Screen capture tools have been available for a long time, although its use in radiology has few reports on the literature, mostly in research and academic purposes [9, 12]. This may be due to an inherent discomfort towards using this technology for imaging study report purposes. They may take longer to create and edit in comparison to traditional and well-established text reports. The elaboration of a medical audiovisual report in a comfortable and easy-to-use application fully integrated with PACS and EMR for patient confidentiality could empower radiologists and increase the perception of quality and precision in their work when evaluated by other physicians and patients.



**Fig. 5** Distribution of answers given to questions of the second questionnaire

In this work, a dedicated workflow was developed to upload and share radiology video reports with referring clinicians using screen capture software integrated with the institution's PACS for urgent musculoskeletal cases. This evaluation suggests the feasibility of an enhanced radiology reporting system that includes an audio/visual platform to help focus on pertinent findings for referring clinicians and facilitates decision-making in treatment. Our study suggests that the audiovisual report has potential to replace conventional text-based reports, as it showed to be easier and faster to understand and to answer clinical questions in all cases. However, this technology may not be so useful in normal cases and does not include other minor findings that may be helpful in a medical legal setting.

Short-term video communication between physicians and radiologists also serves as a platform for teaching videos and case conference presentations [13]. Such technology may also enable referring clinicians an efficient means to share radiologic images with their patients on handheld devices, such as smartphones and tablets [12]. Protected health information in this project was safeguarded through use of a PACS feature that hides annotations on clinical images. Additionally, the videos could only be recovered using a confidential link known only by the radiologist and referring clinician. Further security was provided by ensuring that all content was automatically deleted within 24 h of posting, if not by the user, after viewing. However, a practical implementation must ensure a high level of security by requiring registered users to provide passwords prior to viewing videos in the final product. Acceptance of online video reporting may also depend on the continued adoption of cloud storage technology and development of adequate security measures.

One surprising observation of our study is that most referring physicians were not willing to share the audiovisual report with family or patients. This may be due to an insecurity of the impact of this new technology in the patient's understanding of the care by providers. In our opinion, a radiology report containing a video with the radiologist narrating and pointing to the findings is a great tool to increase the patient's knowledge of their own condition and also reduces the anxiety that a technical text-only report may bring. A recent study showed that traditional lumbar spine MRI reports are too complex for the average patient to comprehend [14]. This is an important observation to consider as patients are increasingly accessing online portals to view their imaging studies and read reports. In the current world, the internet and social media provides a great amount of audio and video content. The ease of finding information on the web translates into rapid growth of search for health doubts and concerns [15]. A recent report showed that 59% of adults were looking up health information online, including popular social media such as the video platform YouTube [15]. We think that an audiovisual report with medical content meets the patient's expectation of a dynamic way of expressing the findings of their imaging studies, although the patient's experience with the audiovisual reports was not assessed in this work.

## Limitations

The reported use of an audiovisual report tool in emergency musculoskeletal cases was feasible in a research environment. Only half of the local musculoskeletal radiology staff was evolved in this project as a restriction measure not to affect the efficiency of the radiology team. However, the fact that during the 2 months of the study only 47 cases from the emergency department had musculoskeletal imaging studies, could infer that the radiology team division to produce audiovisual reports might not be necessary as a routine measure.

The radiologists' experience with this new technology and the learning curve for the creation of the audiovisual content were not the focus of this work and could be studied in other research. In our opinion, this tool could be used in all cases from the emergency department at our institution as part of the regular workflow. The custom-made integrated solution with local PACS involved screen capture software, making this process faster. Allowing for these disparate parts, total time for producing and uploading the video was less than 5 min for each case. This would support the future viability of video technology from the radiology perspective. In high volume settings, video reporting may affect productivity if both video and text reports have to be made. They could be only applicable in some settings such as a complete substitute for the text report, with a direct request by the ordering physicians, for select cases that are difficult to articulate by text alone, or even in urgent cases only to answer a single clinical question, such as joint dislocation and/or fractures.

The creation of supplemental video reports creates potential conflicts with text reports if they are made by different radiologists. We emphasize that the audiovisual reports should be made simultaneously with the creation of text reports by the same radiologist to reduce discrepant findings. Inconsistencies could arise between the two forms, and it is the radiologist's responsibility to keep both consistent, such as a phone communication of the imaging findings.

One limitation that must be noted is the most significant participation of at least two physicians in the questionnaire response, who were mainly responsible for the prompt care of the hospital. As stated above, this may be related to different age, seniority and schedule of orthopedic surgeons of the emergency department. Therefore, more than one physician could be responsible for each case, helping in clinical decision making for patient care, as well as responding the questionnaires of this work. Consequently, a misleading observation can be made of the sample collected (41 of the 63 responses obtained were given by only two physicians). Also, the questionnaires have important considerations, such as the limited number of questions (information bias), due to being an emergency environment and a low sample size with a probable selection bias.

Even with these limitations, the results show the potential of this new form of radiological report. Therefore, these findings can be complemented by studies with larger sample size and more comprehensive questionnaires.

## Conclusion

This work focuses on audiovisual reports being a supplemental form of communication in emergency department musculoskeletal cases. An application was created to integrate the video content in PACS, allowing an initial evaluation of this form of supplemental radiology reporting system in the workflow of musculoskeletal urgent cases. This report format provides case summaries, pointing and explaining relevant the imaging findings as well as answering specific clinical questions. Our evaluation suggests that it may improve communication between radiologists and referring providers while making the imaging studies' findings easier and faster to understand.

Further studies are necessary to access the acceptance of this form of radiology report in non-urgent cases and other radiology specialties such as neuroradiology, internal medicine, breast imaging, and interventional radiology. Continued development of integration of the described audiovisual report with traditional radiology workflow may encourage future adoption. The transformation of audiovisual report into a billable and profitable radiology activity with the potential of replacing the traditional text report will likely be determined by its acceptance by radiologists, ordering physicians and patients, after its widespread acknowledgement and proven effectiveness for healthcare improvement.

**Acknowledgements** The authors would like to thank the orthopedic surgeons and radiologists involved in this work.

**Availability of Data and Materials** The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

**Authors' Contributions** IG provided the clinical data included in the text. IG wrote the manuscript draft. IG and LPN revised it critically and approved the modified text. IG, LPN, and AS approved the final version of the manuscript. All authors read and approved the final manuscript.

## Compliance with Ethical Standards

**Ethics Approval and Consent to Participate** This study was approved by the Institutional Review Board and was compliant with HIPAA guidelines.

**Consent for Publication** A written informed consent was obtained from the subjects for publication.

**Competing Interests** The authors declare that they have no competing interests.

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