Efficient Collaboration Between Radiologists Using the PACS-Integrated Refer Function to Reduce Communication Times

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Abstract

The purpose of this study was to assess the utility of a picture archiving and communication systems (PACS)-integrated refer function for improving collaboration between radiologists and radiographers during daily reading sessions. Retrospective analysis was conducted on refers sent by radiologists using a PACS-integrated refer system from March 2020 to December 2021. Refers were categorized according to receiver: radiologists in the same division (intra-division), radiologists in a different division (inter-division), and radiographers. The proportions of answered refers, content of refers, and timing of refer posts were evaluated. Additionally, time intervals in minutes from initial refer post to refer response were assessed to assess the efficiency of the refer system and compared according to receivers using the Mann–Whitney U test. Among a total of 691 refers posted by radiologists, 579 (83.8%) were answered directly using the refer function in PACS. Of the answered refers, 346 refers (59.8%) were made between radiologists, and 173 (50%) were intra-division refers. About the content of refers, about 82.6% of radiologists' refers were about imaging interpretation consultation, and about 98.9% of refers from radiologists to radiographers were for image quality control. The median time interval until refer response was 9 min, and this response time did not differ between intra-division and inter-division refers ($p = 0.998$). Of the refers that got responses, 74.3% (257/346) were sent among radiologists before official reports were made, and the median time until refer response was 9–10 min. The proportion of refers answered by radiographers was 85.7% (233/272). The median time interval until refer response by radiographers was 87 min for all refers, and 63% were made within 6 h. Therefore, the PACS-integrated refer function can facilitate communication between radiologists for image interpretation and quality control.

Keywords Radiologists · Communication · Workflow · Reading · Quality control

Abbreviation
PACS   Picture archiving and communication system

Introduction

The picture archiving and communication system (PACS) has established itself as an efficient integration system that improves the overall workflow of radiologists [1, 2]. It plays an important communications role by storing, transferring, and displaying medical images to radiologists, radiographers, and clinicians [1, 3]. PACS provides a comprehensive way to access images, report, and display readings, and continues to evolve at a rapid pace with its integration into electronic medical reports [4]. With the implementation of PACS, healthcare professionals have found it easier to store and utilize medical imaging examinations. The ability to access and refer to recorded interpretations, important images, and annotated findings within PACS has significantly facilitated the process of referencing imaging results. In this regard, the utilization of PACS has marked a crucial turning point in the utilization and communication of medical imaging.

Efficient communication throughout the radiology department is a key factor for obtaining accurate imaging results. In previous studies, communication was shown to improve after the introduction of PACS and about 70% of cases benefited from technologists' notes in PACS that were made available to radiologists during interpretations [5–7]. In addition, a PACS-integrated peer review system was introduced to strengthen collaboration between

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radiologists [8]. However, the methods proposed so far have facilitated communication within PACS by allowing the inclusion of keywords or annotations on the images. It should be clarified that there is currently no published evidence supporting the claim that PACS has directly aided in the process of direct communication among healthcare professionals. In practice, when there is a need for communication, healthcare professionals have traditionally resorted to face-to-face interactions or phone calls, rather than utilizing PACS for direct communication. These methods have been deemed inefficient and ineffective in facilitating smooth and efficient communication due to the additional time required for physically seeking out individuals or locating phone numbers. The ability to chat within PACS or engage in direct communication related to patient images has not been available thus far. Therefore, no study

has demonstrated the direct integration of a communication function in PACS and objectively assessed the impact of this function on communication among radiologists in everyday clinical practice.

However, recently, a PACS-integrated communication function, named the refer system, is a subsystem of the messaging application in PACS, and this has been implemented in our institution that enables direct communication between radiologists or radiologic technologists through chat, specifically related to the interpretation of patient images conducted through PACS. This system has been actively utilized in real clinical settings. Therefore, the purpose of this study was to demonstrate the actual utility of the PACS-integrated communication function in daily readings through evaluation and comparison of communication times to assess how it improved the radiology workflow.
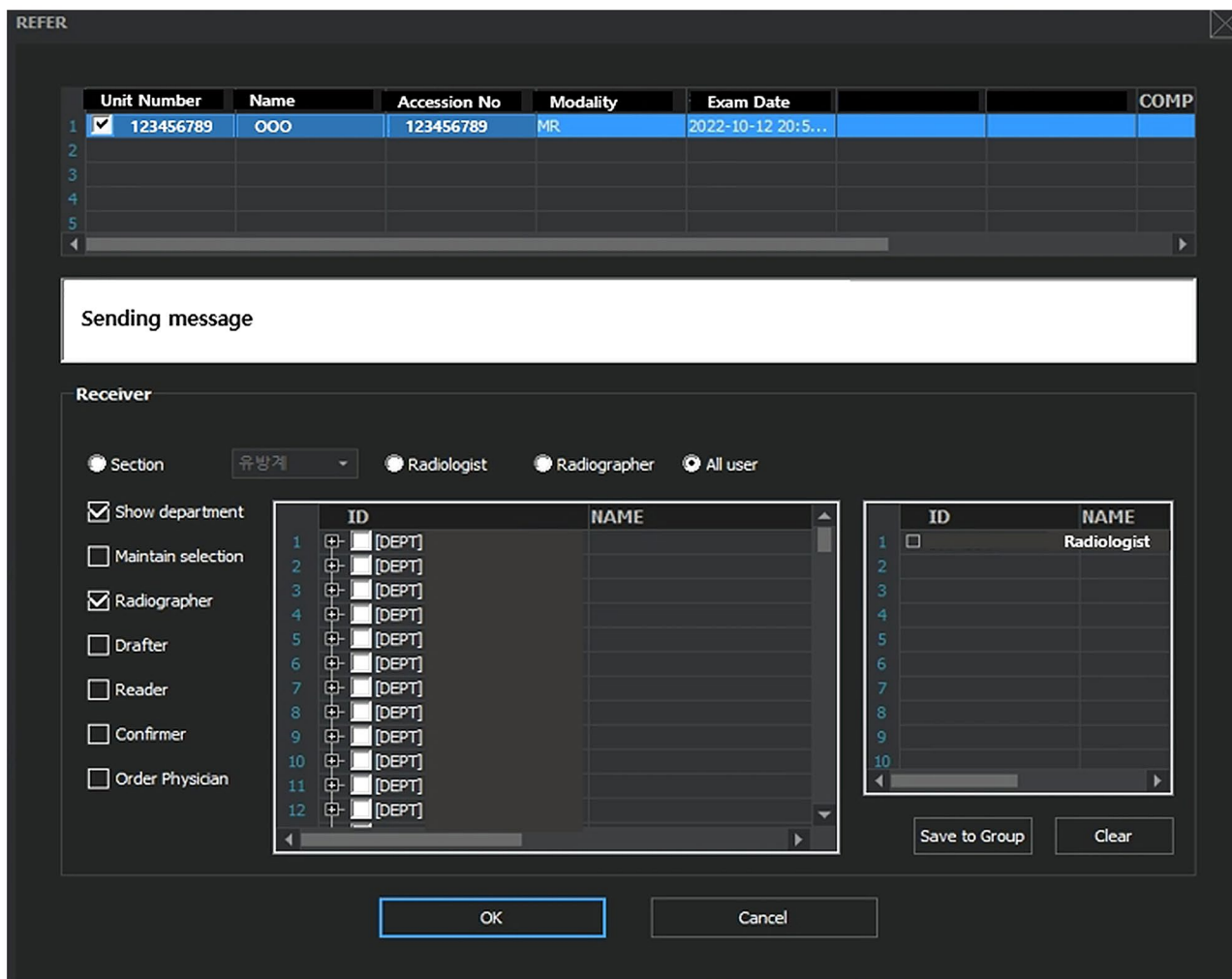

Fig. 1 The refer function on PACS. By clicking on the image on the worklist that they wish to discuss, radiologists could send a new refer post to other radiologists or radiographers. The performing radiographer or report radiologist was automatically selected as default on PACS, but users can freely change the receivers of the refer posts by activating or deactivating check boxes (name and unit number are blinded)

Methods

Ethics Statement

The Institutional Review Board of our hospital approved this retrospective study (No. 9–2022-0165), and the requirement for informed consent was waived. The study was conducted according to the guidelines of the Declaration of Helsinki and Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).

A PACS-Integrated Communication Function: the Refer System

Our institution uses a PACS-integrated refer system, which is a messaging application embedded directly in PACS (Zetta PACS, Taeyoung Soft Co. Ltd., Korea). A refer post aids users by grouping messages sent through the system with their replies on a specific imaging study in PACS. Radiologists can create a refer post simply by selecting an imaging study from the worklist and picking a particular person to whom they wish to send the refer message (Fig. 1). All radiographers and radiologists included in the PACS database are listed as potential receivers of messages. While the radiographers who perform the imaging study are automatically selected as receivers by default, any other PACS user can be invited or deselected from the same refer post. There are three panels in the refer window with the headings, "receive," "send," and "history." After a refer post is submitted, the receive panel automatically pops up on the receiver's PACS viewer if the receiver is logged into the system and displays the refer post. Receivers can directly reply to the message, and their responses automatically show up on the sender's PACS viewer. The sender can view the replies in the send panel at any time (Fig. 2). Closed refers are archieved separately in the history panel, and all PACS users can retrieve past refer posts for review (Fig. 3). Time records are also available for each refer post. The referred imaging study can also be brought up on the PACS viewer by double-clicking the refer list which is shown in all three panels (send, receive, history).
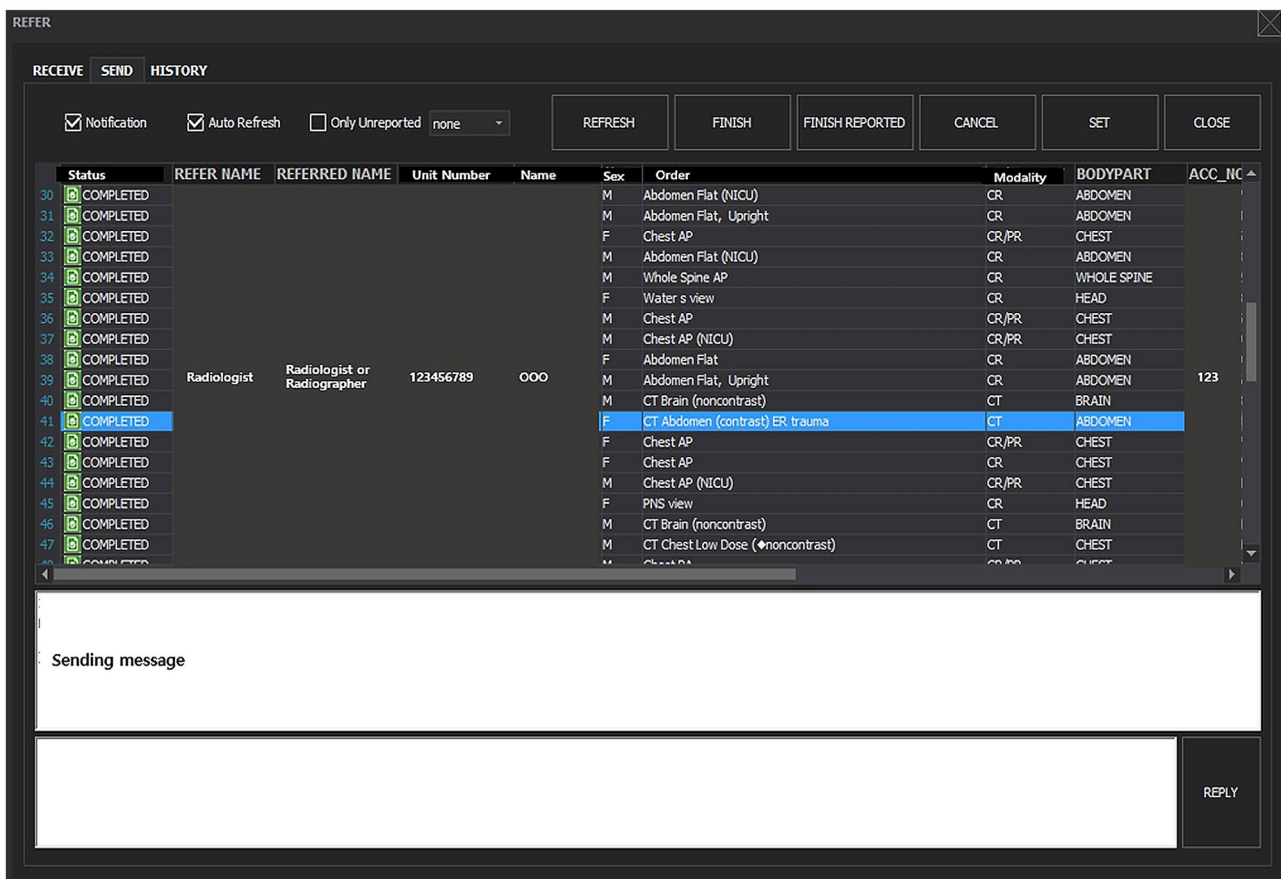

Fig. 2 Send panel of the refer window. By replying to messages directly on PACS, users can answer questions and share images. Ongoing feedback discussions are also possible for each refer as responses are recorded under the refer post of interest and there is a time record for all communication (name and unit number are blinded)

Fig. 3 History panel of the refer window. Users can review all refers including messages, relevant images, and time of post, and this data can be used to check for quality control in the department (name and unit number are blinded)

Utility Analysis of the Refer Function by Radiologists

We retrospectively analyzed the number of refers sent by radiologists using this refer function in PACS from March 2020 to December 2021. The number of refers was divided according to the receiver; radiologists in the same division (intra-division), radiologists in a different division (inter-division), and radiographers. For example, "intra-division" refers to the scenario where specialists within the same subspecialty, such as breast imaging, engage in discussions, and consultations regarding specific imaging cases about breast imaging. On the other hand, "inter-division" signifies situations where a breast imaging specialist seeks answer from a specialist in another subspecialty, such as chest imaging, regarding imaging findings. This distinction is made to account for the varying accessibility between specialists within the same subspecialty, and it emphasizes the need for specific considerations based on whether the subspecialties are the same or different within the field of radiology. The term "division" encompasses a total of eight subspecialties, including thoracic, abdominal, genitourinary, musculoskeletal, neuro, breast-thyroid, pediatric, and interventional radiology. However, nuclear medicine, being a separate field from diagnostic radiology in our country, was not included in these divisions.

Refers were also analyzed by the modalities used for the imaging study of interest. Imaging modalities were classified as computed radiography (CR), ultrasonography (US), computed tomography (CT)/magnetic resonance imaging (MRI), and others which included mammography, fluoroscopy, and interventional procedure-related images. To assess the content of the sent refers, they were categorized into four categories: consultation to gather opinions on image interpretation, image quality control, sharing the obtained results or giving feedback on the interpretation, and others. To evaluate response to the sent refers, the proportion of answered refers via PACS were calculated. In addition, we counted the number of refers that were sent before the official reports of corresponding images were made. This was done to assess whether radiologists sent the refers to get a second opinion or to modify the acquisition techniques for capturing the images being sent to radiologists for interpretation. When the refers were sent after official reports were uploaded, we assumed that radiologists wanted to share their results with colleagues or give feedback about the technical aspects of the imaging study with radiographers.

The time interval in minutes from sending a refer (initial refer post) to getting a response (refer response) was assessed to evaluate the effectiveness with which radiologists utilize

the refer system in their clinical workflow. The time was automatically recorded in the PACS log file and could be retrieved from the history file. For the refer posts between radiologists and radiographers, the amount of time taken for answering refers was subdivided as 0–6 h, 6–12 h, 12–24 h, and more than 24 h because radiographers work in three shifts in our hospital, and this could affect the checking and response times during online access of PACS.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was used to test for normality. Mann–Whitney U test was used to compare time intervals among the three groups. A p-value less than 0.05 was considered statistically significant.

Results

During the study period, a total of 481,594 exams were conducted in the radiology department of our hospital, and among them, a total of 691 refers were sent by radiologists using PACS. Refers were most frequently posted for imaging studies with CT/MRI for all refers (426/691, 61.7%). Between radiologists, refers were most frequently sent for CT/MRI regardless of division (319/419, 76.1%), while refers were most frequently sent for CR from radiologists to radiographers (154/272, 56.6%) (Table 1).

Regarding the content of the refers, the majority of the content of intra-division refers was related to consultation, accounting for 171 out of 208 (82.2%). Similarly, in inter-division refers, consultation was also the most prevalent

category, with 175 out of 211 (82.9%) refers falling into this category. Among the refers sent from radiologists to radiographers, the dominant content was related to image quality control, representing 269 out of 272 (98.9%) refers.

Among them, 579 (83.8%) were answered directly using the refer function of PACS. Of the answered refers, 346 refers (59.8%) were between radiologists, and 173 (30% of all answered refers, 50% of answered refers between radiologists) were intra-division refers. The median time interval for refer response between radiologists was 9 min, and this did not differ between intra-division and inter-division ($p = 0.998$).

The refers between radiologists could be divided as those sent before and after the official reports of the referred examinations were made. Among the answered refers, 70.5% (122/173) and 78% (135/173) were sent between radiologists before the official reports were made to obtain a second opinion during image interpretation. The median time interval to refer response was 9–10 min, and this did not differ according to division ($p = 0.998$). The remaining refers were sent after the official reports were uploaded, and we assume they were posted to share the results of imaging studies with other radiologists.

The proportion of answered refers sent from radiologists to radiographers was 85.7% (233/272). About 79.4% (185/233) were sent before giving official reports. The median time interval for refer response by radiographers was 87 min for all refers and 86 min for refers sent before reading. Among all the answered refers by radiographers, the time taken for refer response was as follows: 0–6 h: 63.1% (147/233); 6–12 h: 6.4% (15/233); 12–24 h: 13.3% (31/233); and more than 24 h: 17.2% (40/233). When analyzing the response times for refers sent by radiologists to radiographers, segmented by modality, we observed the following

Table 1 Number and time interval of refer messages between radiologists and radiographers

	R→R (intra-division)[1]	R→R (inter-division)[2]	R→T	Total	p-value[1 vs. 2]
Total number of refers sent	208	211	272	691	
Modalities (CR:US: CT/MR: etc.)	6:31:151:20	38:4:168:1	154:4:107:7	198:39:426:28	
Number of refers categorized by content (consultation: quality control: share results and feedback: etc.)	171:15:13:9	175:25:7:4	0:269:0:3	346:309:20:16	
Number of refer responses via PACS (%)	173 (83.2%)	173 (82%)	233 (85.7%)	579 (83.8%)	
Median time interval for refer response (minute)	9 (4–29)	9 (3–51.5)	87 (13.5–868.5)	17 (4–236)	0.998
Proportion of refers answered before reading (%)	122 (70.5%)	135 (78%)	185 (79.4%)	442 (76.3%)	
Median time interval to refer response before reading (minute)	10 (4–28.5)	9 (3–50)	86 (14–847)	18 (5–176.5)	0.998

Data are presented as numbers with percentages or interquartile ranges

R radiologist, *T* radiographer, *CR* computed radiography, *US* ultrasonography, *C* computed tomography *MRI* magnetic resonance imaging, etc., mammography, fluoroscopy, and interventional procedure-related images

median response times: 87 min for CR, 127 min for US, 48 min for CT/MR, and 22 min for other modalities.

Discussion

Our study demonstrated the actual utility of a refer function that this is well integrated in PACS. We objectively quantified the impact of implementation on communication between radiologists and radiographers by measuring the number of refers and time until refer response. Nine minutes to response from radiologists was a surprising and impressive result, and this finding implies that the refer function is a quick and efficient tool for facilitating discussions about images between radiologists. Radiographers took more than an hour to respond, perhaps because they need more time to evaluate the problem and provide solutions. Another factor to consider is that radiographers work in three shifts, unlike radiologists, and this would have affected how and when they check PACS. Even so, 63% of refers answered by radiographers were done within 6 h which is an encouraging result. The PACS-integrated refer function acts as an efficient tool to communicate with radiographers, because radiologists will not need to call or find each radiographer who took the relevant images, and sending a simple refer via PACS is enough for discussions to take place on protocol or problems during image acquisition. In addition, it allows radiographers enough time to assess problems. We could suggest that the PACS-integrated refer function is the most efficient way to communicate with other radiologists and radiographers on image acquisition. In addition, this system could be used to share educational material or quality control examples between radiographers. Enabling the direct opening of referred images with relevant messages on PACS could facilitate the feedback process by sharing technical problems that have arisen during image acquisition in the radiology department.

Previous studies discussed the importance of PACS as a communication system between radiologists and radiographers [5–7]. Improving communication via note function in PACS resulted in rapid, safe, and high-quality examinations between the radiology department [5]. Contents sent to radiographers were about contrast, protocol, quality control, and patient safety [5, 6]. In addition, this could act as a communication tool between radiologists or with clinicians, for other purposes such as peer review, conferences, lesion tracking, or education [8–11]. With a PACS-integrated alert system, clinicians gain advantages from timely communication for unexpected, but important image findings [12].

However, our method was different from prior studies in several aspects. First, this refer function was directly implemented in PACS, and radiologists could send directly linked images in real time, while they were reading images when they wanted to discuss their findings with others. Even

without the help of additional software, radiologists could easily send the refer by clicking the tab for the examination of interest in the worklist. Second, radiologists could select the receiver of the message by simply clicking on the name of radiologist or radiographer. In addition, when the refer was sent, a message automatically popped up simultaneously on the receivers' PACS whenever the receivers were logged in PACS. Therefore, it was possible to confirm and respond to the refers without delay. In addition, there was no need to seek radiologists or radiographers to solve the problems, and it also allowed the receivers more time to find answers to questions raised by the senders.

Our study was meaningful because we first demonstrated the current clinical usage status of the refer function and answered via PACS. In addition, we proved the content of refers and exact duration taken to answer it. About 82.6% of the refers between radiologists were aimed at seeking opinions on imaging findings. This enables radiologists to consult with each other in their respective areas of expertise, leading to more specialized interpretations and providing immediate assistance in patient diagnosis. Furthermore, 98.9% of the refers between radiologists and radiographers were related to image quality control. Specifically, reaching out to the radiographer who performed the imaging, evaluating the image quality, making adjustments, and requesting immediate corrections are not an easy task and require significant time and effort. However, this result demonstrated that the refer function had advantages by facilitating the exchange of immediate opinions for image quality adjustments during the interpretation process. In addition, about the time, receiving answers from other radiologists in 9 min is an effective way to discuss images. We also demonstrated that the refer function was used not only to discuss findings before official reports were made, but also to share results with other radiologists. A time interval of 87 min to discuss images between radiologists and radiographers is also effective. This system has been routinely used into our department and is now considered an efficient method to enhance communication between radiologists.

This study has several limitations. First, we could not assess the reasons why certain refer posts were not answered via PACS because this was a retrospective study. About 16.2% (112/691) of refers sent through PACS were not answered through it. We suspected that the unanswered refers were answered with the receiver directly contacting the sender, but we could not prove it in this study. Second, we did not assess whether this could affect quality control or even improve it. In addition, although we analyzed and categorized the content of the refers, it was challenging to provide concrete data regarding the influence of radiographers' shift rotations on response times. Therefore, we could only offer interpretations and possibilities based on the results. However, it is important to note that the shift rotations of radiographers differ from those of radiologists in the

field of radiology. During their off-hours, radiographers may not have access to the PACS, which could result in delays in confirming or responding to referrals. This explanation could serve as a persuasive reason for potential delays. Indeed, due to these shift rotations, without the refer function, it would require significantly more effort for radiologists to provide feedback and exchange opinions with radiographers, aligning with the time when the radiographer who performed the imaging returns to work. It is widely agreed upon that this would demand additional resources. Hence, the advantages of the refer function are evident as it facilitates the exchange of feedback and opinions between radiologists and radiographers, overcoming the challenges posed by shift rotations. At last, prior to the implementation of this system, communication typically involved in-person visits or phone calls, making it impossible to directly measure the time spent. As a result, a major limitation of this study was the absence of a control group or direct statistical comparison of time before and after integration of this system. It was not possible to directly measure the time spent on the traditional communication methods of physically visiting or calling the counterpart before the implementation of the refer system. Additionally, even if we retrospectively tried to assess the time taken for communication before the refer system was implemented, it would have been challenging to establish a scientifically accurate measurement method that would warrant the inclusion of a control group. Furthermore, in retrospective study designs like this, objective presentation becomes even more difficult unless measurement is initiated prospectively. Therefore, in this study, we believed that analyzing the actual time data recorded in the PACS system, specifically the time taken for sending and receiving referrals, would provide a more accurate approach for presenting the results. Despite these limitations, we consider the refer system integrated into the PACS to play a meaningful role in clinical practice. Moreover, the measurement approach used was not arbitrary but rather based on the analysis of the information recorded in the PACS log records. Therefore, it is important to note that while direct numerical comparisons were not made, the presented time values were perceived as shorter compared to the time typically spent physically visiting healthcare professionals or searching for contact information and the presented time values still hold meaningful results in a real clinical situation. Future studies are needed to evaluate whether the benefits of improved communication between clinicians extend to patient safety or quality control.

Conclusion

Our study demonstrated that 83.8% of refers sent were answered by radiologists in about 9 min and by radiographers in 87 min using PACS. The PACS-integrated refer function could be used to discuss images with other radiologists before giving official reports, share results after final reports, and also discuss acquisition methods and quality control with radiographers. The utility of PACS-integrated refer function could promote efficient radiologists' communication workflow by reducing time while reading relevant images.

Declarations

Ethics Approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Yongin Severance Hospital (No. 9–2022-0165).

Consent to Participate The requirement of informed consent was waived due to the study's retrospective design.

Conflicts of Interest The authors declare no competing interests.

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