



Practical Use of a Communication Application on Mobile Devices by Our Stroke Team

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Objective: To describe our 1-year experience of the practical use of a mobile communication application by our stroke team.

Methods: The mobile Join application (Allm Inc., Tokyo, Japan) was introduced into our stroke team for the purpose of immediate sharing of the patient information. We analyzed the usage situation for 1 year after the introduction of Join, particularly its efficacy in improving the door-to-puncture time (D2P) for thrombectomy cases, and reported our inter-hospital collaboration with the use of Join.

Results: The total number of events notified by Join was 337, and they included acute stroke potentially leading to reperfusion therapy in 23% (76 events), head trauma in 14%, brain hemorrhage in 12%, other infarction in 10%, subarachnoid hemorrhage in 8%, and the others in 34%. The information of the patients was shared among the team members before arrival to our hospital in 42% of acute stroke cases. Of 31 patients undergoing mechanical thrombectomy, the median interval between arrival and groin puncture for the directly transported patients with/without pre-hospital information was 77.5 min/87 min, respectively, whereas that of the patients transferred from primary hospitals with/without pre-hospital information was 19 min/71 min ($p < 0.0001$), respectively, demonstrating the efficacy of information sharing in advance through Join in improving the timing of endovascular therapy. For inter-hospital collaboration using the telestroke system, we concluded the partnership agreement with three local primary hospitals by communication via Join at a reasonable cost.

Conclusion: Active and effective utilization of the mobile Join application for communication by our stroke team was demonstrated, and it is expected to promote inter-hospital collaboration in stroke treatment.

Keywords ► mechanical thrombectomy, medical informatics, mobile smartphone application, stroke team, telemedicine

Introduction

In Japan, applications for communication among medical staff using smartphones and tablets are being introduced

for the diagnosis and treatment of stroke, but there have been few reports on their actual state of utilization.

Join (Allm Inc., Tokyo) is a communication application for medical workers approved by the pharmaceutical affairs regulatory authorities as a program for general-purpose diagnostic imaging, the security of which is guaranteed by conforming to guidelines proposed by related ministries and agencies.¹⁾ Join makes it possible to have chats within a team using mobile devices and view anonymized DICOM images in the hospital PACS, as well as to share information with other facilities that have adopted Join via a special server. In April 2018, our hospital was the first in the prefecture to install Join for prompt sharing of information among members of the Brain Disease Center, consisting of neurosurgeons and neurologists, and initiation of treatment, relieving the burden on on-call doctors in the stroke care unit, in addition to consultation with orthopedists/radiologists on standby outside the hospital from

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the emergency room. In this study, we analyzed the state of utilization of Join in our hospital, and assessed its usefulness for the diagnosis and treatment of stroke 1 year after its introduction. Moreover, as its application to inter-hospital cooperation has recently been started, its actual situation of utilization in our hospital is reported.

Materials and Methods

Join, which was introduced to our hospital in April 2018, is run by restricting the members to doctors, organizing voluntary groups among doctors with a license to use Join, and allowing registered members in each group to have chats. Concerning the diagnosis and treatment of stroke, the Brain Disease Center group, in which all neurosurgeons and neurologists are registered, was established, and small groups are added as appropriate to be participated in by a small number of staff members. In the orthopedics and radiology departments, a group is organized among emergency room doctors, and consultations with on-call doctors concerning treatment and imaging diagnosis are made through this system. However, this is out of the range of the present analysis.

In this study of the state of utilization of Join in the Brain Disease Center, we analyzed chats about cases and communication conducted based on the judgment that it was necessary to have all members of the Brain Disease Center registered in Join informed regardless of whether it was daytime or nighttime during the 1 year from April 2018 to March 2019. Concerning these chats and communication: (1) Monthly changes in the number of contacts, percentages of contacts at different periods of the day and content of consultations, number of comments and number of persons who commented about each case, and the presence of attached images were analyzed. (2) In patients with cerebral infarction who may have undergone recanalization therapy in particular, the details of actually performed treatments and the time from arrival at the hospital to femoral artery puncture (door-to-puncture time [D2P]) for those who underwent thrombectomy were compared with those before the introduction of Join. (3) In addition, as we have recently worked to develop inter-hospital cooperation using Join, what has been accomplished is reported.

Statistical comparison of two groups was performed by the Mann–Whitney U test using the statistical analysis software Statcel ver. 3 (OMS Publishing Inc., Saitama, Japan).

Results

State of the use of Join in the Brain Disease Center group

During the 1 year after its introduction, Join was used 337 times and 16–35 times per month (median 27.5 times). In the same period, the number of patients hospitalized in the Brain Disease Center of our hospital was 1289 in the year and 77–123 (median: 110) per month. The percentage of patients treated using Join relative to the monthly number of inpatients was 14%–45% (median: 25%) (**Fig. 1**). Join was frequently used in the second half of the year and immediately after its introduction, and the frequency of its use increased, especially in the fourth quarter. Join was used on Saturdays, Sundays, and holidays in 35% of the contacts, and during the nighttime on weekdays in 18%. It was used during off-duty hours in the majority, but was also used during duty hours on weekdays in 47% (**Fig. 2**). The content of communication was ultra-acute cerebral infarction possibly requiring recanalization therapy in 76 (23%), head trauma in 46 (14%), cerebral hemorrhage in 41 (12%), lacunar infarction or old cerebral infarction in 33 (10%), subarachnoid hemorrhage in 28 (8%), demyelinating disorders/inflammation in 9 (3%), brain tumor in 5 (1%), epilepsy in 4 (1%), and business communication, such as notification of rescheduling of conferences and operations, in 76 cases (**Fig. 3**). In the 261 cases after exclusion of business contacts, 1–5 members sent messages per case

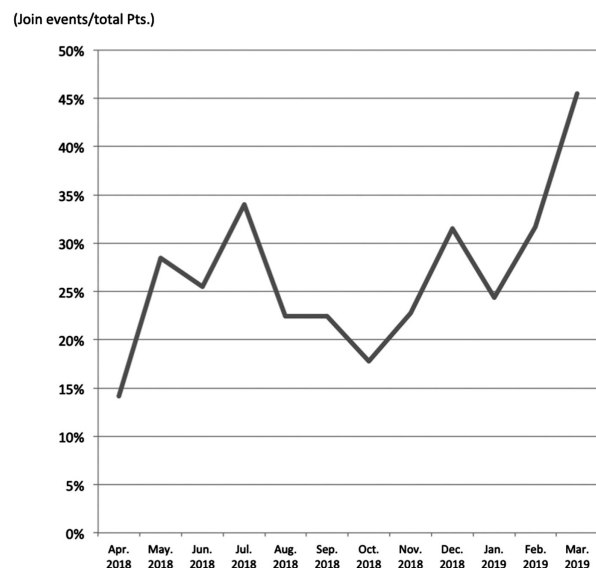


Fig. 1 A graph demonstrating the percentages of events discussed using Join among the number of the patients admitted to Brain Disease Center in our hospital per month after the introduction of the Join application, which increased in the fourth quarter.

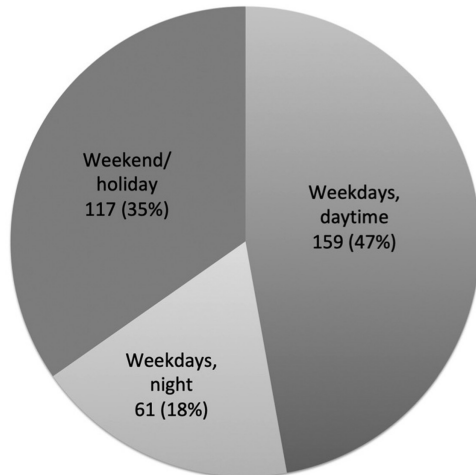


Fig. 2 A pie chart showing the number of events discussed using Join and the percentage in each time period. The messages were sent during weekdays/daytime, weekdays/night, and weekend/holidays in 47%, 18%, and 35%, respectively.

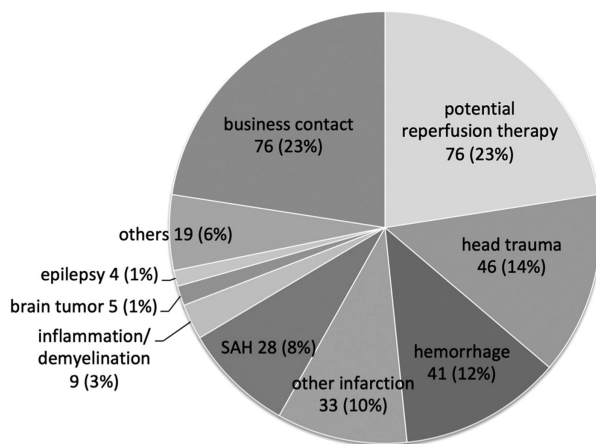


Fig. 3 A pie chart showing the number and the percentage of types of events, including potential reperfusion therapy in 76 (23%), head trauma in 46 (14%), brain hemorrhage in 41 (12%), other brain infarction in 33 (10%), SAH in 28 (8%), demyelination/inflammation in 9 (3%), brain tumor in 5 (1%), epilepsy in 4 (1%), and business contact in 76 (23%). SAH: subarachnoid hemorrhage

(median: 2, interquartile range [IQR] 2–4), the number of comments per case was 1–19 (median: 3, IQR 2–4), and DICOM images were attached in 132 cases (51%).

Effects of the use of Join on D2P for patients who underwent thrombectomy

Of the 76 patients with acute cerebral infarction possibly requiring recanalization therapy, 36 actually underwent an endovascular recanalization procedure, such as emergency carotid artery stenting and thrombectomy, accounting for

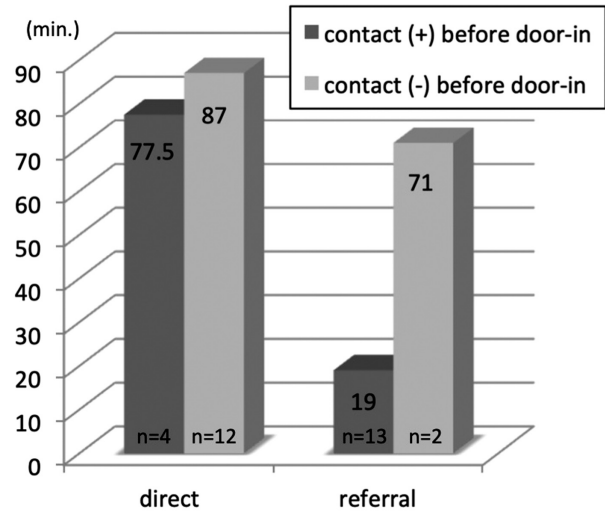


Fig. 4 A graph showing the median interval between arrival at our hospital and the puncture for mechanical thrombectomy for the patients transported directly or transferred from primary hospitals with or without contact using Join before their arrival to our hospital. The time was significantly shorter for patients transferred from the primary hospitals with contact before arrival than for those without ($p < 0.0001$).

89% of the total number of endovascular recanalization procedures performed during the same period. Seven patients each underwent intravenous thrombolysis with recombinant tissue plasminogen activator (rt-PA) therapy alone and DSA alone. Of these 76 patients, information was shared by the members through Join before their arrival in 42%. Concerning the 31 patients in whom D2P was known among the 32 in whom thrombectomy was performed using Join, the median D2P for the patients who were directly transported to our hospital with ($n = 4$) and without ($n = 12$) pre-hospital information was 77.5 (IQR: 45.5–79.5) and 87 (IQR: 70.8–101.5) minutes, respectively, and that for the patients transferred from other hospitals with ($n = 13$) and without ($n = 2$) advance information was 19 (IQR: 17–29.5) and 71 (IQR: 65–77) minutes, respectively, with the D2P being significantly shorter for those transferred with advance information compared with those who came directly to our hospital ($p < 0.0001$) (**Fig. 4**). When D2P was compared between those with and without advance information among those who were transported directly to our hospital and those transferred from other hospitals, it did not differ significantly for those transported directly ($p = 0.36$), but was significantly shorter for those transferred with advance notification ($p = 0.026$). However, the median D2P was also short (22.5 minutes) for the 20 patients transferred during the year prior to the introduction of Join, and the difference compared with those

transferred with advance information after the introduction of Join was not significant ($p = 0.78$).

Present state of use for inter-hospital cooperation

Concerning the use of Join for inter-hospital cooperation, an agreement of coordinated treatment of brain disease patients using Join with our hospital as the hub institution was concluded among our hospital and three hospitals in the prefecture. All hospitals that joined the agreement were capable of performing MRI examination for 24 hours a day 7 days a week, although they had no regular neurosurgeon or neurologist and were unable to treat patients with brain disorders on holidays and during the nighttime. These facilities avoided installation of an expensive special server to operate Join and lowered the hurdles for the introduction of Join by using it under a licensing agreement alone. Therefore, they cannot send DICOM images directly to our hospital, but as they prepared videos of scrolled images by deleting personal information and sent them to our hospital, we were able to obtain sufficient information for the diagnosis and judgment of whether transfer of the patient is necessary. As for the number of communications through Join with the three hospitals during the year, only test communication has been finished with one hospital, but information about 5 and 4 patients, respectively, has been exchanged with the other two hospitals. Of these patients, 4 and 1, none of whom required thrombectomy, were transferred to our hospital.

Discussion

Due to the spread of smartphones and progress of information and communication technology (ICT), the development of mobile applications to be used by doctors, nurses, patients, and caregivers has accelerated in the medical field.²⁾ The objectives of their use vary among applications, including triage and tracing of transport of acutely ill or injured patients, transmission of messages at the time of disaster, patient education for secondary prevention, and search of guidelines and literature, and the introduction of applications usable in team medical care for stroke is also underway.^{1,3,4)} Join is an application for communication among medical workers approved by pharmaceutical affairs authorities incorporating security measures against tapping and falsification in compliance with Japanese guidelines. It has been adopted by approximately 300 facilities in Japan at present and is also spreading to institutions in Western countries. Regarding its functions, Join makes it possible for the medical staff not only to chat and share

image information with anonymization of the patients' personal information but also to deliver monitor images by streaming and track the state of patient transport.¹⁾ However, only the former function was used at our facility. During the 1 year after its introduction to our facility, Join was used a monthly mean of 28 times with no gradual decrease in its frequency of use despite initial concerns, and the frequency of its use for all inpatients increased in the fourth quarter. In addition, it was used frequently during on-duty hours on weekdays as well as the nighttime on holidays. As communications to which images were attached accounted for approximately half of all communications, transmission of images, which is handled by doctors treating emergency cases, is not considered burdensome. Consultations with attached images guaranteed the reliability of the diagnosis and determination of the treatment plan for young doctors on duty alone, and also reduced exhaustion of senior doctors by eliminating the need of coming to the hospital simply for checking images on holidays and during the nighttime. According to a questionnaire survey by Munich et al., for example, after the introduction of Join, the medical workers had generally favorable impressions of the application, with 87.5% of the respondents reporting good operability of the application and 82.5% recommending its continued use.¹⁾

It is widely recognized that shortening the time from onset to the initiation of treatment is important for improving the outcome of acute cerebral infarction, and there have been reports about the effects of the introduction of the application on shortening the time.^{5,6)} Alotaibi et al.⁷⁾ evaluated the effects of the smartphone application SunnyStroke, which promotes prompt chatting within the stroke team, on thrombectomy, and reported that the time from CT imaging to arterial puncture was significantly shortened from 127 minutes before to 69 minutes after its introduction. Furthermore, Shkirkova et al.⁸⁾ analyzed the actual state of the use of Synapse ERm for 84 stroke patients within the University of California, Los Angeles (UCLA) stroke team, and reported that the images attached were viewed a median of two times per medical worker, that tweets through the application were read by a median of one medical worker per case, and that the median D2P was shortened to 94.5 minutes for those who underwent thrombectomy compared with 133 minutes in the control group. At our hospital, analysis 1 year after the introduction of Join revealed that relatively many doctors sent comments through Join, and that many patients with ultra-acute cerebral infarction underwent thrombectomy, intravenous thrombolysis with rt-PA

therapy, and DSA. For those who underwent thrombectomy, the median D2P was markedly shorter (19 minutes) for those transferred from other hospitals with advance information through Join compared with those transported directly to our hospital, probably because preparations for prompt examinations and treatment were able to be arranged by information delivered through Join before their arrival, and examinations performed by the previous hospitals were omitted at our hospital. However, as the D2P was often short in transferred cases from before the introduction of Join, further evaluation by accumulation of cases is considered necessary concerning this time-shortening effect.

Our hospital is located in a secondary medical region in the southeastern part of the prefecture with a population of 920,000 and has four specialists of neuroendovascular therapy, which is the largest number excluding university hospitals. Therefore, we often accept patients referred from six primary stroke centers in the same medical region. According to the statistics of the prefecture, 80 (59%) of the 135 cases of thrombectomy performed in this medical region during the 2 years in 2017–2018 were handled at our hospital, but the number of thrombectomy cases per population is smaller in the entire secondary medical region than not only the national average⁹⁾ but also those in other medical regions in the prefecture. Therefore, it is an urgent task of our medical region to increase cases of thrombectomy, and one measure for this is reinforcing cooperation with primary care facilities. Concerning inter-hospital cooperation, the establishment of a hub-and-spoke type telestroke network has been reported not only to improve the patient outcome but also to reduce the medical cost of the entire network.¹⁰⁾ There have also been reports of the use of mobile applications for the establishment of networks.^{11,12)} Kageji et al. reported the development of a telestroke system in which a general internist begins intravenous thrombolysis with rt-PA therapy at a primary care facility under the guidance of a specialist at a hub stroke center using the Synapse ERm application before the patient is transferred to the stroke center.¹¹⁾ In conducting such drip-and-ship treatment for acute cerebral infarction via such a telestroke system, it has been suggested that the stay in the primary care facility that conducts intravenous thrombolysis with rt-PA (door-in-to-door-out time [DIDO]) is prolonged, resulting in prolongation of the time from onset to recanalization (onset-to-recanalization time [O2R]).^{12–15)} McTaggart et al.¹⁴⁾ reported that DIDO was able to be shortened by education of the primary care facility and sharing of images through a cloud service, but Froehler et al.¹³⁾ reported by a

prospective observational study 984 cases in which the O2R was significantly prolonged with deterioration of the outcome in patients transferred from other hospitals compared with those directly transported to the hospital. All primary care facilities with which we concluded the cooperation agreement were located in the city or near the city border, and it is possible to promptly diagnose acute cerebral infarction through Join and to finish transfer of patients to our hospital in 20–30 minutes. Prompt initiation of recanalization therapy at our hospital is considered to shorten DIDO and O2R, and improve therapeutic results.¹³⁾ Even if time is expected for MRI examination at a primary care facility, DIDO and O2R may be shortened by evaluating using CT images and the diagnostic scale for large-vessel occlusion alone,^{16,17)} sharing the information with us by chats through Join, and immediately transferring the patient to our hospital. To save more patients, it is considered desirable to establish two thrombectomy stroke centers in each medical region and concentrate the medical staff and patients, and to arrange shifts of multiple thrombectomy teams in each facility. For the time being, however, we aim to develop links of cooperation between our hospital and other facilities while reducing the cost of the introduction of Join, and to increase the number of patients who benefit from recanalization therapy.

Conclusion

At our hospital, Join, an application for communication among medical workers, is used actively for the diagnosis and treatment of stroke, particularly for acute cerebral infarction. In the future, we plan to play a more active role as a stroke center by applying Join to cooperate with other facilities without stroke specialists.

Disclosure Statement

The first author and the co-authors have no conflicts of interest.

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