ORIGINAL ARTICLE

Telemedicine approach for patient follow-up after total knee and reverse total shoulder arthroplasty: a pilot study

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Abstract
Purpose   The study aimed to demonstrate the reduction in postoperative follow-up visit time for patients receiving total knee arthroplasty (TKA) or reverse total shoulder arthroplasty (RTSA) by implementing a novel asynchronous telemedicine system compared to face-to-face visits. The range of motion interobserver agreement and patient satisfaction were evaluated in the telemedicine group.
Methods   A randomized controlled trial was conducted with a total of 28 patients with a mean age of 71 years (range 13.3). Patients were distributed into two study groups, TKA ($n = 14$) and RTSA ($n = 14$), and each group was randomly allocated into a face-to-face or virtual follow-up visit group. For the virtual group, software was designed including patient-specific model items (X-ray, range of motion and functional scores) for each arthroplasty. Functional assessment was conducted using the International Knee Documentation Committee (IKDC) score for TKA and American Shoulder and Elbow score (ASES) and Simple Shoulder Test (SST) for RTSA. The range of motion interobserver concordance was conducted in the virtual follow-up groups via an intraclass correlation coefficient. Finally, a satisfaction survey was performed in the virtual follow-up groups. Mann–Whitney U test was used for statistical analysis.
Results   Mean time differences between face-to-face and virtual follow-ups were 502.5 s (95% CI 387.8–617.1; $p < 0.002$) in the RTSA group and 710 s (95% CI 597.91–822; $p < 0.002$) in the TKA group. The range of motion interobserver concordance in the virtual group was 0.974 for TKA and 0.804 for RTSA. Finally, virtual follow-up satisfaction using the telematic method was 8.9 out of 10.
Conclusion   The results of this study showed that a virtual follow-up using asynchronous telemedicine systems could reduce visit times, allow a correct articular range of motion evaluation and maintain satisfaction perception for patients. Asynchronous telemedicine could be an efficient method to conduct postoperative follow-up after knee and shoulder arthroplasty.

Keywords Patient care management · Telehealth · Arthroplasty · Internet-based intervention

Introduction

Osteoarthritis has become one of the main problems in terms of disability and chronic pain in developed countries [1]. Total joint arthroplasty is a common surgical procedure that has been demonstrated to improve the quality of life in advanced osteoarthritis [2]. Due to the aging population,

the use of arthroplasty has increased significantly in Spain in recent years and will continue to increase [2–5]. The upward trend in Spain in primary knee arthroplasty reached 38,756 interventions in 2009; between 1997 and 2011, the Spain National Health System (SNS) carried out 431,349 primary knee arthroplasties [6]. Arthroplasty is a procedure that generates waiting lists [7, 8], requires long-term follow-up after the surgical procedure to monitor the evolution and detect complications such as infection or implant failure [9]. The COVID-19 pandemic in developed countries demanded the application of new strategies for patient follow-up after surgery [10, 11].

Telemedicine is a branch of telehealth defined as a digital intervention that could bring patients and practitioners closer

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together, allowing information exchange despite being geographically separated, using smartphones, computers or other electronic devices [12–15]. Telemedicine solutions could be a more efficient and reliable approach to monitor and follow-up patients in different fields of medicine than the current methods employed in developed countries [15–20]. From the patient's perspective, using telemedicine-based technologies could reduce direct and indirect costs associated with face-to-face visits at healthcare centers [14].

Telemedicine systems are classified into two types: synchronous and asynchronous. Synchronous systems involve a real-time visit between patient and practitioner, whereas, in asynchronous systems, patients generate and send data, then practitioners can review this information in a non-real-time visit [21]. Marsh et al., demonstrated that a web-based asynchronous telemedicine follow-up after total knee and total hip arthroplasty could reduce visit times for the practitioner and achieve a good level of satisfaction compared with a face-to-face follow-up [22–25].

The purpose of this study was to compare visit times between face-to-face and telematic/virtual visits in total knee and reverse total shoulder arthroplasty follow-ups by implementing new asynchronous telematic software consisting of obtaining radiological images, functional tests and self-recorded videos for articular range of motion (ROM) analysis. Interobserver concordance for the range of motion analysis and patient satisfaction were evaluated in the telematic group.

Materials and methods

This study was a single-center randomized controlled trial. Patients who received total knee or reverse total shoulder arthroplasty within the period 2018–2019 were consecutively contacted by telephone. After formal consent was obtained, they were allocated into one of the two procedure-dependent groups: TKA and RTSA. The study was conducted over 4 months, from December 2020 to March 2021, and approved by the Institutional ethics committee (Code: 01-20-105-093).

It was not possible to conduct a formal sample size calculation, patients were consecutively recruited, selecting those operated within the period 2018–2019 from our department database. Of the 163 patients contacted telephonically ($n = 55$ RTSA and $n = 108$ TKA), 28 agreed to participate in the trial ($n = 14$ RTSA and $n = 14$ TKA). Groups were similar as regards distance from our healthcare center, postoperative follow-up time and economic resources. A total of four patients did not complete the study protocol and were established as losses ($n = 2$ RTSA and $n = 2$ TKA) (Fig. 1). Patients with no email address, telephone number or unable to use smartphones were excluded. Elderly patients

were encouraged to seek support in order to perform a better virtual follow-up.

Randomization

The study included a total of 28 patients distributed into two groups: TKA and RTSA. Each group contained 14 patients who were randomly distributed into two further groups: virtual or face-to-face follow-up.

Patient-specific model definition

An asynchronous telemedicine software was designed, integrating a patient-specific model (PSM) concept for each arthroplasty follow-up group. The PSM was built on three basic analysis items: articular ROM, functional status of the patient evaluated by functional scores and X-ray images. Routine Data assessment and patient management were performed using AlmaHealthPlatform software. This platform integrated a PSM designed for this study and allowed us to obtain relevant clinical data and analyze all the information on a single screen.

The PSM was defined by our orthopedic surgery department and was structured on two different protocols for each arthroplasty intervention. The protocol defined the clinical information needed to assess postoperative results and the actions that the users must carry out to collect and analyze said data. These protocols were created based on the work of Marsh et al. [23] and our orthopedic surgery department's clinical experience. The platform automatically collected the patient's age and gender and the protocol requested the following data from the patient via the platform asynchronously:

Articular range of motion: Self-recorded videos were obtained using smartphones or tablets. Before each recording request, patients had a video tutorial on how to record the video. The software video tool allowed the patient to send an encrypted 10-s video to the surgeon (Fig. 2). The interobserver concordance between measures in the virtual group obtained in situ by a study team member was compared to the analogic goniometer measures visually analyzed via the video tool.

- The RTSA protocol patients had to record anterior elevation, internal and external rotation, abduction and hand-to-head movement
- The TKA protocol patients had to record knee flexion and extension in the sitting position.

Functional scores: These were automatically calculated and stored by the software. For functional evaluation, the different groups were assessed by validated international scales.
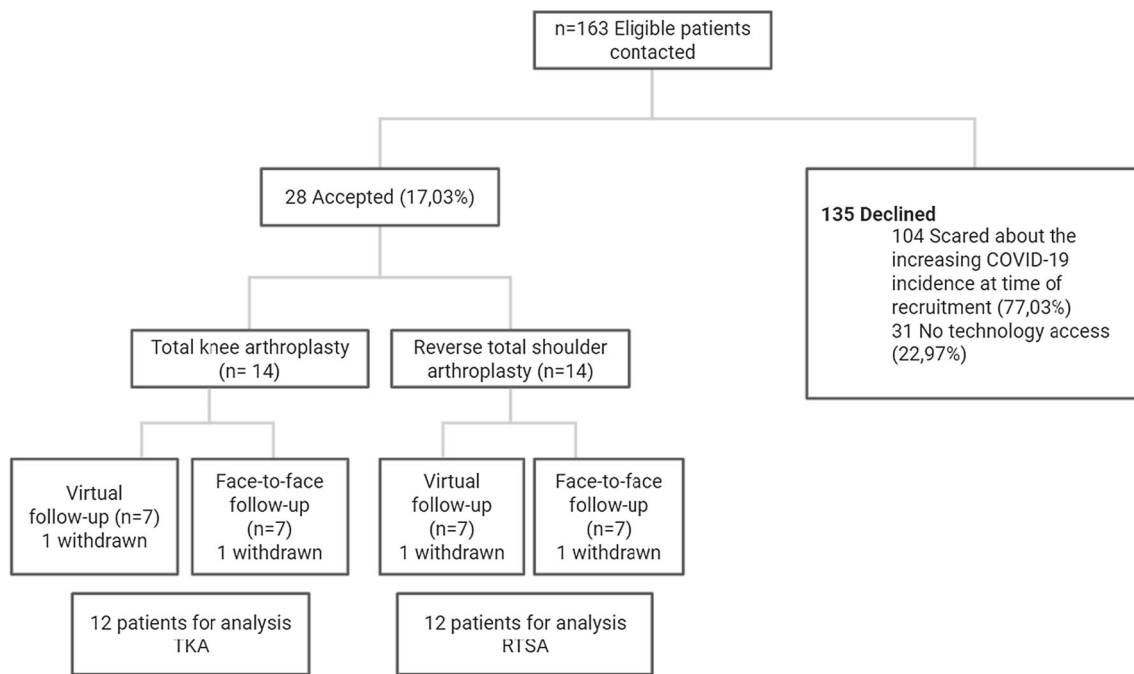
Fig. 1 Recruitment phase and randomization

Fig. 2 Self-recorded video for ROM assessment in the RTSA group. Image was recorded by using the application's recording tool

– The RTSA group was assessed using the Simple Shoulder Test (SST) and American Shoulder and Elbow Surgeons (ASES) scores.
– The TKA group was assessed by the International Knee Documentation Committee subjective score (IKDC subjective score)

Radiology: a simple X-ray was uploaded and assessed using a certified radiological viewer integrated into the software (Fig. 3).

– TKA and RTSA patients underwent an anteroposterior and lateral X-ray projection.

Face-to-face follow-up group

Patients were scheduled for X-rays at our healthcare center and face-to-face visits were conducted the same day. They had to complete functional scores, ROM measures with an analogic goniometer and X-ray assessment by the orthopedic surgeon. Face-to-face visits were conducted by two different knee and shoulder specialist orthopedic surgeons. The time for surgeons to complete a face-to-face visit was recorded and measured in seconds by a study team member using a stopwatch.

Virtual follow-up group

Patients were scheduled for X-rays at our healthcare center. The same day, patients received an individual five-minute face-to-face standardized briefing regarding the basic functionalities of the asynchronous telemedicine software and they had to complete the software registration using a personal email address. The orthopedic surgery assistant conducted an in situ articular ROM assessment using an analogic
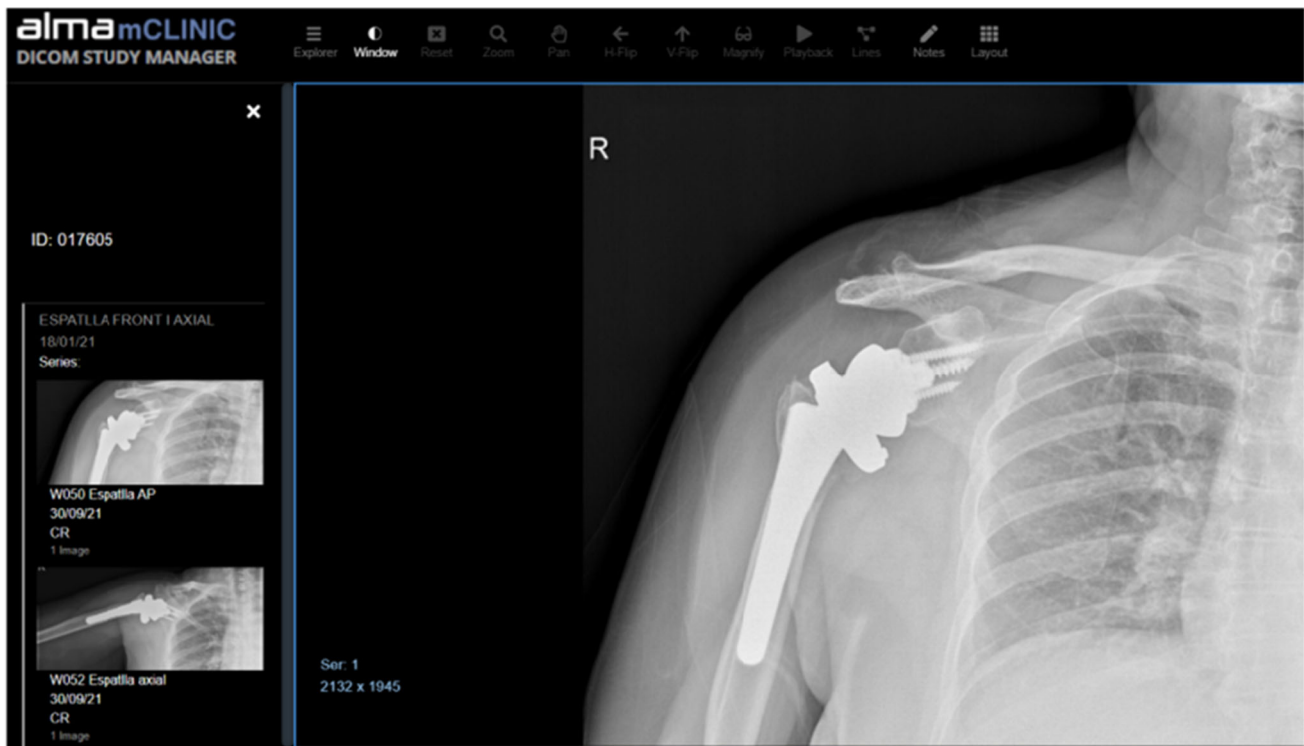
Fig. 3 Radiological assessment in the reverse shoulder arthroplasty group. Image shows a reverse total shoulder arthroplasty X-ray in radiological viewer

goniometer for virtual TKA and RTSA groups. When basic training was completed, patients had to conduct a virtual follow-up protocol using their smartphone or tablet in a separate room without any help from the study team. At the end, the patients completed a satisfaction survey developed ad hoc for virtual visit satisfaction evaluation. The survey has only been used in this study and asked specific questions about the virtual follow-up visit and software satisfaction, no validation process was passed. The survey was written in Spanish, the most widely spoken language in the region (Annex 1). Functional scores for the RTSA group were assessed using SST and ASES scores and the TKA group was assessed via the IKDC subjective score. X-ray images evaluated osteolysis in TKA and notch and stress-shielding in RTSA. Articular ROM was visually analyzed using the video tool and the surgeon had to report, on the platform, the degrees that they considered could be appreciated in the video. Lateral leg view was recorded for the TKA group whereas the RTSA protocol patients had to record anterior elevation, internal and external rotation, abduction and hand-to-head movement. Finally, surgeons reported back to patients using an individual text box incorporated into the software and scheduled the next follow-up visit. The time to complete a virtual follow-up was recorded in seconds by a study team member using a stopwatch.

Descriptive analysis:

– Demographics
– X-ray searching for notch, stress-shielding for RTSA group and implant failure for TKA group
– RTSA group: ASES, SST TKA group: IKDC score
– Ad hoc survey to evaluate subjective perception in the telematic group

Statistical analysis:

– Time spent by surgeons conducting a face-to-face or a telematic visit
– Interobserver concordance evaluation in the virtual follow-up group

Statistical analysis

The time difference was compared between face-to-face and virtual follow-ups using an independent sample Mann–Whitney U test due to the non-normal data distribution, verified by a significant Shapiro–Wilk test. Significance was established at $p < 0.05$. Interobserver concordance evaluation was performed between in situ and virtual ROM measures in the

virtual follow-up group using the intraclass correlation coefficient. All data analysis was carried out with SPSS software.

Results

Reverse total shoulder arthroplasty group

RTSA patients ($n = 12$ women) had an overall mean age of 73.8 years (range 66.4–81.2 years), with a mean of 69.8 years for the virtual follow-up group and 77.3 years for the face-to-face group.

Visit time

The time, in seconds, invested by physicians in completing virtual and face-to-face follow-ups was compared. Mean visit time for the virtual RTSA group was 400.33 s $\pm$ 109.15 vs. 902.8 s $\pm$ 39.37 for the face-to-face group. The mean difference was 502.5 (95% CI 383.82–617.17). Due to the non-normal distribution, a nonparametric statistical analysis was conducted (Mann–Whitney U test). We found a statistical difference in terms of time between virtual and face-to-face visits ($p < 0.002$) (Table 1).

Range of motion

The intraclass correlation coefficient for the interobserver correlation of ROM measure analysis in the RTSA group was 0.804, signifying a good correlation between measures [26].

Functional evaluation

The telematic follow-up group results presented 61.33 $\pm$ 24.59 mean points for SST and 5 $\pm$ 2.28 mean points for ASES. Conventional follow-up results were 71.3 $\pm$ 13.2 mean points for SST and 7.1 $\pm$ 2.1 mean points for ASES.

Radiographic evaluation

IN the virtual follow-up group, two patients were found to have a stress-shielding effect and proximal notch was found in two other patients. Osteolysis, stress-shielding or notch were not detected in the face-to-face visits.

Total knee arthroplasty group

TKA patients ($n = 12$, 2 men and 10 women) had an overall mean age of 69 years (range 64.1–73.9 years), with a mean of 67 years for the virtual follow-up group and 71.4 years for the face-to-face group.

Visit time

The time, in seconds, invested by physicians in completing virtual and face-to-face follow-ups was compared. Mean visit time for the virtual TKA group was 192.50 s $\pm$ 17.5 vs. 803.83 s $\pm$ 76.21 for the face-to-face group. The mean difference was 710 (95% CI 597.91–822). Due to the non-normal distribution, a nonparametric statistical analysis was conducted (Mann–Whitney U test). We found a statistical difference in terms of time between virtual and face-to-face visits ($p < 0.002$) (Table 1).

Range of motion

The intraclass correlation coefficient for the interobserver correlation of ROM measure analysis in the TKA group was 0.974, signifying an excellent correlation between measures [26].

Functional evaluation

The telematic follow-up group presented a mean result of 63.3 $\pm$ 11 and the face-to-face group 72 $\pm$ 8.9 mean points.

Radiographic evaluation

Neither the virtual nor the face-to-face follow-up group detected any signs of osteolysis.

Patient satisfaction evaluation in the virtual follow-up group

Seventy-five percent of patients had no difficulties accessing the software, 91% believed that its use was intuitive and 91% believed that they did not waste time using the virtual system. Seventy-five percent answered that they would use virtual follow-up for the next appointment, 8% responded that they would prefer a face-to-face follow-up, and 16.6% did not know. All patients (100%) answered that the virtual follow-up had advantages over a face-to-face visit, saving money and travel time to complete the follow-up. At the end, the patients evaluated the virtual follow-up with an 8.9 out of 10 in a COVID-19 pandemic context. Finally, patients concluded that they would consider web-based follow-up in the case of good arthroplasty results, otherwise, in the case of pain or other complications, they would prefer a face-to-face visit with a surgeon.

Discussion

Telemedicine solutions have been used for a long time, but their use has increased since the COVID-19 pandemic was

Table 1 Mean time in seconds (range)

Arthroplasty group	Face-to-face follow-up group	Virtual follow-up group	p-value
RTSA	902.8 (39.37)	400.33 (109.15)	0.002*
TKA	803.83 (76.21)	192.50 (17.54)	0.002*

RTSA reverse total shoulder arthroplasty, *TKA* total knee arthroplasty

*$p < 0.05$

declared by the World Health Organization (WHO) on March 11, 2020 [10, 11]. In addition, the rising osteoarthritis incidence has led to an increased demand for joint arthroplasty, overwhelming clinics with postoperative follow-ups [2, 27].

This study demonstrated that telemedicine could significantly reduce follow-up times using a virtual visit modality, not only would it save time for practitioners and patients, but this type of virtual follow-up could also reduce the economic impact on our healthcare system [28, 29]. The virtual follow-up model could be efficient for total knee and reverse total shoulder arthroplasty, investing less time per visit compared with a face-to-face follow-up.

It is believed that time-saving occurs because of the automatic data gathering and storage in specific software, capable of requesting critical data from the patient for the analysis of the state of their arthroplasty; in addition, this automatic data collection system reduces information loss as it does not depend on its collection by the physician [30]. No missing values were detected in the functional scores completed by patients in this study, this occurs because, until all fields are completed, the software does not allow the patient to continue to the next step, forcing them to duly complete the test, unlike the paper test where information loss is common.

Patient-specific model design comprising video images, functional scores and X-ray images partially based on previous publications and our orthopedic surgery department's experience could allow us to obtain sufficient data to conduct a telematic visit without missing any important clinical data [23]. One point that surgeons reported regarding the use of the software was that all the patient's information was displayed on a single screen and this made the analysis of the virtual visit comfortable and fast. An interobserver concordance of ROM analysis was conducted, comparing in situ and virtual measures for the same patient in the telematic group with a good and excellent correlation for different group measures; it seems that video-assisted ROM assessment was similar to that of face-to-face visits, obtaining similar values in person and virtually, as long as the quality of the recording was optimal [17, 31, 32].

Virtual visits detected four postoperative X-ray stress-shielding and notch in reverse shoulder arthroplasty with no clinical significance on functional scores, even in the case of finding alterations in X-rays, a functional analysis could be performed using the scores and it allowed completion of the actual arthroplasty status. In the case of pathological findings, changing the follow-up mode to face-to-face is recommended to establish a new diagnosis.

This study has some limitations. In the recruitment phase, only 17.03% of the patients contacted agreed to participate in our study. When those that refused to participate were asked the main reason for declining: 77.03% ($n = 104$) stated they were scared to travel to the hospital due to the increasing rate of COVID-19 spread during the recruitment period in Spain; the other 22.97% ($n = 31$) stated difficulties with internet or computer access. In view of these results, we believe that the difficulties in patient recruitment for our study were due to the increasing COVID-19 incidence in Spain during this period and not due to difficulties accessing the technology.

Difficulties using telematic tools could represent a formal limitation for telemedicine implementation and application in healthcare systems but recent studies have demonstrated that patient satisfaction using telemedicine health consultations was similar to conventional face-to-face visits. Patients who experienced a virtual follow-up were more predisposed to continue with a subsequent virtual appointment due to less time lost in displacement and economic savings [33, 34]. As seen in the study, virtual follow-up had an excellent subjective result with a score of 8.9 out of 10 and 75% of patients would conduct their next assessment using virtual tools. The need for further studies is recognized to establish virtual follow-ups as a formal type of medical assessment in the immediate postoperative period. Face-to-face visits have been the gold standard until today, but the use of new technologies and implementation of new tools in the near future could allow the patient and surgeon to communicate more efficiently.

Conclusion

Virtual follow-up visits using asynchronous telemedicine systems could reduce visit times compared with conventional face-to-face visits. Asynchronous telemedicine could be an effective method to assess knee and shoulder arthroplasty follow-ups in terms of ROM analysis. The interobserver concordance of ROM analysis for virtual follow-ups was good in the RTSA group and excellent in TKA group. Participant perception scored 8.9 out of 10 using the new software to

conduct a virtual visit with no important difficulties in its use.

Declarations

Ethical disclaimer All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all participants included in the study.

Conflict of interest Author Hugo Herrero Antón de Vez, MD declares a conflict of interest regarding the use of proprietary software (Alma Health Platform) which was developed by a company in which he undertakes private activity. The other authors declare no conflict of interest.

Annex 1

See Table 2.

Table 2 Satisfaction survey created ad hoc for telematic satisfaction evaluation

Have you had difficulty accessing the application?	
Yes	No
Do you think its handling is intuitive?	
Yes	No
Do you think you have wasted time using it?	
Yes	No
Do you think it is too complex a system to carry out a visit?	
Yes	No
Would you use this system again for follow-up in external consultations?	
Yes	No
Have you needed help from the medical team to carry out the telematic monitoring?	
Yes	No
Do you think that the telematic system is advantageous compared with the traditional visit?	
Yes	No
Do you consider that you have spent less time on the telematic visit compared with a conventional face-to-face visit?	
Yes	No
Rate, on a scale from 0 to 10, the medical visit made in the context of COVID-19 (encircle)	
0 1 2 3 4 5 6 7 8 9 10	

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