A Feasibility Pilot Study on the Use of Telemedicine for the Examination of the Knee Joint

Eine Pilotuntersuchung zur Machbarkeit der Videosprechstunde bei muskuloskelettalen Beschwerden des Kniegelenks

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ABSTRACT

Background In times of a pandemic threat, such as COVID-19, and the need for reduced direct doctor-patient contact, internet-based telemedicine has attracted more and more attention as a surrogate service. Suspending the diagnosis and treatment of non-virus related diseases for longer periods of time is not a viable option since this would only exacerbate problems on the patient and national level. The need for alternative treatment modalities increased rather quickly. So far, telemedical applications have mainly focused on teleradiological diagnosis, follow-up and monitoring of psychiatric and internal diseases, as well as geriatric patient care. As far as these authors are aware, orthopaedic physical examination of the knee joint, including trauma work-up, has not been the subject of any studies to date. This feasibility study explores how video consultation can be designed and implemented in the context of history taking and physical examination in knee joint complaints.

Material and Method 21 patient actors (PA) with simulated complaints of the knee joint were examined individually for each diagnosis, first via video consultation and then directly by a specialist (SP). One PA group has a medical background, the other was made up of laypersons. The time was measured for both types of consultation. The physician documented the detected symptoms, the quality of implementation of the self-examination steps, and the derived diagnosis on an assessment form. After completion of both consultation sessions, the PAs were handed a questionnaire on the respective examination modality.

Results With the video consultation the examination lasted 8.63 (± 2.5) minutes on average and with the regular consultation in person 5.63 (± 1.7) minutes ($p < 0.001$). For the group with medical background the examination lasted 7.67 (± 1.4) minutes on average, while for the lay group the video consultation took 9.7 (± 3.1) minutes ($p = 0.049$). With increased age, the video consultation was prolonged ($p = 0.032$; $r = 0.47$). The mean value for self-examination of leg axis, gait pattern and degrees of freedom was 9.32 (± 0.4) of 10 points. The following functional tests resulted in lower mean values (points): Payr 7.2 (± 2.3), Merke 5.9 (± 2.8), no-touch Lachmann 6.4 (± 2.7), gravity sign-recurvatum 6.7 (± 2.4). The mean grade by the PAs for the feasibility of self-examination was 2.43 (± 0.98) out of 5 points.

Conclusion The video consultation for musculoskeletal complaints of the knee joint allows exploratory remote examination and helps to minimise the number of patients in hospitals and practices. It takes longer for the physician to perform and

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does not permit functional testing for ligament injuries of the knee joint. In its present form, telemedical examination is not able to fully replace personal consultation.

ZUSAMMENFASSUNG

Hintergrund In Zeiten einer pandemischen Bedrohungslage, wie bei COVID-19, und der Notwendigkeit reduzierter direkter Arzt-Patienten-Kontakte rückte die internetbasierte Videotelefonie mehr und mehr als Ersatzserviceleistung in den Fokus. Um individuellen oder gesamtwirtschaftlichen Problemen entgegenzuwirken, darf die Erkennung und Behandlung anderer Erkrankungen keine längerfristige Unterbrechung erfahren. In kurzer Zeit stieg der Bedarf alternativer Methoden zur Patientenbetreuung. Bisherige telemedizinische Einsatzgebiete lagen vor allem im Bereich der radiologischen Befundung, der Nachsorge und des Monitorings psychiatrischer und internistischer Erkrankungen sowie geriatrischer Patientenbetreuung. Studien zur Einsatzmöglichkeit für eine orthopädisch-unfallchirurgische Untersuchung des Kniegelenks existieren nach Autoreninformationen bislang nicht. Wie sich der Einsatz einer Videosprechstunde in der speziellen Anwendung für die Anamnese und Untersuchung bei Beschwerden des Kniegelenks konzipieren und umsetzen lässt, soll im Rahmen dieser Machbarkeitsstudie erarbeitet werden.

Material und Methodik 21 Schauspielpatienten (SP) mit simulierten Beschwerden des Kniegelenks wurden für jede Diagnose einzeln zunächst über Videotelefonie und anschließend im direkten Kontakt durch einen Facharzt (FA) untersucht. Eine Gruppe der SP war medizinisch vorgebildet, die andere bestand aus Laien. Von beiden Untersuchungseinheiten wurde die Zeit gemessen. Die erkannten Symptome, die patientenseitige Durchführungsqualität der Eigenuntersuchungsschritte und die abgeleitete Diagnose wurde auf einem Bewertungsbogen durch den Arzt dokumentiert. Die SPs erhielten zum Abschluss beider Untersuchungseinheiten einen Bewertungsbogen zur jeweiligen Untersuchungsmethodik.

Ergebnisse Die Untersuchungseinheit der Videosprechstunde dauerte im Mittel 8,63 (± 2,5) min, die der normalen Sprechstunde 5,63 (± 1,7) min ($p < 0,001$). Die Dauer der Videountersuchung zeigte für die Gruppe mit medizinischem Vorwissen einen Wert von 7,67 (± 1,4) min, wohingegen die Untersuchung der Laiengruppe im Mittel 9,7 (± 3,1) min dauerte ($p = 0,049$). Ein höheres Alter verlängerte die Dauer der Videountersuchung ($p = 0,032$; $r = 0,47$). Im Mittel wurden 9,32 (± 0,4) von 10 Punkten für die Eigenuntersuchungen der Beinachse, des Gangbildes und der Freiheitsgrade erreicht. Niedrigere Mittelwerte erreichten die Funktionstests: Payr-Test 7,2 (± 2,3) Punkte, Merke-Test 5,9 (± 2,8) Punkte, No-touch-Lachmann-Test 6,4 (± 2,7) Punkte, Gravity-Sign-Recurvatum-Test 6,7 (± 2,4) Punkte. Die Durchführbarkeit der Eigenuntersuchungen bewerteten die SP im Mittel mit 2,43 (± 0,98) von 5 Punkten.

Schlussfolgerung Die Videosprechstunde für muskuloskelettale Beschwerden des Kniegelenks ermöglicht eine orientierende Fernuntersuchung und hilft, das Patientenaufkommen in Kliniken und Praxen zu minimieren. Sie geht mit einem zeitlichen Mehraufwand für den Arzt einher und findet ihre Limitierung in den Funktionstests der Kniebinnenstrukturen. Die telemedizinische Untersuchung ersetzt in der heutigen Form keine persönliche Sprechstunde.

Introduction

In times of the COVID-19 pandemic [1], it is necessary to ensure continued broad medical care of the public in parallel with the necessary prioritisation of diagnosis, containment and treatment of the SARS-CoV-2 patients. Suspending the diagnosis and treatment of non-virus related diseases for longer periods of time is not a viable option since this would only exacerbate problems on the patient and national level. Musculoskeletal diseases, such as joint infections, fractures or tumours of the musculoskeletal system, can lead to acute deterioration or even chronicity of findings due to late contact with the physician and delayed initiation of treatment, e. g., due to discontinued office hours or the fear of becoming infected in the practice or hospital.

As part of the primary measures of the German government against COVID-19, a nationwide lockdown was instituted, accompanied by an increase in the number of intensive care beds and a reduction in the number of patients and operations in offices and hospitals. The need for alternative treatment modalities increased rather quickly[2]. In this pandemic threat and the need for reduced direct doctor-patient contact, internet-based telemedicine attracted more and more attention as a surrogate service.

So far, telemedical applications had mainly focused on teleradiological diagnosis, follow-up and monitoring of psychiatric and internal diseases, as well as geriatric patient care[3 – 8]. Telemedical applications have also been used in rural areas, e. g., in Australia and the USA [5]. Its use in emergency services, also in the context of supporting first responder units, had already been proven in practice in the past [9]. As far as these authors are aware, orthopaedic physical examination of the knee joint, including trauma work-up, has not been the subject of any studies to date [3].

While the basic technical requirements for telemedicine have been in place for years [10], most people today also have their own computer or smartphone with video conferencing capability [10]. This feasibility study explores how video consultation can be designed and implemented in the context of history taking and physical examination in knee joint complaints.

Method

As part of the preliminary work on this study, a focused medical history form and questionnaire for the assessment and examination of knee joint complaints using standard examination techniques was developed [11]. The development attached importance to the fact that the exploratory examination steps could be carried out the same way both in a direct doctor-patient examination and as a self-examination in front of the video camera at the patient's home.

▶ **Table 1** Demographic data of the recruited patient actors and their assigned diagnoses.

	Overall	Group 1*	Group 2#
Patient:s	21	11	10
▪ Female	9 (43%)	5	4
▪ Male	12 (57%)	6	6
▪ Age (median, min.–max.)	33 (28–70)	32 (28–54)	40.5 (28–70)
Diagnoses			
▪ Medial meniscus pathology	4	2	2
▪ Lateral meniscus pathology	4	2	2
▪ Medial knee osteoarthritis	4	2	2
▪ Symptomatic Baker cyst	4	3	1
▪ Articular effusion, septic	6	3	3
▪ Articular effusion, aseptic	5	2	3
▪ Medial collateral ligament, tear	4	2	2
▪ ACL tear	4	2	2
▪ PCL tear	3	2	1
▪ Tibial plateau, fracture	4	2	2

* medical background; # medical layperson

The consultation workflow was tested by recruiting patient actors (PA) to demonstrate clinical conditions based on a set of prepared symptom forms. Each lay patient actor was assigned 2 clinical conditions (▶ **Table 1**).

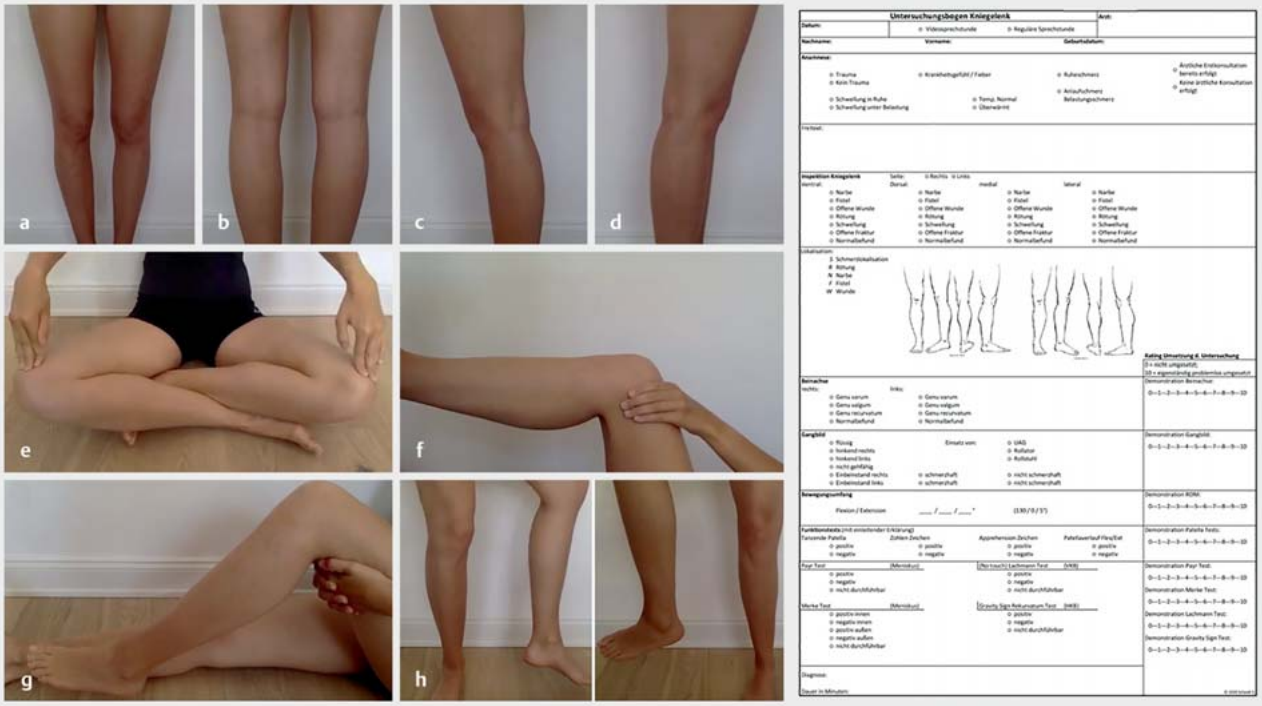
The cohort studied comprised 21 PAs with simulated knee joint complaints (43% female, 57% male). The median age was 33 years (28–70). Each patient was assigned 2 diagnoses. For the analysis, each PA was assigned to one of two groups according to their previous medical background. Eleven patients had a medical background (medical student or trained nurse), ten were medical laypersons. During the video conferences carried out, there were no breakdowns in communication; both sound and image was transmitted reliably and consistently in all video consultations. The patient actors (PA) were examined individually for each diagnosis, first via video consultation and then directly by a specialist (SP). For the examination by personal contact, the SP was blinded for the diagnosis. The time was measured for both types of consultation. The examination unit was defined as the focused completion of the questionnaire and examination form by the SP in exactly the same order (▶ **Fig. 1**). The physician documented the detected symptoms, the quality of implementation of the self-examination steps, and the derived diagnosis on an assessment form. After completion of both consultation sessions, the PAs were handed a questionnaire on the respective examination modality. Pathologic examination results that could not be demonstrated by the PA, such as a positive gravity sign for the posterior cruciate ligament, after the PA had performed the examination step were designated according to the diagnosis to be demonstrated. The medium employed for the video consultation was a video platform approved by the hospital management and conforming to data protection regulations. The feasibility criteria for the video based consultation were the basically successful completion of the video conference and the medical assessment of the self-examination. Success was defined in advance as a minimum score of 6 out of 10.

The data are presented as median (minimum–maximum/interquartile range) or mean (standard deviation) depending on their normal distribution. The comparison between 2 groups was performed either as Wilcoxon or Mann-Whitney U-test or as t-test for dependent or independent samples according to normality and statistical dependence. Correlations were calculated by means of the Spearman rank correlation coefficient. The two-sided p-values presented here have a significance level of $\alpha = 0.05$. Since this is an exploratory study, no α adjustment for multiple testing was performed, but rather all p-values are presented as calculated. The statistical analysis and graphic presentation was carried out with Prism 8 (GraphPad Software, USA). Before the study was initiated, the ethics commission of the medical faculty had rendered its positive approval (No. 163/20).

Outcome

With the video consultation the examination lasted 8.63 (± 2.5) minutes on average and with the regular consultation in person 5.63 (± 1.7) minutes ($p < 0.001$). For the group with medical background the examination lasted 7.67 (± 1.4) minutes on average, while for the lay group the video consultation took 9.7 (± 3.1) minutes ($p = 0.049$). Higher age prolonged the duration of the video consultation ($p = 0.032$; $r = 0.47$; ▶ **Fig. 2**).

Of the 21 APs, 81% (n = 17) indicated that, in the future and based on their experience in this study, they would consider medical consultations via video as an option. However, 86% (n = 18) of the APs preferred a „regular“ consultation over the digital alternative. No age or gender dependency was found ($p = 0.407$; $p = 0.526$).



▶ **Fig. 1** Examination steps: Recording of a video consultation examination work-flow. **a** Anterior aspect standing; **b** Posterior aspect standing; **c** Lateral aspect standing; **d** Lateral aspect standing; **e** Payr test; **f** Gravity-sign recurvatum test (posterior cruciate ligament); **g** No-touch Lachmann test (anterior cruciate ligament); **h** Merke test in medial rotation (medial meniscus); **i** Merke test in lateral rotation (lateral meniscus); Right: Knee examination form.

On the medical assessment scale, a mean score of 9.32 (± 0.4) out of 10 points was recorded, indicating very good feasibility for self-examination of the leg axis, gait pattern, and degrees of freedom. Functional tests demonstrated lower mean values for these tests: Payr 7.2 (± 2.3) points, Merke 5.9 (± 2.8) points, No-touch Lachmann 6.4 (± 2.7) points, and gravity-sign recurvatum 6.7 (± 2.4) points. The quality of implementation of the gravity-sign recurvatum test decreased with increasing age of the actor patients ($p = 0.045$; $r = -0.4421$).

The mean grade awarded by the patients themselves for the feasibility of the self-examinations was 2.43 (± 0.98) out of a possible 5 points. According to this, most patients needed „few“ to „some“ instructions from the video examiner to implement the instructions correctly. After initial medical explanation, 24% of patients (n = 5) performed the examination step without error.

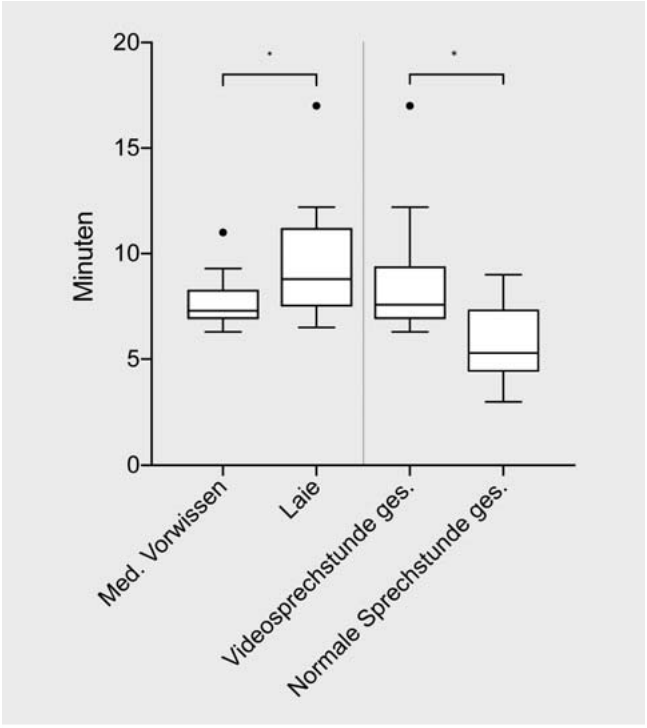
Discussion

In order to ensure the care of patients with musculoskeletal complaints even in times of a pandemic, it makes sense to add the option of telemedicine services to the medical workflow. While it is easy to take a medical history via videophone, the physical examination of a extremity in particular can cause problems and may require more time. Telemedical examinations of smaller functional units, such as the hand, can be performed by supporting the contralateral side with pressure, strain and stretching exercises in front of the video screen. Implementation for the larger joints is more difficult due to different physical conditions and longer leverage [12]. The examination approaches tested in this study could be performed by a group of actor patients without medical background. While stance and gait examinations can generally be performed with a high degree of accuracy even by medical laypersons, carrying out functional tests of the knee ligaments revealed deficits in the understanding of the requirements and feasibility. This impairs the efficacy and significance of these examination steps. The greatest difficulty in the self-examination of the knee joint seems to be relaxing the muscles of the leg.

Modifications of usual medical examination steps are necessary to allow self-examination via video consultation. The functional tests adopted in this study offer the benefit of using them in patient self-examination as well as in examinations by the physician [11]. One basic condition for successful video consultation is the physical and cognitive capacity of the patient to implement the instructions given by the physician.

Remote assessment of tissue hyperthermia, for example, is difficult. At present, it seems that this deficit cannot be solved, since, for example, thermographic cameras or smartphones with such an additional function can contribute to the solution, but are not widely available to patients [13].

When interpreting the above results, it should also be noted that the cohort studied here comprised young actor patients without any real complaints. It is conceivable, for example, that



▶ **Fig. 2** Duration of the video consultation: Boxplot of the mean duration (with standard deviation) of overall consultation between patients with medical background and laypersons. The total duration of the particular type of consultation without group classification is also plotted. Significant differences are marked with * and outliers with a dot.

frail, obese and pain-impaired patients might, on average, yield poorer examination outcomes. More studies, accompanying video consultations with real patients and for a larger population, are necessary to supplement this feasibility study with figures from everyday clinical practice.

It can be stated that basic knee joint assessment is possible via video consultation and that this type of patient contact with a physician is received positively. Medical history and inspection as well as the examination of stance and gait on both sides pose few problems. Once the technical hurdles for the older population have been overcome, valuable remote assessments will become possible. This type of examination format reaches its feasibility limits in more complex functional tests of the knee ligaments, particularly in older patients.

Perhaps it will become possible in the future, once a more intensive and everyday use of digital teaching and study contents in the context of medical studies has become more common, to develop ideas for further developments in the implementation of video consultations including clinical examination [14].

Video consultation for the assessment of knee complaints has its rationale primarily as a preclinical selection tool. Advanced modalities such as MRI and CT may already be initiated and performed prior to personal consultation.

Abstract

The video consultation for musculoskeletal complaints of the knee joint can be a useful addition to the medical treatment portfolio and is positively accepted in the cohort of actor patients. It can facilitate exploratory remote examination and help minimise the number of patients in hospitals and offices. It takes longer for the physician to perform and does not permit functional testing for ligament injuries of the knee joint. In its present form, telemedical examination is not able to fully replace personal consultation. Further studies in the context of video consultation with real patients should be conducted in particular to be prepared for future or persistent crisis situations.

Conflict of Interest

The authors declare that they have no conflict of interest.

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