Practicability of a Virtual Consultation to Evaluate the Shoulder Joint

Durchführbarkeit einer digitalen Sprechstunde zur Untersuchung des Schultergelenkes

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ABSTRACT

Objective In the course of the corona pandemic, resource conservation and the protection of further infections have made it necessary to break new ground in the organisation of orthopaedic and trauma surgery consultations. One solution is consistent digitisation and the offer of video consultation hours. In this study, non-contact examination of patients with shoulder disorders is described and critically examined.

Methods Thirty patients who presented with pathologies of the shoulder joint in a university outpatient clinic were subjected to a physical examination in a conventional and contactless manner. The data obtained on mobility, function and provocation test of both examinations were compared to draw conclusions about the virtual feasibility.

Results 46 % of the patients suffered from a traumatic shoulder lesion, and 54 % showed degenerative lesions. The assessment of mobility showed a high correlation of 70–90 % between the two examinations. Common tests to evaluate the supraspinatus, infraspinatus, subscapularis and the long head of the biceps could be adequately performed in a contactless version by more than three quarters of the patients, but with low-to-moderate performance values.

Conclusion Contact-less examination is particularly disadvantageous when evaluating stability criteria. For the medical history and functional test, there were no significant differences between the classic consultation and contactless consultation. Although virtual consultation is a widespread and valuable addition in pandemic times, it cannot replace a safe assessment and indication by personal examination.

ZUSAMMENFASSUNG

Hintergrund In der Coronapandemie ist es zur Vermeidung weiterer Infektionen sowie zur Optimierung des Einsatzes von medizinischem Klinikpersonal erforderlich, neue Wege bei der Ablauforganisation von orthopädischen und unfallchirurgischen Sprechstunden zu gehen. Ein Lösungsansatz ist eine konsequente Digitalisierung und das Angebot von Videosprechstunden. In dieser Arbeit soll die Durchführung von Anamnese und Untersuchung von Patienten mit Schultergelenkspathologien beschrieben und kritisch hinterfragt werden.

Material und Methoden 30 Probanden, die sich mit Pathologien im Bereich des Schultergelenks in einer Hochschulambulanz vorstellten, wurden auf herkömmliche Weise und kontaktlos einer Untersuchung unterzogen. Die gewonnenen Daten von Beweglichkeit, Funktion und Provokationstests beider Untersuchungen wurden verglichen, um Rückschlüsse auf die virtuelle Durchführbarkeit zu ziehen.

Ergebnisse 46 % der Probanden litten an einer traumatischen Schulterläsion und 54 % an einer degenerativen Erkrankung. Die Bewertung der Beweglichkeit zeigte eine hohe Korrelation (70–90 %) zwischen beiden Untersuchungen. Herkömmliche Tests für die Evaluierung der Supraspinatussehne, der Infraspinatussehne, der Subscapularissehne und der langen Bizepssehne konnten von mehr als ¾ der Patienten in ihrer kontakt-

losen Anpassung angemessen durchgeführt werden, zeigten jedoch geringe bis milde Performance-Werte.

Diskussion Insbesondere bei der Bewertung von Stabilitätskriterien ist die kontaktlose Untersuchung nachteilhaft. Bei der Durchführung von Anamnese und Funktionsprüfung zeigten sich keine signifikanten Unterschiede zwischen der klassischen Konsultation und einer kontaktlosen Konsultation. Obwohl die digitale Konsultation in Pandemiezeiten eine verbreitete und wertvolle Ergänzung darstellt, kann Sie eine sichere Bewertung und Indikationsstellung durch persönliche Untersuchung nicht ersetzen.

Background

In the spring of 2020, the coronavirus disease 2019 (COVID-19) pandemic caused by the SARS-CoV-2 virus caught the German health care system and much of the globalised world off guard. The pandemic spread rapidly from the People's Republic of China to more than 185 countries, necessitating unprecedented restrictions in the public and private sectors [1]. The high rate of severe outbreaks exceeded the local intensive care capacity of some countries, resulting in mortality rates of 0.2–15% depending on age and comorbidities [2]. To minimise the spread of the virus in the Federal Republic of Germany, the Ministry of Health proposed and implemented far-reaching infection control measures [3].

For the orthopaedics and trauma surgery specialties, the onset of the pandemic resulted in the suspension or reduction of consultation hours and substantial restriction of elective surgeries/procedures. In addition, nursing and medical staff were laid off from many clinics to conserve resources, prevent spread of the infection, or train staff reassigned for the treatment of affected patients. These changes severely limited comprehensive patient care and required the prioritisation of the remaining consultation slots for patients requiring urgent diagnoses/treatment. Video consultation services are a method to overcome these limitations in private practices and outpatient departments of hospitals. These video services are already being used worldwide but are more common in rural areas or where medical services are limited [4]. Innovative, time-saving solutions are needed to overcome the challenges imposed by the pandemic so as to maintain a high quality of care for orthopaedic and trauma surgery patients. Every year, Germany records > 25 000 cases of shoulder and elbow arthroplasties and > 80 000 cases of humeral fractures; hence, there is a great need for pre- and post-operative care for patients with injuries or degenerative changes of the upper extremities [5, 6]. Telemedicine services, for which standards and algorithms have not yet been sufficiently investigated, are a promising alternative to in-person consultations during the COVID-19 pandemic.

The aim of this study was to provide specific recommendations for the implementation of video-assisted shoulder examinations. For this purpose, the authors evaluated the accuracy of a contact-less clinical examinations of the shoulder joint and assessed the advantages, disadvantages, and limitations of virtual consultations.

Patients and Methods

Patient population and data collection

In this study, we included outpatients who presented to a German university outpatient clinic for shoulder joint pathology and examined them after obtaining informed consent.

The inclusion criteria included legal age and the presence of pathology in the shoulders (including scapula, clavicle and humeral shaft). The exclusion criteria included the presence of an acute trauma requiring immobilisation of the shoulder joint and cognitive impairment (e.g. in case of dementia) or the patient's refusal to participate. In addition, we excluded patients if they had a language barrier or had recently undergone surgery.

Finally, we included 30 patients in the study. In addition to the examination results, we recorded the patients' age, sex, and pain intensity using a visual analog scale (VAS). The Ethics Committee of the University Hospital Bonn reviewed and approved the study (No. AZ 163/2020).

Investigations

We examined all subjects twice in separate locations, with an interval between the two examinations. After obtaining their consent to participate in the study, we assessed the patients' range of motion (ROM) in terms of abduction, flexion, internal and external rotation, and shoulder function and provocation tests [7] without contact between the patient and examiner. An experienced specialist in trauma surgery and orthopaedics performed the examinations, followed by the conventional examination (after 5–20 minutes) in a separate room by the same examiner. The scheduled time per examination was 15–30 minutes.

To best simulate a possible virtual consultation, the use of measuring devices was avoided during the contact-less examination, similar to that in previously published studies describing patient self-assessment of the Constant–Murley Score (CMS) [8, 9]; accordingly, only plastic bags and 1-L bottles of water were available in the room to simulate the tests. During the conventional examination, the examiner could touch and direct the patient as needed and use a protractor to record measurement data. For ROM assessment, we used the CMS-recommended grading. For all clinical tests, we collected results dichotomously (positive or negative) without grading the results.

Data analysis

A single investigator collected all data in an analog manner and entered the data into a spreadsheet for analysis. We performed statistical analysis using Excel (Microsoft Corporation Inc., Redmond, WA, USA) and GraphPad Prism 6.0 (GraphPad Software

Inc., San Diego, CA, USA). We used the Shapiro–Wilk normality test to assess the normal distribution of the sample and expressed continuous variables as the median and interquartile range (first and third quartiles) or mean ± standard deviation. We expressed categorical variables as number of cases and frequencies. To compare the contact-less assessment with the conventional assessment as the gold standard, we developed contingency tables for the results of each test. A cutoff value of ≥ 75% correct test performance was set for the contact-less adjustments to consider them sufficiently reproducible to proceed with subsequent analysis. Sensitivity, specificity, positive and negative predictive values (PPV and NPV, respectively), and accuracy were calculated, and 95% confidence intervals were determined. We defined sensitivity as the probability of a positive result in the contact-less test when the conventional test was positive and specificity as the probability of a negative result in the contact-less test when the conventional test was negative. We defined PPV as the probability of the conventional test being positive when the contact-less test was positive and NPV as the probability of the conventional test being negative when the contact-less test was negative. We defined accuracy as the probability that a contact-less test result reflected the true conventional test result and assessed ROM accuracy in terms of agreement between contact-less and conventional tests and expressed it as the percentage of non-matching scores over the total number of cases and as the number of outliers by more than one CMS class.

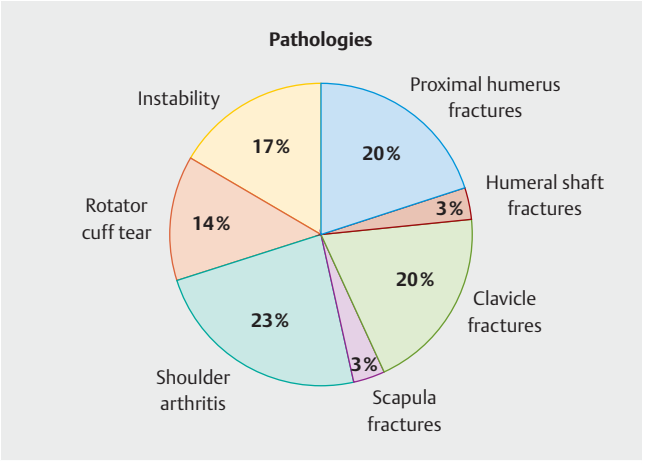
Results

Thirty patients in total were included, and 53.3% of the subjects were female and 46.7% were male. The patients' mean age was 52.6 ± 17.5 years. The VAS score for pain was 2.5 (range: 1.25–5.75) at the time of the clinical assessment. Traumatic shoulder injury was noted in 46% of the subjects and degenerative diseases in 54%. The distribution of underlying pathologies across the study population is shown in ▶ **Fig. 1**.

The agreement between contact-less and conventional assessment of shoulder ROM was 77% for abduction, 70% for flexion, 90% for internal rotation, and 83% for external rotation. In one case, there was a difference of more than one CMS class between the contact-less and conventional assessment techniques for measurement of internal rotation. Because the Whipple, Bear Hug, and O'Brien tests were performed correctly by only 46.7%, 43.3%, and 50% of the patients, respectively, they were the most difficult to perform accurately without any contact guidance. All other tests were performed adequately by > 75% of the patients in the contact-less assessment. The performance measures for each test are summarised in ▶ **Table 1**.

Discussion

This study results demonstrated the basic feasibility of examining the shoulder joint via a virtual consultation and showed its advantages and disadvantages compared with that of a physical consultation. We observed good agreement in terms of medical history, inspection, evaluation of ROM, and functionality. Stability and some provocation tests also showed reasonable agreement.



▶ **Abb. 1** Descriptive presentation of the pathologies in the examined patient group.

The establishment of telemedicine consultations increased after the COVID-19 pandemic started, but it is not a new idea. In a randomised controlled trial, Buvik et al. compared patient satisfaction between face-to-face and video-assisted consultations and found no significant difference in overall high scores of satisfaction (99% satisfaction in both cases). Eighty-six percent of the patients stated that they would consider a video-assisted option for further consultations. Furthermore, a health questionnaire revealed no negative effect on patient health 12 months after the consultation [10]. Prada et al. studied the use of telemedicine patient care in rural areas in Chile among 293 patients and reported a significant reduction in patient waiting times and optimisation of patient outcomes and costs [11]. With the use of telemedicine, other studies have confirmed a reduction in unnecessary face-to-face consultations, more reliable diagnosis, and good post-operative follow-up [12–14].

A recent study by Bini et al. even described numerous promising virtual novelties that may move to the forefront in the context of the pandemic [15]. The authors described telemedicine platforms already as the backbone of virtual care, which can be used as a valuable tool for triage of patients, to relieve pressure on emergency hospitals, and for comprehensive primary care while adhering to the concept of social distancing. They also highlighted many other virtual solutions and referred to them as a means of complementing video consultations, for example virtual physiotherapy and telerehabilitation as safe, affordable and personalised physiotherapy for patients following operations. Other examples include the use of artificial intelligence software in the form of chatbots to facilitate appointments or the use of so-called fitness trackers that can determine post-operative mobilisation data, vital signs and outcomes.

However, one has to critically examine video consultations as well. Holderried et al. surveyed 255 patients in 2016 on the topic of telemedicine in orthopaedics and trauma surgery and found that 59% of the respondents stated privacy concerns. On the other hand, 77–81% of the respondents noted the prospect of saving time and visits to the clinic [16]. Although the respondents ex-

▲ **Tab. 1** Evaluation of the various tests used to assess the shoulder joint.

Test	n.	Sn	CI [95%]	Sp	CI [95%]	PPV	CI [95%]	NPV	CI [95%]	Acc	CI [95%]
Jobe	28	80.00	66.75–93.25	66.67	51.05–82.28	57.14	40.75–73.54	85.71	74.12–97.31	71.43	56.46–86.40
Lift-off	23	75.00	60.65–89.35	42.11	25.75–58.46	21.43	7.83–35.02	88.89	78.48–99.30	47.83	31.28–64.38
WER	30	100.00	100.00–100.00	66.67	51.05–82.28	56.25	39.81–72.69	100.00	100.00–100.00	76.67	62.65–90.68
Palm-up	28	66.67	51.05–82.28	84.21	72.13–96.29	66.67	51.05–82.28	84.21	72.13–96.29	78.57	64.98–92.17
Apprehension	30	44.44	27.98–60.91	61.90	45.82–77.99	33.33	17.72–48.95	72.22	57.38–87.06	56.67	40.25–73.08

Acc: accuracy; CI [95%]: 95% confidence intervals; NPV: negative predictive value; PPV: positive predictive value; Sn: sensitivity; Sp: specificity; WER: weakness in external rotation. For the Whipple test, the Bear Hug test and the O'Brien test, compliance problems prevented correct execution in more than 25% of the patients, therefore they were excluded from diagnostic performance analysis.

pressed a generally positive attitude towards telemedicine, 71% of all the respondents expressed concern regarding a deterioration in the doctor–patient relationship. The doctor–patient contact or the doctor–patient relationship is a complex construct of mutual expectations, emotions, and potential conflicts. Trusting relationships are generally recognised as having a positive effect on the progress and results of therapy. The patient–doctor interaction creates a specific experience that can be reassuring and satisfying on the one hand but also disappointing and annoying on the other. Many patients feel that their questions, problems, and concerns are not adequately perceived and feel misunderstood or objectified [17]. The extent to which these known problems can be improved or aggravated by telemedicine remains completely unclear. Another aspect is the limited application or understanding of this type of media among older people, who are often the primary population and whose acceptance of the method has not been scientifically clarified.

In relation to specific shoulder tests, this study describes the results of contact-less examination aimed to develop telemedical shoulder examinations and highlights their potential limitations. Rotator cuff lesions and shoulder joint instability are two important subspecialties of shoulder surgery that have developed rapidly over the past decades, both in terms of treatment options, diagnostic precision, and understanding of pathophysiology [18, 19].

Our study's design reflects the approach of Lamplot et al., who proposed a comprehensive shoulder joint and knee joint examination for sports injury-related telemedicine visits. Comparing conventional and contact-less assessments, our study adds to and further enriches the study by Lamplot et al. by presenting results and relevant information [20]. Similar to a previous American study, our study confirmed the feasibility and equivalency of physician-guided but patient-administered assessment of ROM and some basic rotator cuff tests [21]. However, when assessing more specific tests or examinations of instability, the accuracy of the contact-less examination was affected by either patient problems in reproducing the correct movements or physician difficulties in interpretation. In many hospitals and private practices, the COVID-19 pandemic was the impetus for establishing a telemedicine infrastructure.

A limitation of this study is the small sample size; in addition, the video consultations were only performed in a simulated environment. Considering the possible changes in operating conditions due to hardware or software limitations, such as an inadequate examination room, limited camera field of view, limited video resolution, low-quality audio, delays between video and audio signals, and interruptions in virtual communication, etc., a translation of the results to telemedical practice is only possible to a limited extent.

As telemedicine becomes more widely used, one can expect the number of patients to increase, which will make large-scale prospective studies possible and necessary.

Conclusion

Considering our results and the current literature, a further increase in telemedical consultations can be expected in the field of orthopaedics and trauma surgery. Patients may benefit from contact-less evaluation of shoulder joint motion and function, which may be acceptable for follow-up examinations primarily aimed at evaluating ROM and ruling out post-operative complications, recurrences or failures. Contact-less evaluations, however, do not show sufficient accuracy for provocative tests to be recommended to rule out possible underlying pathology or to indicate an operation with no need for additional conventional consultations. In summary, the following recommendations can be made regarding virtual consultations of shoulder joints:

- Contact-less ROM evaluation is possible with minor deviations from conventional clinical evaluation.
- Only some basic provocative tests are adequately reproducible in contact-less assessments. More sophisticated tests, such as the Whipple, Bear Hug and O'Brien tests, are considered too complex to be adequately reproduced by the patient in the absence of physical guidance by the examiner.
- Provocative tests of the rotator cuff, such as the Jobe test, lift-off test and evaluation of external rotation weakness, are reproducible when using a contact-less method and have acceptable sensitivity and NPV but exhibit low-to-moderate accuracy and very poor specificity and PPV. Therefore, the contact-less version of these tests should not be used to rule out a possible rotator cuff lesion or to indicate surgery without additional conventional consultation.
- Evaluation of signs of instability via a contact-less video-recording test has low accuracy, low sensitivity, and low specificity and is therefore not recommended.

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Dr. Gathen and Dr. Cucchi contributed equally to the manuscript and should be considered as coauthors.

Conflict of Interest

The authors declare that they have no conflict of interest.

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