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Cross-sectoral use of Patient-Reported Outcomes (C-PRO)–the effect on the cost per improvement in quality of life for patients with chronic degenerative shoulder conditions-a protocol for a randomised controlled trial

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Cross-sectoral use of Patient-Reported Outcomes (C-PRO) – the effect on the cost per improvement in quality of life for patients with chronic degenerative shoulder conditions - A protocol for a randomized controlled trial

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Abstract

Background

This study aims to investigate the effect of the systematic use of patient-reported outcomes (PROs) across healthcare sectors on treatment outcome and cost-effectiveness (measured as cost per improvement in quality of life) in people with chronic degenerative shoulder conditions.

Methods: In this randomized controlled trial with a 1-year inclusion period and two years follow-up, patients with a degenerative shoulder condition (glenohumeral impingement / pain of the acromioclavicular joint, glenohumeral osteoarthritis, rotator cuff degeneration or frozen shoulder) will be included. Every 2nd month they will be asked to complete questionnaires about the shoulder function (Oxford Shoulder Score), quality of life (EQ5D-5L) and a trial specific questionnaire. Healthcare contacts at the general practitioner (GP), the orthopaedic department and the municipal physiotherapeutic centres will be registered prospectively during the follow-up period. In the intervention group all collected data will be available to the patient and any treating party (GP, orthopaedic surgeons and physiotherapists). For the control group, trial data will be collected, but neither patient nor healthcare professionals will have access to these. After trial termination, follow-up data on use of healthcare services during the two-year follow-up time will be collected from the Danish National Registries and the intervention and the control group will be compared with regards to use of healthcare services and satisfaction with the evaluation and treatment of their shoulder-problem.

Discussion:

Systematic use of PROs may be a tool to provide patients and clinicians with an insight into symptom development during treatment and to optimize both the treatment of the individual patient as well as a smarter use of the resources available in the healthcare system.

The inclusion of patients begins 12th of August 2024.

Keywords

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Degenerative shoulder disease; Patient Reported Outcome; Impingement; AC joint Arthrosis; Frozen Shoulder; Degenerative rotator cuff disease; Glenohumeral Arthrosis; Healthcare economics; Quality of life

Background

Patients are increasingly expected to be active partners in clinical decision-making processes and to be the best assessors of treatment outcomes.

To secure informed consent for any treatment plan, the healthcare professional must provide the patient with a balanced and fair assessment of their condition, treatment options, and expected outcomes.. Based on this and a dialogue between patient and the healthcare professional, treatment decisions are reached based on the needs, risks and preferences of the individual patient(1). This nominal description may underestimate central issues of communication between the patient and the healthcare professional: 1) the patient's difficulty of clearly presenting symptoms and health status to the healthcare professional, and 2) the healthcare professional's difficulty of presenting relevant aspects of the treatment and outcomes to the patient. Furthermore, in cases with problems occurring over a longer time-period and with several different sectors involved in the treatment, presenting a clear description of any improvement or deterioration may be hindered by recall bias and information-loss between the individual sectors and may lead to an insufficient basis for making an optimal treatment plan.

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The use of patient-reported outcome measures (PROMs) in a systematic and uniform way may be able to address these issues (2). Generic PROMs assess basic functions of human life, e.g. motion, state of mind and pain, without any specific disease in mind(3) while shoulder disease-specific PROMs ensure a thorough evaluation of relevant aspects (4)of the shoulder-problem in relation to daily activities.(4) By using PROMs systematically, the patient will be motivated to reflect on all aspects of the problem and the impact on their daily living, and as a consequence be better prepared when consulting a healthcare professional(5). The answers to the questions of these PROMs form the basis of simple arithmetic calculations resulting in a number, the Patient-Reported-Outcome (PRO), that quantifies the magnitude and the impact of the evaluated

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problem in the patient's daily living and may give a more uniform basis for a further evaluation and treatment plan.

PROMs have primarily been used as research tools. However, several steps are being taken to incorporate the use of PRO-data "live" in the clinical setting, to improve diagnostics and treatment of patients (6–8).

Objectives

Aim

This trial aims to investigate the effect of a systematic use of patient-reported outcomes across healthcare sectors on treatment outcome and cost-effectiveness (cost per improvement in life quality) in people with chronic degenerative shoulder conditions.

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Hypotheses

We assume that

- systematic utilization of sequentially collected PRO data for the individual patient will improve communication between involved parties (patient and healthcare professionals), particularly when crossing treatment sectors, i.e. between general practitioners, physiotherapists and the secondary healthcare system.
- the utilization of PRO data will facilitate rational and uniform treatment choices.
- the utilization of PRO data will improve patients' understanding of their condition and its natural course/development, and modify their expectations for treatment, and that this improved insight will strengthen their empowerment and thereby reduce the need for further unnecessary evaluation and prolonged treatment.

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Based on these assumptions we hypothesse that systematic use of cross-sectorial PRO data in the everyday clinical setting will result in a higher benefit-to-cost ratio, where benefit is expressed by time-weighted PROs.

Methods

Trial design

The C-PRO trial is planned as a randomised controlled trial with two parallel groups. The trial is planned as a superiority study. Participants will be randomised with 1:1 using permuted blocks (sizes 4,6 and 8) to intervention or control with stratification according to age and gender. Participants and healthcare professionals involved in the trial will not be blinded, but the evaluation of the outcomes at the end of trial will be performed by evaluators blinded to the randomization.

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Trial setting

The trial will be conducted in a collaboration between the primary healthcare sector represented by a general practitioner ("Mit Lægehus Rødovre"), the municipal rehabilitation facilities in the municipalities of Gentofte and Rødovre, and the secondary healthcare sector represented by the shoulder and elbow department at Copenhagen University Hospital Gentofte in the Capital Region of Denmark.
All trial-sites are located within the Capital Region of Denmark.
The trial will be conducted in a manner where each patient is followed regardless of which part of the healthcare system they are evaluated and treated in.

Eligibility criteria

Patients are eligible if they have a degenerative shoulder condition with no upper limit to the length of symptoms. Previous treatment of the current shoulder condition or similar current or previous conditions are not an exclusion criterion.

All patients presenting at any of the trial-sites are eligible for the trial when they:

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- are older than 17 years
- display shoulder pain for >3 months with no obvious acute trauma as cause (any trauma to the shoulder with direct onset of pain immediately following the trauma)
- have Danish social security number (CPR-number)
- understand spoken and written Danish sufficiently to answer the questionnaires
- have and use a public electronic communication mail address (E-boks)

"E-boks" (www.eboks.dk) is a secure digital platform for communication, document delivery, and storage of important documents. It is widely used for communication between the healthcare system and the citizens and have largely replaced letters by post. (9)

The exclusion criteria are:

1. Employee at a participating centre or other relation to participating healthcare professionals that might affect independent consent
2. Having another diagnosis than the 4 below mentioned of the shoulder in question (i.e., shoulder instability or pain following trauma).
3. Psychiatric conditions, mental conditions and substance abuse that might affect the ability to provide informed consent or respond to PROMs
4. Disseminated malignant conditions, other serious medical conditions or other life crises where the focus on a shoulder research project is unreasonable.
5. Already included in the trial, either at another trial-site or with the other shoulder
6. Having previously declined participation

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A note regarding the diagnosis:

Only the following subgroups of degenerative shoulder conditions will be considered:

- Impingement / AC-joint pain
- Glenohumeral osteoarthritis
- Rotator cuff degeneration

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- Frozen shoulder

The diagnosis of the shoulder condition is not known at time of inclusion. The classification into one of these four categories will be done whenever the participant is seen for an appointment by the treating healthcare professional and will be based on the currently best evidence at each consultation (Please see supplementary – "Questions for healthcare professionals"). This may lead to a patient being included, but upon the first evaluation by the healthcare professional it turns out that the diagnosis is different from the above mentioned. In such cases the patient will be excluded.

Screening and inclusion

All patients attending one of the participating trial-sites (general practitioner, rehabilitation unit and surgical referral centre) are screened for eligibility by the secretary at the trial-sites who handles all primary contacts and referrals. The result of this primary screening thus simply assesses eligibility. Data on any eligible patient based on the primary screening will be presented to the site-specific project coordinator.

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All eligible patients will be sent an email with information about the trial and an invitation to participate (see supplementary file: PATIENT INFORMATION). Following the email, the site-specific project coordinator will contact the patient by phone with an oral presentation of the trial and perform the secondary screening, where it is determined whether the patient fulfils any of the exclusion criteria. This secondary screening is documented in the trial-database by the site-specific project coordinator. If the patient is excluded, reason for exclusion is noted to enable a drop-out analysis. If no exclusion criterion is fulfilled, the patient will be invited to participate in the trial. All patients are offered a minimum of 24-hour reflection period prior to accepting inclusion in the trial. The flow of the screening is presented in Figure – Screening and in Figure – SPIRIT figure.

Allocation

Upon acceptance of participation, the participant is registered in the trial database with their specific identifier (CPR-number)(10). Randomization will occur after inclusion within the trial database system by a

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computer-generated algorithm , using permuted block-randomization *(block sizes 4, 6, and 8)* and stratification according to age (<50; 50-70 and >70 years of age), and sex (male/female). The allocation sequence will not be accessible for any investigators in the project. The system does not allow for alteration of the randomization and does not allow multiple entries of the same patient. The patient will be informed of the randomization upon completing the first questionnaires.

Sample size

A sample size calculation was made based on the data available from Sørensen et al.(11) on cost of patients with degenerative shoulder diseases in the Danish healthcare system. The expected cost of the first two years following acquiring a degenerative shoulder diagnosis was 52,300 DKK with a standard deviation of 57,700 DKK, and the minimal clinical important difference was decided to be 25% (7,840 DKK). With a significance level of 0.05 and a power of 80%, the calculation resulted in 618 patients in total, 309 in each group.

The surgical referral centre receives approximately 150-200 new referrals regarding non-acute shoulder problems each month. If we assume that 90% of patients are eligible and that 50% of these accept participation, it is reasonable to expect inclusion of 900 participants at the surgical referral centre.

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The participating general practitioner covers 14,000 citizens. We estimate that they see approximately 5-10 relevant patients each week. Assuming a participation rate of 50% as well we expect to include 100-200 patients.

The participating rehabilitation centre covers the entire Rødovre Municipality (Rødovre Kommune) with a population of 41,000 and Gentofte Municipality (Gentofte Kommune) with a population of 73,000 but will mainly receive patients referred from either the surgical centre or the general practitioner and we do therefor not expect to include additional patients from these centres. If a relevant candidate presents at a rehabilitation centre, they will be invited by the rehabilitation centre to be screened by the surgical centre.

It should therefore be reasonable to expect to include the needed number of participants during a 1 year inclusion period.

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Data collection for all included participants during the trial period

A multitude of different specific PRO measures are available. The European Quality of Life (EQ-5D-5L) and the Oxford Shoulder Score (OSS) were chosen since they are both widely used and are both translated and validated in Danish (2–4,12,13). The EQ-5D-5L evaluates more general topics of health, defined in 5 domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. The answers result in the EQ-5D-value from -1 (worst) to 1 (best). Additionally, the EQ-VAS evaluates the self-perceived health with a range from 0 (worst imaginable health) to 100 (best imaginable health). The OSS evaluates the impact of the shoulder problem on several aspects of the daily activities such as activities of daily living, ability to work, sleep and perform recreational activities. Based on the answers a score from 12 (worst) to 48 (best) is calculated.

Participants in both groups will be asked to complete questions about shoulder problems (OSS; disease specific), quality of life (EQ-5D-5L; generic) and trial-related PROM (See supplementary file - “Questions for participants”) at inclusion and after 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24 months (a total of 13 PROM completions - See "Figure – Participant Timeline”).

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In the odd months between the PROM questionnaires, each participant will be asked to answer a short status questionnaire on the current treatment of the shoulder (See Supplementary file “Status questionnaire” and "Figure – Participant Timeline”).

All invitations to complete PROMs and status questionnaires will be sent from the trial database electronically to the participants’ personal secure E-boks, which will link to an electronic version with submission of the answers directly into the trial database.

To be able to use the PRO scores in clinical practice, data on the treating clinician’s findings and treatment plan, including use of local steroid injections, will be collected each time a participant is seen in an out-patient clinic. To enable evaluation of the use of PRO in physiotherapist-guided training, the treating physiotherapist will be asked to evaluate 1) each time they have a consultation with a participant who

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follows an individual training programme or 2) every 4 weeks for patients who are enrolled in weekly trainings sessions/classes. Furthermore, the physiotherapist will be asked to evaluate if the training has been successful or not at the end of a treatment-programme and state the reason for ending the programme using a standardised form (See supplementary file - "Questions for healthcare professionals"). As for the participant, all reports from the healthcare professionals will be made electronically directly in the trial database.

The trial-specific questionnaires used in this trial has been developed and evaluated in collaboration with 5 treating orthopaedic surgeons with experience in shoulder surgery, 2 treating physiotherapists and 3 patient representatives.

Intervention

The control group

The comparator in this trial will be "usual care with the usual level of information available" which is evaluation and treatment in accordance with the current local guidelines.

The clinical evaluation and treatment setup in the control group and the experimental intervention group will be identical, with no difference in indication for choice of treatment or planning of follow up.

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For participants in the control group, PRO results will not be available to patients, healthcare professionals or anyone else. The data within the trial database will not be accessible to the participants or the healthcare professionals during the study-period. Consequently, all assessments, decisions and communication will take place as prior to the trial.

The intervention group

The experimental intervention group will also receive the "usual care" (evaluation and treatment in accordance with the current local guidelines), but for the participants in this group the PRO data will be used in the clinical setting during the trial period:

- After each PROM completion, an automatically generated report will be sent electronically from the trial database to the participant containing:

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  - The answers and calculated results of the latest PROM reply
  - A graphical view of historical PRO results for the individual patient showing trajectory and treatment stages (please see “Figure – patient trajectory”)
  - A graphical reference of the collected data to results collected from published literature (please see “Figure – patient trajectory”)
- Similar data and graphics will be available within the trial database to healthcare professionals involved in the treatment of the participant giving a simple and straightforward overview of the past treatment and its trajectory effects.

The reference data have been collected from published studies for patients with the included conditions prior to onset of the current study (14–20).

Criteria for discontinuing or modifying allocated interventions

Participants included in this trial will receive evaluation and treatment of their shoulder problem in accordance with the current guidelines and practises of the trial-sites, regardless of which group they are randomly assigned to, which will also be the same as for patients not included in the trial.

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It may be time-demanding for the participants to fill out the PROMs so many times during the long trial period, but we have tested this for now 8 months with two patient representatives who consider this time-consumption to be of an acceptable magnitude for the participants.

There is a risk of an unknown magnitude that repeatedly requesting the completion of PROMs may retain the participant in a patient role, but since the conditions studied are chronic conditions we believe that the risk is minimal.

We do not expect any relevant risk, side-effects or other major nuisances related to participating in the trial.

We do not expect any scenario where the inclusion in this trial should be discontinued or the intervention should be modified.

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A participant can exit the trial prior to end of follow up upon request.

Strategies to promote participant retention and complete follow-up

When receiving a PROM, the participant will have 4 days to complete the questionnaires. The database system is setup in such a way that if no completion has been registered, an automated reminder will be sent to the participant. If further 3 days pass without completion of the questionnaire, an automated note will be sent to the sitspecific coordinator, who will contact the participant by phone to either facilitate completion or explore the reason for the missing completion. The participant will be contacted twice a week until completion of a questionnaire. A patient will be allowed to have missed PROMs and will be retained in the trial until end of study-period or they ask to exit the trial prior to end of study period.

Relevant concomitant care permitted or prohibited during the trial

Participation in this trial does not require any reservations or prohibitions with regards to any treatment of the shoulder or of any other conditions.

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Provisions for post-trial care

As evaluation and treatment of the patient in this trial does not differ from standard of care for patients with degenerative shoulder conditions this is not relevant.

Evaluating intervention fidelity

During the study-period, the project manager will do a monthly check up of included patients to ensure that the clinicians has done the relevant reporting to the trial database system when the participant has the initial contact to a trial-site, and any missing reporting will be made based on the medical reports. At each reporting to the trial database system, the reporting person will be asked if the PRO data was used in evaluating the patient (please see Supplementary file “Questions for healthcare professionals”).

Data collection for all included participants after the trial period has ended

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When the trial period (the 2-year follow-up of each included participant) has ended, data on any contacts, type (admission, out-patient-visit, contacts to emergency department, physiotherapy sessions, surgeries) and length of contact with the healthcare system will be collected from the National Patient Registry (NPR), the Diagnose Related Group Registry (DRG) and The National Health Insurance Service Registry. Data on public transfer will be obtained from The Ministry of Employment's case management database DREAM and The Danish Income Registry. This collection of data will be performed by The Danish Centre for Social Science Research, Copenhagen (VIVE).

In Denmark all citizens are provided with a personal identification number (CPR), which makes it possible to link information on PRO data and EQD5-L5 with each registry on an individual level (10).

Data management

During inclusion and follow-up of the patients, with collection of the PRO scores, all data handling will be performed in either the local medical chart system or the trial database, which is managed by Procordo ApS, Copenhagen, Denmark. Procordo is a web-based database company with a general permission to manage research databases. When PRO data collection has been completed, data with person specific identifiers (CPR-number) will be withdrawn un-anonymised from the trial database and be transferred to Statistics Denmark's servers for further data collection from the registers and further data handling. When all relevant data has been collected from the registers, the data will be anonymised before further analysis.
All data will be processed using either "R(21)" or STATA 18 (or the at that time newest version).

Confidentiality

All patient information will be kept within systems that have been evaluated by the IT security department and fulfils all requirements for this use.

Blinding

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Neither patients nor clinicians are blinded to the intervention caused by the nature of the intervention. The statisticians performing the outcome evaluation will be blinded to the group allocation.

Outcomes and evaluation plan

The primary outcome of this trial is:

The treatment cost during the trial period expressed as the incremental cost per improvement in life quality (quality adjusted life years). The total incremental cost will be calculated from cost of intervention, hospital contacts, physiotherapy sessions, primary healthcare contacts and with and without cost of public transfers. We will use EQ5D-5L as a generic life quality measure.

The effects and costs of the intervention are calculated using a difference-in-difference (DiD) setup, where the consumption of healthcare services for both the intervention and control groups are assessed both prior to and after the intervention (baseline period and respectively one and two years after index date). This method accounts for any baseline cost differences between the intervention and control groups that are not captured by controlling for medical history and background characteristics.

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$$\Delta Cost = \Delta Cost_{Treat} - \Delta Cost_{Control}$$

$$\Delta QALY = \Delta QALY_{Treat} - \Delta QALY_{Control}$$

Cost-effectiveness of the intervention is measured using incremental cost-effectiveness ratio (ICER). ICER captures the cost per unit change in the QALY.

$$ICER = \frac{\Delta Cost}{\Delta QALY}$$

There is some uncertainty associated with calculating ICER on a smaller sample. This uncertainty is illustrated by creating an ICER scatter plot using bootstrapping. Bootstrapping is a sampling method that

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involves drawing new samples (with the possibility of resampling) from the observed sample. The distribution of the new bootstrap samples provides an estimate of the distribution of, for example, the mean among the full population, thereby enabling examination of the uncertainty in the sample. Additionally, a cost-effectiveness acceptability curve (CEAC) is calculated based on the scatter plot. The CEAC indicates the probability that the intervention is cost-effective at different threshold values.

The individual responses to the EQD5-L5 creates a five-digit index, which we will comprise to individual QALYs using a Danish "time trade-off" value set (22). The EQD5-L5 will be completed at inclusion and each of the 12 follow-ups.

To evaluate the secondary outcomes, the plan for each outcome is presented in Table 1.

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Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data

Data will be analysed based on an intention to treat principle. The treatment cost for each patient is available through registrations of hospital contacts, training sessions, GP contacts etc. There is a risk of participants dropping out and not completing the PROM questionnaires, especially in the control group. If the magnitude of missing observations is small and the distribution does not appear biased based on the available background information and treatment outcomes a strategy of complete case analysis will be applied. If the magnitude of missing observations is significant and the distributions looks biased, multiple imputation will be performed. Sensitivity analysis of the different strategies for handling missing observations will be performed. In case of death the QALY-value and economic cost will be set to zero.

Plans to give access to the full protocol, participant level-data and statistical code Data will be extracted from the database by two of the main investigators (AMN and AO), who will mask group allocation. Data will subsequently be transferred to statisticians who will perform all main outcome analyses. Secondary

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outcomes will require demasking of group-allocation.The trial has been registered at clinicalTrials.gov. Due to legal concerns, it is not possible to make data available outside the study investigators at participant level without an approval from the regional or national ethics committee. Help to apply for this will be provided upon reasonable request. The statistical code will be made available by reasonable request.

Organization of the trial

The steering committee (the sponsors) consists of Anne Marie Nyholm, Jakob Kjellberg, Bente Appel Esbensen, Carsten Bogh Juhl, Bo Sanderhoff Olsen, Anders Odgaard.

The trial will be conducted at the following trial-sites with the local trial-coordinator(s):

Shoulder- and elbow division, Orthopaedic department at Copenhagen University Hospital Herlev and Gentofte

- Anne Marie Nyholm, Orthopaedic surgeon (also primary responsible of the trial)
- Bo Sanderhoff Olsen, Professor, Orthopaedic surgeon

Department of Physiotherapy and Occupational Therapy at Copenhagen University Hospital Herlev and Gentofte

- Hanne Hornshøj, Physiotherapist
- Bjarke Berendt Haugan, Physiotherapist
- Carsten Bogh Juhl, Professor, Physiotherapist

”Mit Lægehus”, Rødovre, part of Greater Copenhagen

- Marie-Louise Hvass Sixhøj, MD, Family Doctor

Genoptræning og rehabilitering, Rødovre municipality, part of Greater Copenhagen

- Henriette Bjerrum, Physiotherapist

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Afdelingen for ambulant Genoptræning, Gentofte Kommune, Pleje & Sundhed, Center for Rehabilitering og Forebyggelse, Gentofte Municipal, part of Greater Copenhagen

- Therese Toftgaard Jarløv, Physiotherapist

Furthermore, the following departments are involved in the planning of the trial and evaluation of the data collected:

Orthopaedic department– Copenhagen University Hospital Rigshospitalet

- Anders Odgaard, Professor, Orthopaedic surgeon

Department of Rheumatology at Copenhagen University Hospital Rigshospitalet Glostrup:

- Bente Appel Esbensen, Professor, Nurse

VIVE

- Jakob Kjellberg, Professor
- Caroline Louise Westergaard, senior research analyst

Patient representatives

- Stig Svensson, retired highschool science teacher and school Librarian. Has a history of previous supraspinatus rupture with successful suture.
- Vibeke Rothoff Danielsen, librarian with experience in literature research. Has a history with previous lateral clavicle fracture and a suspected frozen shoulder in remission.

Both have participated in the development of the patient information material and are invited to participate in meetings of the project's steering group to ensure the patient's perspective. Furthermore, they will be invited to help in the evaluation of the results.

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Composition of the data monitoring committee, its role and reporting structure

This trial is performed without a data monitoring committee. Due to the trial setup and use of the data "live" in the intervention group, a continuous monitoring of the data will occur during the trial. To evaluate the primary outcome the national registers need to have received all relevant data, and therefore it is was not possible to perform an "interim"-analysis off the outcome during study-period.

Adverse event reporting and harms

Due to the trial type and intervention investigated (completion of PROMs), we do not expect any relevant major risk, side-effects or other major nuisances related to participating in the trial. There may be a potential risk of keeping a patient unnecessarily in the role as a patient when confronting them repeatedly with their shoulder problem every month, which we would expect would result in an increase in need of evaluation and/or treatment. Patients experiencing problems with continuing to complete PROMs will be allowed to be excluded.

Frequency and plans for auditing trial conduct

No auditing of the trial conduct has been planned.

Dissemination plans

We plan to disseminate the results in peer reviewed journals and relevant conferences. All contributors who fulfil the ICMJE Guidelines for authorship will be invited as an author on any relevant manuscript produced from this study. Contributors that do not fulfil these criteria will be acknowledged.

Discussion

Clinical impact: Pain in a shoulder due to a degenerative condition is a very common problem in the population with increasing incidence of referrals to the hospital sector (23). In many cases the natural history of these conditions is benign, but it may fluctuate in severity and is often of a longer duration, and it is quite common that a patient experiences repeated referrals and treatment in different sectors. That several locations and sectors are involved over time introduces a great risk of distorted and incomplete information flow which gives rise to a varied evaluation and treatment approaches and may lead to prolonged or

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unnecessary evaluations and/or treatments. This is time-consuming and costly. Use of PROM scores in the clinical setting has been demonstrated to improve the patient's own understanding of their problem and to set expectations for the potential benefit of different treatment options(5,7,8), but the impact of a systematic use of PROM scores are still warranted. This trial aims to test if a uniform and systematic collection of patient-reported outcomes and treatment data can help the patient to present the problem, understand and follow the progress, and facilitate the evaluation and treatment of their shoulder pain due to degenerative conditions in the shoulder. This could result in a more efficient use of the available resources.

Strengths and limitations: In this trial-setup the possible effect of introducing this uniform and systematic data collection is tested in an already established clinical setting. No new diagnostics or treatment is introduced which makes the investigation focus on the effect of having a wider information available for evaluating and explaining the problems. By randomizing patients and using registry data on number and types of healthcare contacts prior to and during the trial period we expect to be able to assess if any clinically relevant effect is present of this system. A limitation is the fact that for practical reasons this trial only includes a general practitioner, a hospital department, and the municipal physiotherapeutic centers. A part of the included participants is quite likely to receive evaluation and treatment from alternative facilities/treaters where the system tested will not be made available, e.g. a patient in the intervention group will receive the "usual care" without the PRO scores available to the health-care professionals.This may introduce an uncertainty in the evaluation of the use of healthcare services and may introduce a bias to underestimate the effect of the intervention.

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Future aspects of this trial: This trial will evaluate if trial introducing a system for systematic evaluation of patient with pain in a shoulder due to a chronic shoulder disease is realistic, of benefit to the patient and economically feasible. If no effect of the intervention can be seen in the expected 1000 participants, intuitively the intervention is not worth pursuing.

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Trial status

Pilot was started at "Mit Lægehus i Rødovre" 1st of june2024.

Full trial was started at 12th of august 2024.

Recruitment end date: 1st of september 2025

Protocol Version

1.0 f 30th September 2024.

The trial is registered on ClinicalTrials.gov with identifier NCT06435494.

Authors' contributions

AMN is the Principal investigator. She has been included in planning the details of the trial, written and revised the protocol, obtained all relevant approvals for the trial, participated in developing the trial-database in Procordo and are coordinating the trial sites.

BAE has been included in conceiving the trial, has been included in planning the trial, applied for funding and has revised the protocol.

JK has been included in conceiving the trial, has been included in planning the trial and has revised the protocol.

CLW has been included in planning the trial with specific focus on the economic analyses, has participated in writing the protocol and has revised the protocol.

CBJ has been included in planning the trial, has been included in planning the trial, has participated in developing the trial-database in Procordo and has revised the protocol.

BSO has been included in conceiving the trial, has been included in planning the trial, applied for funding and has revised the protocol.

AO has been included in conceiving the trial, has obtained the funding, are the primary developer of the trial-database in Procordo and has revised the protocol.

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Funding

The Trial has been funded by Novo Nordisk Fonden by 1.000.000 DKK and by the Capital Region of Denmark by 2.000.000 DKK. None of these institutes have had any involvement in the planning or the conduction of the trial.

The funding will be used for establishing and maintaining the trial database, as well as salary for some of the involved participants.

The included participants will not be offered any salary or monetary compensation for participation in the trial.

Ethics approval and consent to participate

This trial has been approved by our regional Ethics committee (Center for Sundhed De Videnskabsetiske Komiteer, Region Hovedstaden, Denmark) with Journal-nr.: H-23039139, with date of registration 2nd October 2023. The participant will give written informed consent prior to inclusion in the trial.
Should any important protocol modifications be necessary, the regional Ethics committee will be contacted for approval prior to making the changes. If any modifications will have an impact for the included patients they will be informed of the changes via secure personal email system, with and invitation to contact the steering-committee with any further questions.

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Competing interests

Anders Odgaard is a founder of Procordo Software and remains a minority stockholder. Procordo is the manager of the trial databse. AO will participate in the construction and management of the trial database. All economical negotiations between Procordo and the project will be without involvement or intervention from AO.

Bente Appel Esbensen, Anne Marie Nyholm, Carsten Bogh Juhl, Bo Sanderhoff Olsen, Caroline Louise Westergaard and Jakob Kjellberg declare that they have no competing interests in relation to this trial.

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References

1. Hall DE, Prochazka A V., Fink AS. Informed consent for clinical treatment. CMAJ Canadian Medical Association Journal. 2012;184(5):533–40.

2. Dawson J, Fitzpatrick R, Carr A. Questionnaire on the perceptions of patients about shoulder surgery. Journal of Bone and Joint Surgery - Series B. 1996;78(4):593–600.

3. Devlin NJ, Brooks R. EQ-5D and the EuroQol Group: Past, Present and Future. Appl Health Econ Health Policy. 2017;15(2):127–37.

4. Frich LH, Noergaard PM, Brorson S. Validation of the Danish version of Oxford shoulder score. Dan Med Bull. 2011;58(11).

5. Hansen ST, Jensen RS, Holm HA, Liljensøe A. Original Article Patient-reported outcome measures in orthopaedics. 2024;1–10.

6. Makhni EC. Meaningful Clinical Applications of Patient-Reported Outcome Measures in Orthopaedics. Journal of Bone and Joint Surgery. 2021;103(1):84–91.

7. Greenhalgh J, Dalkin S, Gooding K, Gibbons E, Wright J, Meads D, et al. Functionality and feedback: a realist synthesis of the collation, interpretation and utilisation of patient-reported outcome measures data to improve patient care. Vol. 5, Health Services and Delivery Research. 2017. 1–280 p.

8. Santana MJ, Tomkins DJ. Patient-led use of patient-reported outcome measure in self-Management of a Rotator Cuff Injury. J Patient Rep Outcomes. 2021;5(1):4–9.

9. Digitaliseringsstyrelsen. Digital inklusion. 2025 [cited 2025 Oct 3]. Digital inklusion. Available from: https://digst.dk/digital-inklusion/viden-om-digital-inklusion/hvem-oplever-udfordringer-ved-det-digitale/#:~:text=I april 2025 var 5,særligt af de ældste borgere.

10. Frank L. Epidemiology. When an entire country is a cohort. Vol. 287, Science (New York, N.Y.). 2000. p. 2398–9.

11. Sørensen L, Van Tulder M, Johannsen HV, Ovesen J, Enemark U, Blæhr EE, et al. Costs of shoulder disorders in Denmark: a nationwide cost-of-illness study investigating 617,334 patients and matched controls. Pain. 2022;163(11):2162–71.

12. Singh HP, Haque A, Taub N, Modi A, Armstrong A, Rangan A, et al. Floor and ceiling effects in the Oxford Shoulder Score: An analysis from the National Joint Registry. Bone and Joint Journal. 2021;103 B(11):1717–24.

13. Jensen MB, Jensen CE, Gudex C, Pedersen KM, Sørensen SS, Ehlers LH. Danish population health measured by the EQ-5D-5L. Scand J Public Health. 2021;(September):1–9.

14. Rangan A, Brealey SD, Keding A, Corbacho B, Northgraves M, Kottam L, et al. Management of adults with primary frozen shoulder in secondary care (UK FROST): a multicentre, pragmatic, three-arm, superiority randomised clinical trial. The Lancet. 2020;396(10256):977–89.

ARTICLE IN PRESS

15. Gallacher S, Beazley JC, Evans J, Anaspure R, Silver D, Redfern A, et al. A randomized controlled trial of arthroscopic capsular release versus hydrodilatation in the treatment of primary frozen shoulder. J Shoulder Elbow Surg. 2018 Aug 1;27(8):1401–6.

16. Jacobsen JR, Jensen CM, Deutch SR. Acromioplasty in patients selected for operation by national guidelines. J Shoulder Elbow Surg. 2017;26(10):1854–61.

17. Beard DJ, Rees JL, Cook JA, Rombach I, Cooper C, Merritt N, et al. Arthroscopic subacromial decompression for subacromial shoulder pain (CSAW): a multicentre, pragmatic, parallel group, placebo-controlled, three-group, randomised surgical trial. The Lancet. 2018;391(10118):329–38.

18. Kristensen MR, Olsen BS. Minimal Clinically Important Differences (MCID) for the Western Ontario Osteoarthritis of the Shoulder Index (WOOS) and the Oxford Shoulder Score (OSS). 2021;(May).

19. Liu P, Afzal I, Asopa V, Clement ND. Changes and thresholds in the Oxford Shoulder Score following shoulder arthroplasty : Minimal clinically important difference , minimal important and detectable changes , and patient-acceptable symptom state. 2023;0(0):1–11.

20. Mowbray J, Niekerk M Van, Frampton C, Hirner M. The outcomes of shoulder arthroplasty in those aged ‡ 70 years with glenohumeral arthritis : a New Zealand Joint Registry study. J Shoulder Elbow Surg. 2022;31(4):799–805.

21. R CT. R: A language and environment for statistical computing. [Internet]. R Foundation for Statistical Computing, Vienna, Austria. 2017. Available from: https://www.r-project.org/.%0A%0A

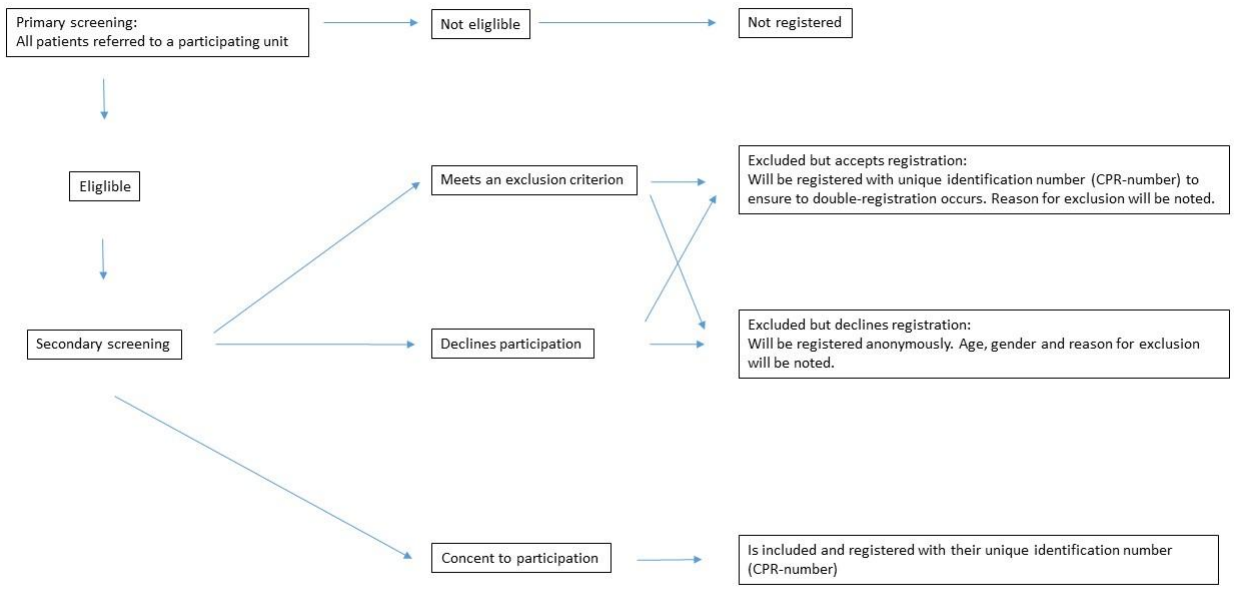
22. Jensen CE, Sørensen SS, Gudex C, Jensen MB, Pedersen KM, Ehlers LH. The Danish EQ-5D-5L Value Set: A Hybrid Model Using cTTO and DCE Data. Appl Health Econ Health Policy. 2021 Jul;19(4):579–91.

23. Monrad N, Ganestam A, Kallemose T, Barfod KW. Alarming increase in the registration of degenerative rotator cuff - related lesions a nationwide epidemiological study investigating 244 , 519 patients. Knee Surgery, Sports Traumatology, Arthroscopy. 2018;26(1):188–94.

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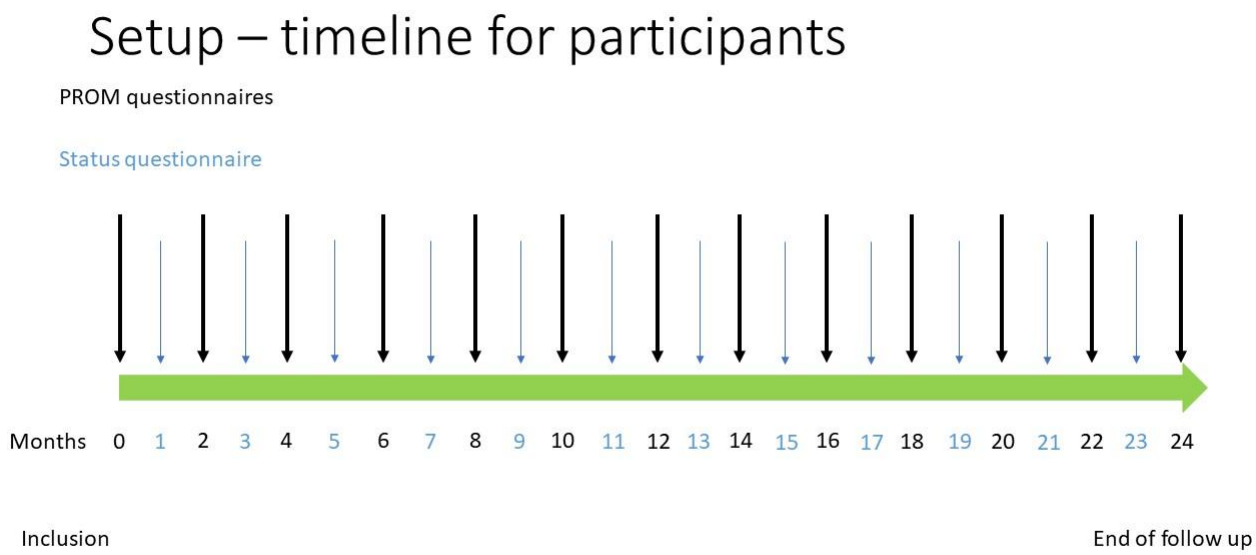
Figure: Screening



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Figure: Timeline for participants



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Figure: SPIRIT figure

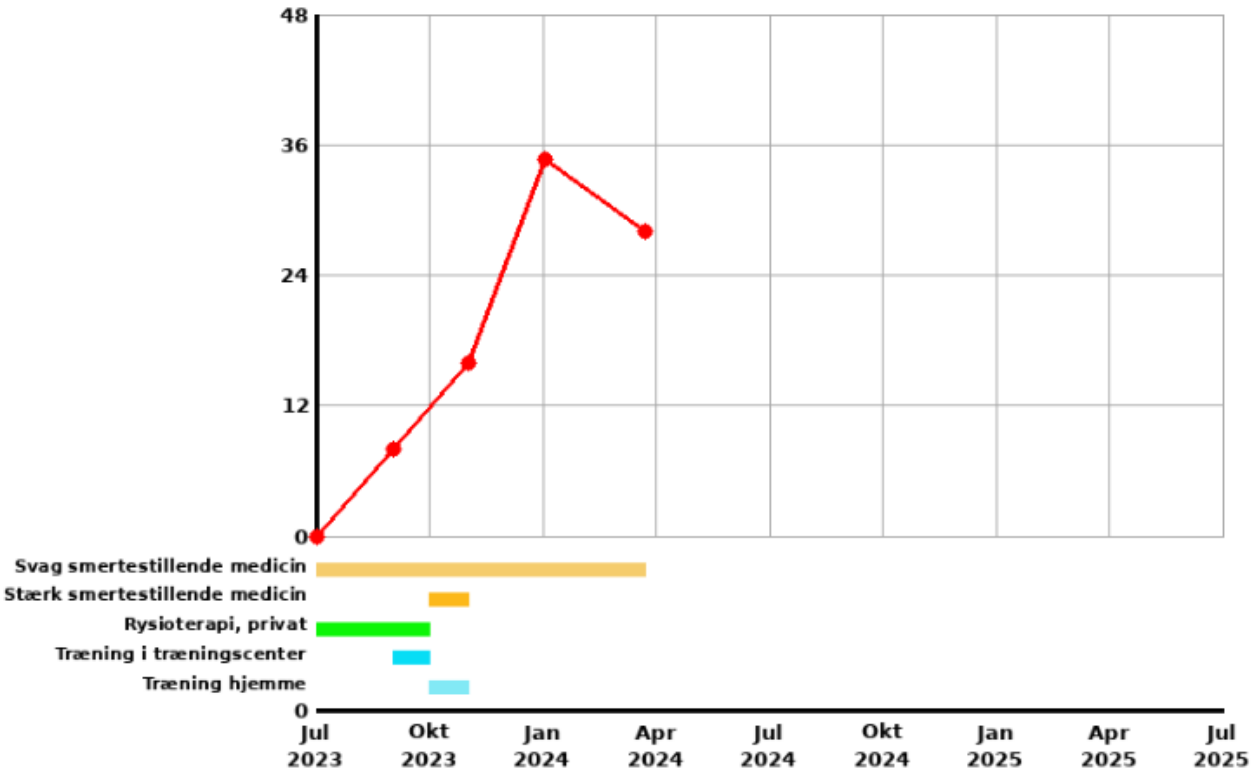
	STUDY PERIOD			
	Enrolment	**Allocation**	**Post-allocation**	**Assessment of data from registers**
TIMEPOINT	***-4 weeks***	**0**	***Study period 0-24 months***	***48 months***
ENROLMENT:				
Eligibility screen	X			
1	X			
Allocation		X		
INTERVENTIONS:				
Intervention: C-PRO data available during follow up visits			Collected PRO data will be available at every visit to a study site, to be included in evaluation and planning of further treatment regimens	
Control: Visits conducted without PRO data available			No PRO data will be available	
ASSESSMENTS:				
Diagnosis, age and gender	X	X		
PROM questionnaires			At every 2 months, please see "Figure: Timeline for participants". Will be collected for both intervention and control group.	
Status questionnaires			At every 2 months, please see "Figure: Timeline for participants". Will be collected for both intervention and control group.	
Questions for healthcare professionals			At every visit to a study site. Will be collected for both intervention and control group.	
Data on contacts with healthcare system from -12 months to end of study period				X

Figure: Patient Trajectory

Kære Test Et.

Tak for besvarelsen af spørgeskemaet. Der er nu gået 6 måneder fra vi startede med af følge funktionen i din Højre skulder.

I den følgende figur forsøger vi at vise, hvordan udviklingen har være for din skulder. Læs venligst forklaringen lige under figuren.



I figuren viser x-aksen tiden fra vi først sendte et spørgeskema til dig og de næste 2 år frem.
Y-aksen viser funktionen af din skulder, så 0 svarer til den dårligst tænkelige skulder, mens 48 svarer til den bedst tænkelige skulder.
De røde prikker viser resultatet af dine svar. Samlet illustrerer prikkerne udviklingen af funktionen i din skulder.

Under grafen vises de behandlinger, som du har modtaget. Disse er også baseret på de svar, som du har givet os.

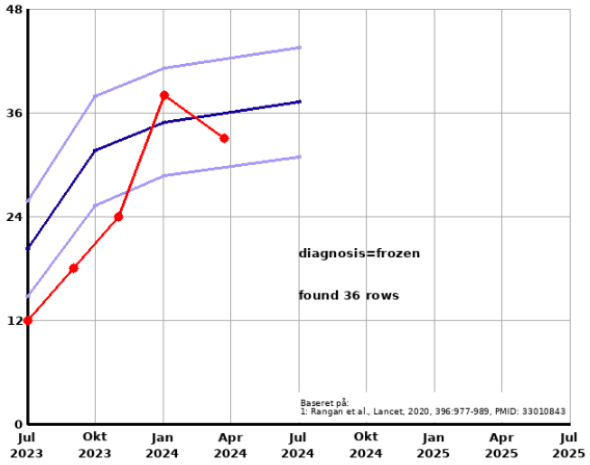
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Figure: Patient Reference

Over de kommende måneder vil der blive tilføjet flere og flere røde prikker, efterhånden som vi modtager dine svar.

Undersøgelse af din skulder har hidtil resulteret i, at din læge mener, at dit problem med skulderen skyldes frossen skulder.

Herunder vises den forventede udvikling i skulderfunktionen sammen med din reelle udvikling basered på diagnose og tidligere erfaring fra behandling.
Den mørkeblå linje er gennemsnittet, og de fleste med dit skulder-problem vil få et resultat, der havner mellem de to lyseblå linjer.



Vi håber, at denne form for visning af din skulders tilstand vil være til gavn for dig og de læger og fysioterapeuter, der behandler dig. Du kan betragte det som en form for dagbog.
Vi håber også, at grafen med forventninger kan give dig et indtryk af, hvad der er muligt.

Vi ser frem til fortsat at følge dig og din skulder.

Hvis du skulle have spørgsmål eller kommentarer i løbet af projektet, er du meget velkommen til at tage kontakt. Vi hører specielt meget gerne fra dig, hvis du skulle have forslag til, hvordan vi på en bedre måde kan vise informationen.

Med venlig hilsen

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Table 1: Secondary outcomes and evaluation plans

Secondary Outcome	Evaluation plan
- Disease specific Quality-of-life improvement divided by treatment cost during the trial period.	The same evaluation as of the primary outcome will be performed for the isolated disease groups
- Patient satisfaction with the treatment of their shoulder problem (measured by the question "Are you satisfied with the treatment of your shoulder so far?" from the trial-specific questionnaire).	The data will be examined using descriptive statistics of means and totals for the intervention and control group and stratified by age, gender and specific diagnosis. A simple comparison will be done by applying a multiple regression model between the intervention group and the control groups controlling for age, gender, specific diagnosis and stratified with regards to gender and specific diagnosis. If there are trend/level differences between the intervention and control group before the intervention a DID strategy will be applied.
- Number of patients treated with surgery - Number of sessions with physiotherapy - Number of contacts with either the hospital or the GP during the trial-follow up, adjusted number of contacts in the baseline period. - Number and types of complications during the treatment of the shoulder problem	The data will be examined using descriptive statistics of means and totals for the intervention and control group and stratified by gender and specific diagnosis. A simple comparison will be done by applying a multiple regression model between the intervention group and the control groups controlling for age, gender, specific diagnosis and stratified with regards to gender and specific diagnosis. If there are trend/level differences between the intervention and control group before the intervention a DID strategy will be applied.
- For patients still working: any periods of sick-leave/unemployment? - If use of systematic PRO scores changes the referral-pattern between the involved sectors	The data will be examined using descriptive statistics of means and totals for the intervention and control group and stratified by gender and specific diagnosis. A simple comparison will be done by applying a multiple regression model between the intervention group and the control groups controlling for age, gender, specific diagnosis and stratified with regards to gender and specific diagnosis. If there are trend/level differences between the intervention and control group before the intervention a DID strategy will be applied.
- Development in the PRO over time for each disease - If a PRO score can differentiate patients with regards to who might benefit from specific treatment regimens/effect of treatments measured by PRO	To evaluate the development in PRO for the different treatment regimens and evaluate if any cut-off value of the OSS can be found to help identify patients in risk of needing surgery by ROC curve analysis. Furthermore, the plan is to evaluate if a MCID can be found for the different diagnoses and to help identify at-risk patients.
- Healthcare professionals' assessments of history and usefulness of the prognosis tools (intervention group only).	The data will be examined using descriptive statistics of means and totals for the intervention group and stratified by gender and specific

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- Patient satisfaction and qualitative assessment of history and prognosis tool (intervention group only).	diagnosis.

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