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# BMJ Open

## Hip abductor muscle strength in patients after total- or unicompartmental knee arthroplasty for knee osteoarthritis or avascular necrosis: A systematic review and meta-analysis protocol

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-038770
Article Type:	Protocol
Date Submitted by the Author:	23-Mar-2020
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Keywords:	Knee < ORTHOPAEDIC & TRAUMA SURGERY, Hip < ORTHOPAEDIC & TRAUMA SURGERY, Adult orthopaedics < ORTHOPAEDIC & TRAUMA SURGERY, REHABILITATION MEDICINE

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5 **Hip abductor muscle strength in patients after total or unicompartmental knee**  
6 **arthroplasty for knee osteoarthritis or avascular necrosis: A systematic review**  
7 **and meta-analysis protocol**  
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32 Protocol manuscript  
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36 January 2020  
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39 For submission to: BMJ Open  
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## ABSTRACT

### Introduction:

Reduced hip abductor strength can indirectly lead to changes in knee kinematics and functional impairment and has been reported in patients with patellofemoral pain and knee osteoarthritis (OA). Limited information is available regarding hip abductor strength following total or unicompartmental knee arthroplasty (TKA/UKA). The aims of this systematic review are to collect all available primary research reporting hip abductor strength following TKA/UKA and conduct a meta-analysis.

### Methods and analysis:

Embase, Medline, SportDiscus, the Web of Science Core Collection and Scopus will be searched for human based clinical studies investigating hip abductor muscle strength after TKA/UKA for knee OA or avascular necrosis (AVN). Articles studying hip abductor strength after knee arthroplasty for posttraumatic OA will not be considered. No restriction on study design, prosthesis design, surgical approach, patient characteristics or severity of OA/AVN will be applied. We will search articles published between January 1, 1990 the date of our last search. Only articles in English or German language will be considered for inclusion. The assessment of quality and risk of bias will be performed with the modified Newcastle-Ottawa scale (NOS). Studies reporting manually measured muscle strength or measurements performed at hip abduction angles other than 0° will be excluded. References will be screened by two reviewers independently. Where necessary, a third author will make the final decision. Data will be extracted and presented in a tabular form. Depending on availability, comparable subgroup and meta-analyses will be conducted. Patient characteristics such as age, sex and surgical approach or rehabilitation program will be analysed, if sufficient data are available.

### Ethics and dissemination:

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3 No ethics approval is required. The results will be published in a peer reviewed journal and  
4 as conference presentation.  
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8 **Registration details:**

9 Registered in PROSPERO, acknowledgement of receipt Nr. 164339.  
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11

12 **Keywords:** abductor muscle strength, hip abductor, knee replacement, knee arthroplasty  
13 knee osteoarthritis, knee avascular necrosis  
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19 **Strengths and limitations of this study:**

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22 - To our knowledge, there is no published systematic review investigating hip abductor  
23 muscle strength following TKA/UKA  
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25 - The subject and inclusion/exclusion criteria are clearly stated to obtain and present  
26 comparable data.  
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28 - Possible limitations are the restricted time period of publication and language  
29 restriction to English or German.  
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31 - Possibility of limited and heterogenous data availability to perform a meta-analysis  
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## INTRODUCTION:

Degenerative diseases of the musculoskeletal system such as osteoarthritis are one of the leading burdens on the health care system, social security system and certainly on individuals. Prevalence of knee OA is estimated to be approximately 10% in men and 13% in women at the age of 60 years or older<sup>1</sup>. OA is expected to be the fourth leading cause of disability by the year of 2020, and the number of knee arthroplasties performed<sup>2,3</sup>.

Different static and dynamic biomechanical components influence the functional knee mechanics. Static elements are alignment and bony geometry. The neutral mechanical axis of the lower limb passes through the center of the tibial plateau in the frontal plane in standing, where the femur and tibia mechanical axes are colinear. This axis is altered in valgus or varus deformity<sup>4,5</sup>. Physiologically, during the stance phase of walking, the centre of load is located over the medial condyle creating an adduction moment<sup>6,7</sup>. Ligaments and muscles of the joint form the group of dynamic stabilizers and mainly resist the adduction moment<sup>7</sup>. As the next proximal articulation, the hip joint contributes to knee biomechanics. The hip abductor muscles abduct the hip joint, support pelvic stability during single leg stance and directly affect the tibiofemoral and patellofemoral joint kinematics. Moreover, the hip abductor muscle group controls the internal rotation of the femur<sup>8</sup>. In case of hip abductor muscle strength deficit, the contralateral pelvic side drops while walking, a condition known as "Trendelenburg gait"<sup>9</sup>. This movement initially leads to a shift of the center of mass away from the stance limb, causing an adduction moment. It can be compensated by leaning the trunk toward the stance limb and shifting the center of mass over the stance limb by a higher abduction moment.<sup>8</sup> The protective effect of greater hip abduction moment has also been reported in terms of reduced medial tibiofemoral OA progression<sup>10</sup>. As a result, patellar tracking can be also altered and cause knee pain<sup>11,12,13</sup>. Isokinetic measurements have shown that hip abductor muscle weakness is present in patients with knee OA<sup>14,15</sup>.

Reduced hip abductor muscle strength can implicate functional and performance-based outcome after TKA, therefore maintaining and strengthening of the hip abductor muscles form a clinically relevant factor in patient receiving knee arthroplasty<sup>16,17</sup>.

The purpose of this protocol is to present a specific methodology for conducting a systematic review and summarizing the available primary research regarding hip abductor muscle strength in patients following TKA/UKA and perform a meta-analysis of the available data. Moreover, we aim to investigate possible influencing factors, such as patient demographics, surgical methods, study methods and rehabilitation programs. We designed the study

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3 question using the PICOS (Population, Intervention, Comparison, Outcome, Study design)  
4 strategy (Table 1)<sup>18</sup>.  
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## 9 **METHODS AND ANALYSES:**

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11 The protocol was developed following the Preferred Reporting Items for Systematic Reviews  
12 and Meta-analyses Protocols (PRISMA-P) guideline<sup>19</sup>(Supplementary a). Bibliographic  
13 database searching was initiated on December 19, 2019. The review was submitted for  
14 registration prospectively in PROSPERO on January 5<sup>th</sup>, 2020 and the expected completion  
15 date is July 1<sup>st</sup>, 2020<sup>20</sup>.  
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### 23 **Eligibility criteria**

#### 24 *Inclusion criteria*

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26 Human based clinical studies reporting on hip abductor muscle strength after primary  
27 TKA/UKA will be considered for inclusion. No restriction regarding the study design,  
28 operative approach, prosthesis design, age and sex of the patients or severity of OA/AVN will  
29 be placed. Date of publication will be limited to a time period from January 1, 1990 to the  
30 date of our last search.  
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#### 36 *Exclusion criteria*

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38 Studies published before 01.01.1990, published in a language other than English or German,  
39 not reporting absolute values of hip abductor muscle strength or torque ratios, or reporting on  
40 hip abductor strength measured with hand-held manometer/dynamometer or at a hip  
41 abduction angle other than 0° will be excluded. Articles reporting posttraumatic indications for  
42 TKA/UKA will not be considered for inclusion.  
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#### 47 *Methodological considerations*

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49 Studies reporting hip abductor strength measurements by isokinetic/isometric dynamometers  
50 and at a 0° hip abduction angle will be considered for inclusion because manual  
51 measurements because the results are not reliable and not directly comparable with studies  
52 using electronic dynamometers and abduction angle other than 0° do not show relevant  
53 muscle function/strength during walking and standing. Furthermore the exclusion of these  
54 studies will allow us to collect standardized, comparable data in order to enable meta-  
55 analysis<sup>21</sup>.  
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## Information sources and search strategy

Text word synonyms and database-specific subject headings for knee OA, knee arthroplasty, and hip abductor function will be used. We will search the electronic databases Embase via embase.com, Medline via Ovid, SportDiscus via EBSCOHost, the Web of Science Core Collection, and Scopus (Supplementary b). In the primary search no language restrictions will be applied. Time period of the search will be limited to articles published after January 1, 1990. References will be exported to Endnote X9 and deduplicated. The detailed search strategy can be found in the supplementary document.

## Study records: data management, selection process and data extraction

Titles and abstracts of all retrieved references will be independently reviewed and screened by two reviewers (PK and PI) to identify studies that potentially meet the inclusion criteria. All potentially relevant references will be collected in full-text and independently assessed by two reviewers (PK and PI). Any disagreements regarding eligibility will be resolved by consensus and by necessity, a third review author (AM) will make a final decision. In order to find possible additional studies, we will screen the bibliographic references of all included articles as well as the citations. Data from the full texts will be extracted and entered into a standardized excel data entry form by PK and PI based piloting extractions. The study selection process will be presented in form of a PRISMA diagram<sup>19</sup>. The information to be extracted can be found in Table 2. We will contact principal investigators and/or corresponding author(s) twice by email, in case of conference abstracts, in order to collect their results. Potential conference abstracts will be considered for inclusion only if appropriate data are available for the outcomes of this study.

## Outcomes and prioritisation

The main outcomes will be:

1. Absolute values of isometric/isokinetic hip abductor torque in patients following TKA/UKA, or in asymptomatic control groups
2. Torque ratio (ipsilateral hip/contralateral hip) of hip abductors following TKA/UKA
3. Change in hip abductor torque/hip abductor torque ratio from baseline to each follow-up
4. Differences in hip abductor torque/torque ratio between patients after TKA/UKA and healthy control groups.

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3 The secondary outcomes will be:

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5 1. Surgical approaches/methods influencing the hip abductor muscle strength deficits after  
6 TKA/UKA  
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8 2. Pre- and postoperative knee alignment influencing the hip abductor muscle strength  
9 deficits after TKA/UKA  
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11 3. Patient characteristics influencing the hip abductor muscle strength deficits after  
12 TKA/UKA  
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14 4. Rehabilitation programs influencing the hip abductor muscle strength deficits after  
15 TKA/UKA  
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### 19 **Risk of bias in individual studies**

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21 To minimise bias, articles that meet the inclusion criteria will be checked by two reviewers  
22 (PK and PI) independently according to a modified version of the NOS<sup>22</sup>(Supplementary c).  
23 According to the modified NOS each study will be valued with 1 to 6 stars where higher  
24 scores indicate higher level of quality. No separate tool will be used to assess the risk of bias  
25 of randomized control trials, since we do not extract estimates of treatment differences from  
26 RCTs but use them as a source for observational data.  
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### 33 **Data synthesis**

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35 We will extract any quantitative/qualitative data from all eligible studies according to the main  
36 outcomes (mean, median, etc.), on the population (SD, interquartile ranges, percentile), on  
37 measurements (standard errors, CI, p-values, sample size), as well as the secondary  
38 outcomes for both purposes (systematic review and meta-analyses). Furthermore, all details  
39 specific to the review question will be extracted. If the information is available for several time  
40 points, the data will be extracted for all time points. The data will be presented in tabular  
41 format and forest plots. Depending on availability of appropriate data for comparable specific  
42 patient groups with same measurement method in different studies, these results will also be  
43 subjected to meta-analysis. Where statistical pooling is not possible, the findings will be  
44 presented in narrative form. Meta regression and subgroup specific meta analyses will be  
45 conducted to investigate the effect of time since TKA/UKA and measurement type (isokinetic  
46 or isometric) on different outcomes. In case that outcomes are not reported directly but  
47 indirect information is available on side specific or time point specific results, the available  
48 information will be transformed accordingly. Meta regression and subgroup specific meta  
49 analyses will be used to investigate the influence of time since TKA/UKA and type of  
50 measurement (isokinetic or isometric) on the different outcomes. In case of sufficient  
51 information, these analyses will be extended to patient characteristics, surgical approach or  
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3 rehabilitation program. We will contact corresponding authors when the necessary data is  
4 missing or unclear. The data extraction will be cross-checked independently.  
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### 8 **Meta-bias(es)**

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10 To explore potential hints to publication bias or selective reporting, we will investigate the  
11 influence of all available study characteristics on the various outcomes.  
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### 14 **Confidence in cumulative evidence**

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16 Grading of Recommendations Assessment, Development and Evaluation system (GRADE)  
17 will be applied<sup>23</sup>.  
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### 20 **Ethics and dissemination**

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22 This study is a protocol for a systematic review and meta-analysis. No human participants  
23 will be recruited. No ethics approval is needed. The study results will be published in a peer  
24 reviewed journal and as conference presentation.  
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### 30 **Patient and public involvement**

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32 There is no patient and/or public involvement planned for this review.  
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### 36 **Authors contributions**

37  
38 PI, PK and AM will perform this systematic review and meta-analysis. The protocol has been  
39 registered in PROSPERO by PK. The search strategy was designed by CA. CN reviewed the  
40 protocol and was responsible for the strategy of data synthesis. All authors provided critical  
41 feedback, have read and approved the final manuscript.  
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### 46 **FUNDING STATEMENT:**

47  
48 This study will be funded by the Department of Orthopaedics and Traumatology and the  
49 Department of Surgery of the University Hospital Basel.  
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### 54 **COMPETING INTERESTS STATEMENT**

55  
56 The authors declare no competing interest.  
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10 **Figures and Legends:**  
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Item	Specification
Population, or participants and conditions of interest	Patients with OA or AVN of the knee (any age, gender and severity)
Interventions	TKA/UKA
Comparisons or control groups	For comparison between limbs of the same subject: asymptomatic contralateral hip and knee For comparison between patients and healthy individuals: asymptomatic control subjects
Outcomes of interest	Muscle strength of hip abductors
Study designs	Any study design, published studies, conference abstracts to be considered

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31 Table 1: The Population, Intervention, Comparison, Outcome, Study design (PICOS) process<sup>18</sup>.  
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No.	Description
1	Authors and year of publication
2	Country of origin of the study
3	Type of study
4	Study population
5	Study completion rate
6	Diagnosis
7	Surgical approach: medial parapatellar; modified medial parapatellar according to Insall; subvastus; midvastus; trivector-retaining; lateral; lateral with tuberositas osteotomy <sup>24</sup>
8	Study population demographics

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9	Pre- and postoperative frontal and sagittal plane knee alignment
10	Measurement methods
10a	Isometric/isokinetic strength measurement
10b	Angle of isometric measurement/velocity of isokinetic measurement
10c	Patient position during the measurement (lying supine/side-lying/standing)
11	Comparators: healthy individuals; asymptomatic contralateral side; no comparator
12	Total duration of follow up (weeks/months after the operation)
13	Measurement stages (preoperative, follow up in weeks/months after the operation)
14	Information regarding the rehabilitation protocols
15	Outcome (mean values, standard deviations (SDs) and confidence intervals (CIs))
15a	Absolute values of hip abductor torque in patients after TKA/UKA, or in asymptomatic control groups
15b	Torque ratio (operated side/contralateral hip) of hip abductors in patients after TKA/UKA
15c	Change in hip abductor torque / hip abductor torque ratio from baseline to each follow-up
15d	Differences in hip abductor torque / torque ratios between patients after TKA/UKA and healthy control groups.
16	Authors conclusions
17	Information regarding risk of bias

Table 2: Data that will be extracted from every study included in the review

# Hip abductor muscle strength in patients after total or unicompartmental knee arthroplasty for knee osteoarthritis or avascular necrosis - Search strategy

## Appendices

### Appendix 1: Search strategies

#### Embase.com

(20191219; 860 hits)

((('knee osteoarthritis'/de OR (((knee OR femorotibial OR patellofemoral) NEAR/5 (osteoarthriti\* OR arthriti\* OR osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR 'degenerative joint disease\*')) OR 'gonarthrosis'):ab,ti)

AND

('knee arthroplasty'/exp OR 'total knee arthroplasty'/de OR 'arthroplasty'/de OR 'total arthroplasty'/de OR 'knee prosthesis'/de OR 'femoral knee prosthesis'/de OR 'hinge knee prosthesis'/exp OR 'patella prosthesis'/de OR 'patellofemoral prosthesis'/de OR 'tibial knee prosthesis'/de OR 'total knee prosthesis'/de OR 'unicompartmental knee prosthesis'/de OR 'joint prosthesis'/de OR 'endoprosthesis'/de OR 'minimally invasive surgery'/de OR (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprosthes\* OR implant\* OR 'artificial knee\*' OR TKR OR TKA OR (('minimally invasive' OR mini-invasive OR minimal OR 'minimal access') NEAR/3 (surgery OR 'surgical method\*' OR 'surgical procedure\*' OR 'surgical technique\*' OR operation OR 'operative treatment' OR 'operative intervention' OR 'operative repair' OR 'operative restoration')) OR 'Active UKA' OR 'Advance Medial Pivot' OR 'Advantim' OR 'ALPINA PS' OR 'Anatomic Graduated Component' OR 'Ascent' OR 'ATTUNE' OR 'Bi-Surface' OR 'Duracon' OR 'EMPOWR' OR 'Genesis II' OR 'iBalance Unicdylar Knee' OR 'Insall-Burstein II' OR 'InterSpace Knee' OR 'KineMax' OR 'KineSpring' OR 'Legion' OR 'Marmor' OR 'Maxim' OR 'Maximum Congruent Knee system' OR 'Miller-Galante' OR 'Natural Knee II' OR 'Natural-Knee Flex System' OR 'NexGen' OR 'Optetrak' OR 'OrthoGlide' OR 'Oxinium' OR 'Persona Knee System' OR 'Press-Fit Condylar' OR 'Profix' OR 'Repicci' OR 'Restoris' OR 'Scorpio' OR 'Search Evolution' OR 'Segmental Knee System' OR 'Series 7000' OR 'Sigma' OR 'Triathlon' OR 'Tricon knee' OR 'UniCAP' OR 'Vanguard' OR 'Advance Total Knee' OR 'Alegretto' OR 'EIUS' OR 'UC Plus Solution' OR 'Uni-Knee' OR 'Uniglide' OR '3DKnee' OR 'Advance Stature Knee' OR 'HemiCAP' OR 'Dual Articular 2000' OR 'Endo-Model' OR 'Endo-Modell' OR 'Endomodel' OR 'EnduRo' OR 'LCS Complete' OR 'Oxford' OR 'P.F.C. Sigma' OR 'PFC Sigma' OR 'Rotaflex' OR 'S-ROM Noiles' OR 'Avon' OR 'Regenerex'):ab,ti))

OR

((('knee osteoarthritis'/de OR 'osteoarthritis'/de OR 'avascular necrosis'/de OR 'bone necrosis'/de OR (osteoarthriti\* OR arthriti\* OR osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR 'degenerative joint disease\*' OR 'gonarthrosis' OR ((avascular OR bone) NEAR/3 (necrosis OR infarction)) OR osteonecrosis OR osteoradionecrosis):ab,ti)



1  
2  
3 AND

4  
5 ('knee arthroplasty'/exp OR 'total knee arthroplasty'/de OR 'knee prosthesis'/de OR 'femoral knee  
6 prosthesis'/de OR 'hinge knee prosthesis'/exp OR 'patella prosthesis'/de OR 'patellofemoral  
7 prosthesis'/de OR 'tibial knee prosthesis'/de OR 'total knee prosthesis'/de OR 'unicompartmental  
8 knee prosthesis'/de OR (((knee OR femorotibial OR patella\* OR patellofemoral) NEAR/3  
9 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprosthesis\*  
10 OR implant\*)) OR 'artificial knee\*' OR TKR OR TKA OR 'Active UKA' OR 'Advance Medial Pivot' OR  
11 'Advantim' OR 'ALPINA PS' OR 'Anatomic Graduated Component' OR 'Ascent' OR 'ATTUNE' OR 'Bi-  
12 Surface' OR 'Duracon' OR 'EMPOWR' OR 'Genesis II' OR 'iBalance Unicondylar Knee' OR 'Insall-  
13 Burstein II' OR 'InterSpace Knee' OR 'KineMax' OR 'KineSpring' OR 'Legion' OR 'Marmor' OR 'Maxim'  
14 OR 'Maximum Congruent Knee system' OR 'Miller-Galante' OR 'Natural Knee II' OR 'Natural-Knee Flex  
15 System' OR 'NexGen' OR 'Optetrak' OR 'OrthoGlide' OR 'Oxinium' OR 'Persona Knee System' OR  
16 'Press-Fit Condylar' OR 'Profix' OR 'Repicci' OR 'Restoris' OR 'Scorpio' OR 'Search Evolution' OR  
17 'Segmental Knee System' OR 'Series 7000' OR 'Sigma' OR 'Triathlon' OR 'Tricon knee' OR 'UniCAP' OR  
18 'Vanguard' OR 'Advance Total Knee' OR 'Alegretto' OR 'EIUS' OR 'UC Plus Solution' OR 'Uni-Knee' OR  
19 'Uniglide' OR '3DKnee' OR 'Advance Stature Knee' OR 'HemiCAP' OR 'Dual Articular 2000' OR 'Endo-  
20 Model' OR 'Endo-Modell' OR 'Endomodel' OR 'Enduro' OR 'LCS Complete' OR 'Oxford' OR 'P.F.C.  
21 Sigma' OR 'PFC Sigma' OR 'Rotaflex' OR 'S-ROM Noiles' OR 'Avon' OR 'Regenerex'):ab,ti))

22  
23  
24 AND

25  
26  
27 ('muscle strength'/de OR 'muscle weakness'/de OR 'torque'/de OR 'hip abductor muscle'/de OR  
28 'pelvic movement'/de OR (((muscle OR muscular) NEAR/3 (strength OR power OR force OR weakness  
29 OR weakening OR insufficiency OR fatigue OR deficit\*)) OR torque OR 'torsional moment\*' OR  
30 'turning force\*' OR newton-meter\* OR 'hip abduct\*' OR gluteus OR 'gluteal muscle\*' OR 'abduction  
31 motion' OR ((pelvic OR pelvis) NEAR/3 movement\*)):ab,ti)

32  
33 NOT

34  
35  
36 (('animal'/de OR 'animal experiment'/exp OR 'nonhuman'/de) NOT ('human'/exp OR 'human  
37 experiment'/de))

38  
39  
40  
41  
42 **Ovid Medline**

43 (20191219; 449 hits)

44  
45 (((osteoarthritis, knee/ OR (((knee OR femorotibial OR patellofemoral) ADJ5 (osteoarthriti\* OR  
46 arthriti\* OR osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR  
47 degenerative joint disease\*)) OR gonarthrosis).ab,ti.)

48  
49 AND

50  
51 (arthroplasty, replacement, knee/ OR arthroplasty/ OR arthroplasty, replacement/ OR knee  
52 prosthesis/ OR joint prosthesis/ OR "prostheses and implants"/ OR minimally invasive surgical  
53 procedures/ OR (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\*  
54 OR endoprosthesis\* OR implant\* OR artificial knee\* OR TKR OR TKA OR ((minimally invasive OR mini-  
55 invasive OR minimal OR minimal access) ADJ3 (surgery OR surgical method\* OR surgical procedure\*  
56 OR surgical technique\* OR operation OR operative treatment OR operative intervention OR  
57 operative repair OR operative restoration)) OR Active UKA OR Advance Medial Pivot OR Advantim OR  
58 ALPINA PS OR Anatomic Graduated Component OR Ascent OR ATTUNE OR Bi-Surface OR Duracon OR  
59 EMPOWR OR Genesis II OR iBalance Unicondylar Knee OR Insall-Burstein II OR InterSpace Knee OR  
60

1  
2  
3 KineMax OR KineSpring OR Legion OR Marmor OR Maxim OR Maximum Congruent Knee system OR  
4 Miller-Galante OR Natural Knee II OR Natural-Knee Flex System OR NexGen OR Optetrak OR  
5 OrthoGlide OR Oxinium OR Persona Knee System OR Press-Fit Condylar OR Profix OR Repicci OR  
6 Restoris OR Scorpio OR Search Evolution OR Segmental Knee System OR Series 7000 OR Sigma OR  
7 Triathlon OR Tricon knee OR UniCAP OR Vanguard OR Advance Total Knee OR Alegretto OR EIUS OR  
8 UC Plus Solution OR Uni-Knee OR Uniglide OR 3DKnee OR Advance Stature Knee OR HemiCAP OR  
9 Dual Articular 2000 OR Endo-Model OR Endo-Modell OR Endomodel OR EnduRo OR LCS Complete OR  
10 Oxford OR PFC Sigma OR Rotaflex OR S-ROM Noiles OR Avon OR Regenerex).ab,ti.))

11  
12  
13 OR

14  
15 ((osteoarthritis, knee/ OR osteoarthritis/ OR osteonecrosis/ OR (osteoarthriti\* OR arthriti\* OR  
16 osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR degenerative joint  
17 disease\* OR gonarthrosis OR ((avascular OR bone) ADJ3 (necrosis OR infarction)) OR osteonecrosis  
18 OR osteoradionecrosis).ab,ti.)

19  
20  
21 AND

22  
23 (arthroplasty, replacement, knee/ OR knee prosthesis/ OR (((knee OR femorotibial OR patella\* OR  
24 patellofemoral) ADJ3 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR  
25 arthroprosthes\* OR endoprosthesis\* OR implant\*)) OR artificial knee\* OR TKR OR TKA OR Active UKA  
26 OR Advance Medial Pivot OR Advantim OR ALPINA PS OR Anatomic Graduated Component OR Ascent  
27 OR ATTUNE OR Bi-Surface OR Duracon OR EMPOWR OR Genesis II OR iBalance Unicdylar Knee OR  
28 Insall-Burstein II OR InterSpace Knee OR KineMax OR KineSpring OR Legion OR Marmor OR Maxim OR  
29 Maximum Congruent Knee system OR Miller-Galante OR Natural Knee II OR Natural-Knee Flex  
30 System OR NexGen OR Optetrak OR OrthoGlide OR Oxinium OR Persona Knee System OR Press-Fit  
31 Condylar OR Profix OR Repicci OR Restoris OR Scorpio OR Search Evolution OR Segmental Knee  
32 System OR Series 7000 OR Sigma OR Triathlon OR Tricon knee OR UniCAP OR Vanguard OR Advance  
33 Total Knee OR Alegretto OR EIUS OR UC Plus Solution OR Uni-Knee OR Uniglide OR 3DKnee OR  
34 Advance Stature Knee OR HemiCAP OR Dual Articular 2000 OR Endo-Model OR Endo-Modell OR  
35 Endomodel OR EnduRo OR LCS Complete OR Oxford OR PFC Sigma OR Rotaflex OR S-ROM Noiles OR  
36 Avon OR Regenerex).ab,ti.))

37  
38  
39  
40 AND

41  
42 (muscle strength/ OR muscle weakness/ OR torque/ OR (((muscle OR muscular) ADJ3 (strength OR  
43 power OR force OR weakness OR weakening OR insufficiency OR fatigue OR deficit\*)) OR torque OR  
44 torsional moment\* OR turning force\* OR newton-meter\* OR hip abduct\* OR gluteus OR gluteal  
45 muscle\* OR abduction motion OR ((pelvic OR pelvis) ADJ3 movement\*).ab,ti.)

46  
47 NOT

48  
49 (exp animals/ NOT humans/)

## 50 51 52 53 SportDiscus

54  
55 (20191219; 283 hits)

56  
57 ((((((TI knee OR AB knee OR TI femorotibial OR AB femorotibial OR TI patellofemoral OR AB  
58 patellofemoral) N5 (TI osteoarthriti\* OR AB osteoarthriti\* OR TI arthriti\* OR AB arthriti\* OR TI  
59 osteoarthrosis OR AB osteoarthrosis OR TI osteoarthroses OR AB osteoarthroses OR TI arthrosis OR  
60 AB arthrosis OR TI arthroses OR AB arthroses OR TI arthropathy OR AB arthropathy OR TI

1  
2  
3 "degenerative joint disease\*" OR AB "degenerative joint disease\*")) OR TI gonarthrosis OR AB  
4 gonarthrosis)) AND (DE "ARTHROPLASTY" OR DE "TOTAL knee replacement" OR DE "ARTIFICIAL  
5 joints" OR DE "PROSTHETICS" OR DE "ARTIFICIAL knees" OR (TI replacement\* OR AB replacement\*  
6 OR TI reconstruct\* OR AB reconstruct\* OR TI arthroplast\* OR AB arthroplast\* OR TI prosthes\* OR AB  
7 prosthes\* OR TI arthroprosthes\* OR AB arthroprosthes\* OR TI endoprosthesis\* OR AB endoprosthesis\*  
8 OR TI implant\* OR AB implant\* OR TI "artificial knee\*" OR AB "artificial knee\*" OR TI TKR OR AB TKR  
9 OR TI TKA OR AB TKA OR ((TI "minimally invasive" OR AB "minimally invasive" OR TI mini-invasive OR  
10 AB mini-invasive OR TI minimal OR AB minimal OR TI "minimal access" OR AB "minimal access") N3  
11 (TI surgery OR AB surgery OR TI "surgical method\*" OR AB "surgical method\*" OR TI "surgical  
12 procedure\*" OR AB "surgical procedure\*" OR TI "surgical technique\*" OR AB "surgical technique\*"  
13 OR TI operation OR AB operation OR TI "operative treatment" OR AB "operative treatment" OR TI  
14 "operative intervention" OR AB "operative intervention" OR TI "operative repair" OR AB "operative  
15 repair" OR TI "operative restoration" OR AB "operative restoration")) OR TI "Active UKA" OR AB  
16 "Active UKA" OR TI "Advance Medial Pivot" OR AB "Advance Medial Pivot" OR TI Advantim OR AB  
17 Advantim OR TI "ALPINA PS" OR AB "ALPINA PS" OR TI "Anatomic Graduated Component" OR AB  
18 "Anatomic Graduated Component" OR TI Ascent OR AB Ascent OR TI ATTUNE OR AB ATTUNE OR TI  
19 Bi-Surface OR AB Bi-Surface OR TI Duracon OR AB Duracon OR TI EMPOWR OR AB EMPOWR OR TI  
20 "Genesis II" OR AB "Genesis II" OR TI "iBalance Unicondylar Knee" OR AB "iBalance Unicondylar  
21 Knee" OR TI "Insall-Burstein II" OR AB "Insall-Burstein II" OR TI "InterSpace Knee" OR AB "InterSpace  
22 Knee" OR TI KineMax OR AB KineMax OR TI KineSpring OR AB KineSpring OR TI Legion OR AB Legion  
23 OR TI Marmor OR AB Marmor OR TI Maxim OR AB Maxim OR TI "Maximum Congruent Knee system"  
24 OR AB "Maximum Congruent Knee system" OR TI Miller-Galante OR AB Miller-Galante OR TI "Natural  
25 Knee II" OR AB "Natural Knee II" OR TI "Natural-Knee Flex System" OR AB "Natural-Knee Flex System"  
26 OR TI NexGen OR AB NexGen OR TI Optetrak OR AB Optetrak OR TI OrthoGlide OR AB OrthoGlide OR  
27 TI Oxinium OR AB Oxinium OR TI "Persona Knee System" OR AB "Persona Knee System" OR TI "Press-  
28 Fit Condylar" OR AB "Press-Fit Condylar" OR TI Profix OR AB Profix OR TI Repicci OR AB Repicci OR TI  
29 Restoris OR AB Restoris OR TI Scorpio OR AB Scorpio OR TI "Search Evolution" OR AB "Search  
30 Evolution" OR TI "Segmental Knee System" OR AB "Segmental Knee System" OR TI Series OR AB  
31 Series OR TI Sigma OR AB Sigma OR TI Triathlon OR AB Triathlon OR TI "Tricon knee" OR AB "Tricon  
32 knee" OR TI UniCAP OR AB UniCAP OR TI Vanguard OR AB Vanguard OR TI "Advance Total Knee" OR  
33 AB "Advance Total Knee" OR TI Alegretto OR AB Alegretto OR TI EIUS OR AB EIUS OR TI "UC Plus  
34 Solution" OR AB "UC Plus Solution" OR TI Uni-Knee OR AB Uni-Knee OR TI Uniglide OR AB Uniglide OR  
35 TI DKnee OR AB DKnee OR TI "Advance Stature Knee" OR AB "Advance Stature Knee" OR TI HemiCAP  
36 OR AB HemiCAP OR TI "Dual Articular" OR AB "Dual Articular" OR TI Endo-Model OR AB Endo-Model  
37 OR TI Endo-Modell OR AB Endo-Modell OR TI Endomodel OR AB Endomodel OR TI EnduRo OR AB  
38 EnduRo OR TI "LCS Complete" OR AB "LCS Complete" OR TI Oxford OR AB Oxford OR TI "PFC Sigma"  
39 OR AB "PFC Sigma" OR TI Rotaflex OR AB Rotaflex OR TI "S-ROM Noiles" OR AB "S-ROM Noiles" OR TI  
40 Avon OR AB Avon OR TI Regenerex OR AB Regenerex))) OR ((DE "OSTEOARTHRITIS" OR DE  
41 "OSTEONECROSIS" OR DE "OSTEOCHONDROSIS" OR (TI osteoarthriti\* OR AB osteoarthriti\* OR TI  
42 arthriti\* OR AB arthriti\* OR TI osteoarthrosis OR AB osteoarthrosis OR TI osteoarthroses OR AB  
43 osteoarthroses OR TI arthrosis OR AB arthrosis OR TI arthroses OR AB arthroses OR TI arthropathy OR  
44 AB arthropathy OR TI "degenerative joint disease\*" OR AB "degenerative joint disease\*" OR TI  
45 gonarthrosis OR AB gonarthrosis OR ((TI avascular OR AB avascular OR TI bone OR AB bone) N3 (TI  
46 necrosis OR AB necrosis OR TI infarction OR AB infarction)) OR TI osteonecrosis OR AB osteonecrosis  
47 OR TI osteoradionecrosis OR AB osteoradionecrosis)) AND (DE "TOTAL knee replacement" OR DE  
48 "ARTIFICIAL knees" OR (((TI knee OR AB knee OR TI femorotibial OR AB femorotibial OR TI patella\*  
49 OR AB patella\* OR TI patellofemoral OR AB patellofemoral) N3 (TI replacement\* OR AB replacement\*  
50 OR TI reconstruct\* OR AB reconstruct\* OR TI arthroplast\* OR AB arthroplast\* OR TI prosthes\* OR AB  
51 prosthes\* OR TI arthroprosthes\* OR AB arthroprosthes\* OR TI endoprosthesis\* OR AB endoprosthesis\*  
52  
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OR TI implant\* OR AB implant\*)) OR TI "artificial knee\*" OR AB "artificial knee\*" OR TI TKR OR AB TKR  
 OR TI TKA OR AB TKA OR TI "Active UKA" OR AB "Active UKA" OR TI "Advance Medial Pivot" OR AB  
 "Advance Medial Pivot" OR TI Advantim OR AB Advantim OR TI "ALPINA PS" OR AB "ALPINA PS" OR TI  
 "Anatomic Graduated Component" OR AB "Anatomic Graduated Component" OR TI Ascent OR AB  
 Ascent OR TI ATTUNE OR AB ATTUNE OR TI Bi-Surface OR AB Bi-Surface OR TI Duracon OR AB  
 Duracon OR TI EMPOWR OR AB EMPOWR OR TI "Genesis II" OR AB "Genesis II" OR TI "iBalance  
 Unicondylar Knee" OR AB "iBalance Unicondylar Knee" OR TI "Insall-Burstein II" OR AB "Insall-  
 Burstein II" OR TI "InterSpace Knee" OR AB "InterSpace Knee" OR TI KineMax OR AB KineMax OR TI  
 KineSpring OR AB KineSpring OR TI Legion OR AB Legion OR TI Marmor OR AB Marmor OR TI Maxim  
 OR AB Maxim OR TI "Maximum Congruent Knee system" OR AB "Maximum Congruent Knee system"  
 OR TI Miller-Galante OR AB Miller-Galante OR TI "Natural Knee II" OR AB "Natural Knee II" OR TI  
 "Natural-Knee Flex System" OR AB "Natural-Knee Flex System" OR TI NexGen OR AB NexGen OR TI  
 Optetrak OR AB Optetrak OR TI OrthoGlide OR AB OrthoGlide OR TI Oxinium OR AB Oxinium OR TI  
 "Persona Knee System" OR AB "Persona Knee System" OR TI "Press-Fit Condylar" OR AB "Press-Fit  
 Condylar" OR TI Profix OR AB Profix OR TI Repicci OR AB Repicci OR TI Restoris OR AB Restoris OR TI  
 Scorpio OR AB Scorpio OR TI "Search Evolution" OR AB "Search Evolution" OR TI "Segmental Knee  
 System" OR AB "Segmental Knee System" OR TI Series OR AB Series OR TI Sigma OR AB Sigma OR TI  
 Triathlon OR AB Triathlon OR TI "Tricon knee" OR AB "Tricon knee" OR TI UniCAP OR AB UniCAP OR TI  
 Vanguard OR AB Vanguard OR TI "Advance Total Knee" OR AB "Advance Total Knee" OR TI Alegretto  
 OR AB Alegretto OR TI EIUS OR AB EIUS OR TI "UC Plus Solution" OR AB "UC Plus Solution" OR TI Uni-  
 Knee OR AB Uni-Knee OR TI Uniglide OR AB Uniglide OR TI DKnee OR AB DKnee OR TI "Advance  
 Stature Knee" OR AB "Advance Stature Knee" OR TI HemiCAP OR AB HemiCAP OR TI "Dual Articular"  
 OR AB "Dual Articular" OR TI Endo-Model OR AB Endo-Model OR TI Endo-Modell OR AB Endo-Modell  
 OR TI Endomodel OR AB Endomodel OR TI EnduRo OR AB EnduRo OR TI "LCS Complete" OR AB "LCS  
 Complete" OR TI Oxford OR AB Oxford OR TI "PFC Sigma" OR AB "PFC Sigma" OR TI Rotaflex OR AB  
 Rotaflex OR TI "S-ROM Noiles" OR AB "S-ROM Noiles" OR TI Avon OR AB Avon OR TI Regenerex OR AB  
 Regenerex)))) AND (DE "MUSCLE strength" OR DE "MUSCLE weakness" OR DE "TORQUE" OR DE  
 "GLUTEAL muscles" OR DE "GLUTEUS medius" OR DE "GLUTEUS minimus" OR DE "PIRIFORMIS  
 muscle" OR (((TI muscle OR AB muscle OR TI muscular OR AB muscular) N3 (TI strength OR AB  
 strength OR TI power OR AB power OR TI force OR AB force OR TI weakness OR AB weakness OR TI  
 weakening OR AB weakening OR TI insufficiency OR AB insufficiency OR TI fatigue OR AB fatigue OR  
 TI deficit\* OR AB deficit\*)) OR TI torque OR AB torque OR TI "torsional moment\*" OR AB "torsional  
 moment\*" OR TI "turning force\*" OR AB "turning force\*" OR TI newton-meter\* OR AB newton-  
 meter\* OR TI "hip abduct\*" OR AB "hip abduct\*" OR TI gluteus OR AB gluteus OR TI "gluteal muscle\*"  
 OR AB "gluteal muscle\*" OR TI "abduction motion" OR AB "abduction motion" OR ((TI pelvic OR AB  
 pelvic OR TI pelvis OR AB pelvis) N3 TI movement\* OR AB movement\*)))))

## Web of Science Core Collection

(20191219; 662 hits)

TS(((((((knee OR femorotibial OR patellofemoral) NEAR/5 (osteoarthritis\* OR arthritis\* OR  
 osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR "degenerative joint  
 disease\*")) OR "gonarthrosis")) AND (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\*  
 OR arthroprosthes\* OR endoprosthesis\* OR implant\* OR "artificial knee\*" OR TKR OR TKA OR  
 ("minimally invasive" OR mini-invasive OR minimal OR "minimal access") NEAR/2 (surgery OR  
 "surgical method\*" OR "surgical procedure\*" OR "surgical technique\*" OR operation OR "operative  
 treatment" OR "operative intervention" OR "operative repair" OR "operative restoration")) OR  
 "Active UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated

Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak" OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-Modell" OR "Endomodel" OR "EnduRo" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) OR ((osteoarthriti\* OR arthriti\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR "degenerative joint disease\*" OR "gonarthrosis" OR ((avascular OR bone) NEAR/2 (necrosis OR infarction)) OR osteonecrosis OR osteoradionecrosis) AND (((knee OR femorotibial OR patella\* OR patellofemoral) NEAR/2 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprothes\* OR implant\*)) OR "artificial knee\*" OR TKR OR TKA OR "Active UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak" OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-Modell" OR "Endomodel" OR "EnduRo" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) AND (((muscle OR muscular) NEAR/2 (strength OR power OR force OR weakness OR weakening OR insufficiency OR fatigue OR deficit\*)) OR torque OR "torsional moment\*" OR "turning force\*" OR newton-meter\* OR "hip abduct\*" OR gluteus OR "gluteal muscle\*" OR "abduction motion" OR ((pelvic OR pelvis) NEAR/2 movement\*))

## Scopus

(20191219; 993 hits)

TITLE-ABS-KEY((((((knee OR femorotibial OR patellofemoral) W/5 (osteoarthriti\* OR arthriti\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR "degenerative joint disease\*")) OR "gonarthrosis")) AND (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprothes\* OR implant\* OR "artificial knee\*" OR TKR OR TKA OR ("minimally invasive" OR mini-invasive OR minimal OR "minimal access")) W/2 (surgery OR "surgical method\*" OR "surgical procedure\*" OR "surgical technique\*" OR operation OR "operative treatment" OR "operative intervention" OR "operative repair" OR "operative restoration")) OR "Active UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"

1  
2  
3 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
4 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
5 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
6 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
7 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
8 Modell" OR "Endomodel" OR "EnduRo" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
9 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) OR ((osteoarthritis\* OR  
10 arthriti\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR  
11 "degenerative joint disease\*" OR "gonarthrosis" OR ((avascular OR bone) W/2 (necrosis OR  
12 infarction)) OR osteonecrosis OR osteoradionecrosis) AND (((knee OR femorotibial OR patella\* OR  
13 patellofemoral) W/2 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR  
14 arthroprosthes\* OR endoprosthesis\* OR implant\*)) OR "artificial knee\*" OR TKR OR TKA OR "Active  
15 UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
16 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
17 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
18 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR  
19 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
20 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
21 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
22 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
23 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
24 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
25 Modell" OR "Endomodel" OR "EnduRo" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
26 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) AND (((muscle OR muscular)  
27 W/2 (strength OR power OR force OR weakness OR weakening OR insufficiency OR fatigue OR  
28 deficit\*)) OR torque OR "torsional moment\*" OR "turning force\*" OR newton-meter\* OR "hip  
29 abduct\*" OR gluteus OR "gluteal muscle\*" OR "abduction motion" OR ((pelvic OR pelvis) W/2  
30 movement\*))

## ADAPTED NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE COHORT STUDIES

### Selection

1. Representativeness of the patient cohort \*
  - a) truly representative of the corresponding patient cohort in the general community (e.g. multi center trial with different types of hospitals) \*
  - b) somewhat representative of the corresponding patient cohort (e.g. single center study in only hospital of the catchment area) \*
  - c) selected group of patients
  - d) no or unclear description of the derivation of the patient cohort
2. Selection of the healthy control cohort (if applicable)
  - a) drawn from the same community as the patient cohort \*
  - b) drawn from a different source
  - c) no description of the derivation of the healthy cohort
3. Ascertainment of exposure (not applicable)
4. Demonstration that outcome of interest was not present at start of study (not applicable)

### Comparability

1. Comparability of cohorts on the basis of the design or analysis (if applicable)
  - a) study controls for age differences between cohorts (e.g. by matching or statistical adjustment for potential confounding) \*
  - b) study does not control for age differences between cohorts

### Outcome

1. Assessment of outcome
  - a) independent assessment (e.g. by nurses or researchers not involved in the study) \*
  - b) assessment by member of the research team
  - c) no information given
2. Was follow-up long enough for patients to recover?
  - a) yes (follow up at least 12 months) \*
  - b) no (follow up less than 12 months)

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3 3. Adequacy of follow up of cohorts  
4

- 5 a) complete follow up - all subjects accounted for \*
- 6 b) subjects lost to follow up unlikely to introduce bias (e.g. drop out  
7 because of medical complications) or at least 90% \*
- 8 c) follow up rate < 90 % or no description of those lost or description  
9 suggests bias  
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12 d) no statement  
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**PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol\***

Section and topic	Item No	Checklist item	Reported on Page
<b>ADMINISTRATIVE INFORMATION</b>			
Title:			
Identification	1a	Identify the report as a protocol of a systematic review	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	n.a.
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	2
Authors:			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	1
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	9
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	n.a.
Support:			
Sources	5a	Indicate sources of financial or other support for the review	9
Sponsor	5b	Provide name for the review funder and/or sponsor	9
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	9
<b>INTRODUCTION</b>			
Rationale	6	Describe the rationale for the review in the context of what is already known	4
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	5
<b>METHODS</b>			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	4
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	6
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	Supplementary file

Study records:			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	6
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the 2 review (that is, screening, eligibility and inclusion in meta-analysis)	2
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	6
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	5-7
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	7
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	8
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised	8
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as $I^2$ , Kendall's $\tau$ )	8
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	8
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	8
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	9
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	9

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015 Jan 2;349(jan02 1):g7647.

# BMJ Open

## Hip abductor muscle strength in patients after total or unicompartmental knee arthroplasty for knee osteoarthritis or avascular necrosis: a systematic review and meta-analysis protocol

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-038770.R1
Article Type:	Protocol
Date Submitted by the Author:	05-Jun-2020
Complete List of Authors:	Kvarda, Peter; University Hospital Basel, Orthopaedics and Traumatology,; Kantonsspital Baselland, Department of Orthopaedic Surgery and Traumatology Nüesch, Corina; University of Basel, Department of Clinical Research Egloff, Christian; University of Basel, Department of Orthopaedics and Traumatology Appenzeller-Herzog, Christian ; University of Basel, University Medical Library, Basel, Spiegelgasse 5, 4051 Basel, Switzerland Mündermann, Annegret ; University Hospital Basel, Orthopaedics and Traumatology; University of Basel, Department of Clinical Research Ismailidis, Petros; University Hospital Basel, Orthopaedics and Traumatology
<b>Primary Subject Heading</b>:	Surgery
Secondary Subject Heading:	Rehabilitation medicine, Evidence based practice
Keywords:	Knee < ORTHOPAEDIC & TRAUMA SURGERY, Hip < ORTHOPAEDIC & TRAUMA SURGERY, Adult orthopaedics < ORTHOPAEDIC & TRAUMA SURGERY, REHABILITATION MEDICINE

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5 2 **Hip abductor muscle strength in patients after total or unicompartmental knee**  
6 3 **arthroplasty for knee osteoarthritis or avascular necrosis: a systematic review**  
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## and meta-analysis protocol

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18 Protocol manuscript

19  
20 June 2020

21  
22 Submitted to: BMJ Open

23  
24 Manuscript # bmjopen-2020-038770

25  
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3 36 **ABSTRACT**  
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6 38 **Introduction:**  
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9 39 Reduced hip abductor strength may indirectly lead to changes in knee kinematics  
10 40 and functional impairment and has been reported in patients with patellofemoral pain  
11 41 and knee osteoarthritis (OA). Limited information is available regarding hip abductor  
12 42 strength following total or unicompartmental knee arthroplasty (TKA/UKA). The aims  
13 43 of this systematic review are to synthesize the evidence of hip abductor muscle  
14 44 strength deficits in patients following TKA/UKA and to determine influencing factors  
15 45 for these deficits.  
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22 47 **Methods and analysis:**  
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25 48 Embase, Medline, SportDiscus, the Web of Science Core Collection and Scopus will  
26 49 be searched for human based clinical studies investigating hip abductor muscle  
27 50 strength after TKA/UKA for knee OA or avascular necrosis (AVN). Articles studying  
28 51 hip abductor strength after knee arthroplasty for posttraumatic OA will not be  
29 52 considered. No restriction on study design, prosthesis design, surgical approach,  
30 53 patient characteristics or severity of OA/AVN will be applied. We will search articles  
31 54 published between January 1, 1990 and the date of our last search. Only articles in  
32 55 English or German language will be considered for inclusion. Studies reporting  
33 56 manually measured muscle strength or measurements performed at hip abduction  
34 57 angles other than 0° will be excluded. References will be screened by two reviewers  
35 58 independently. Where necessary, a third author will make the final decision. The  
36 59 assessment of quality and risk of bias will be performed with the modified Newcastle-  
37 60 Ottawa scale (NOS). Data will be extracted and presented in a tabular form.  
38 61 Depending on availability, comparable subgroup and meta-analyses will be  
39 62 conducted. Patient characteristics such as age, sex and surgical approach or  
40 63 rehabilitation program will be analysed, if sufficient data are available.  
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56 65 **Ethics and dissemination:**  
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59 66 No ethics approval is required. The results will be published in a peer reviewed  
60 67 journal and as conference presentation.  
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3 69 **Registration details:**

4  
5 70 Registered in PROSPERO, acknowledgement of receipt Nr. 164339.  
6  
7 71

8 72 **Keywords:** abductor muscle strength, hip abductor, knee replacement, knee  
9  
10 73 arthroplasty knee osteoarthritis, knee avascular necrosis  
11  
12 74  
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14  
15 76 **Strengths and limitations of this study:**

- 16  
17 77 - To our knowledge, there is no published systematic review investigating hip abductor  
18 78 muscle strength following TKA/UKA.  
19  
20 79 - The subject and inclusion/exclusion criteria are clearly stated to obtain and present  
21 80 comparable data.  
22  
23 81 - Possible limitations are the restricted time period of publication and language  
24 82 restriction to English or German.  
25  
26 83 - Possibility of limited and heterogenous data availability to perform a meta-analysis.  
27  
28 84

## 85 INTRODUCTION:

86

87 Degenerative diseases of the musculoskeletal system such as osteoarthritis are one  
88 of the leading burdens on the health care system, social security system and  
89 certainly on individuals. Prevalence of knee osteoarthritis (OA) is estimated to be  
90 approximately 10% in men and 13% in women at the age of 60 years or older.<sup>1</sup> OA is  
91 estimated to be the fourth leading cause of disability by the year of 2020, and the  
92 most common indication for performing knee arthroplasty.<sup>2,3</sup>

93

94 Different static and dynamic biomechanical components influence the functional knee  
95 mechanics. Static elements are alignment and bony geometry. A neutral mechanical  
96 axis of the lower limb during standing passes through the centre of the tibial plateau  
97 in the frontal plane. This axis is altered in valgus or varus deformity.<sup>4,5</sup>

98 Physiologically, during the stance phase of walking, the centre of load is located over  
99 the medial condyle creating an external knee adduction moment.<sup>6,7</sup> Ligaments and  
100 muscles of the joint form the group of dynamic stabilizers and mainly resist the  
101 adduction moment.<sup>7</sup>

102

103 As the adjacent proximal articulation, the hip joint contributes to knee biomechanics.  
104 The hip abductor muscles abduct the femur, facilitate pelvic stability during single leg  
105 stance and walking, and directly affect the tibiofemoral and patellofemoral joint  
106 kinematics. Moreover, the hip abductor muscle group controls the internal rotation of  
107 the femur.<sup>8</sup> In case of hip abductor muscle strength deficit, the contralateral pelvic  
108 side drops while walking, a condition known as “Trendelenburg gait”<sup>9</sup> because the  
109 external hip adduction moment cannot be sufficiently balanced by the internal hip  
110 abduction moment primarily generated by hip abductor muscles. This can be  
111 compensated by leaning the trunk toward the support limb and shifting the centre of  
112 mass over the support limb and reduce the hip adduction moment.<sup>8</sup> The protective  
113 effect of greater internal hip abduction moment has also been reported in terms of  
114 reduced medial tibiofemoral OA progression.<sup>10</sup> Moreover, patellar tracking can be  
115 also altered and cause knee pain.<sup>11,12,13</sup> Isokinetic measurements have shown that  
116 hip abductor muscle weakness is present in patients with knee OA.<sup>14,15</sup> In a recent  
117 systematic review, Deasy et al. reported hip abductor weakness in patients with knee  
118 OA.<sup>16</sup>



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5 120 Despite of extensive efforts of alternative treatment, today the only treatment for  
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7 121 severe knee OA is total and unicompartmental knee arthroplasty (TKA/UKA).  
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9 122 Reduced hip abductor muscle strength can implicate compromised functional and  
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11 123 performance-based outcome after TKA/UKA, and hence maintaining and  
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13 124 strengthening of the hip abductor muscles form a clinically relevant factor in patients  
14  
15 125 undergoing TKA or UKA.<sup>17,18,19</sup> However, to date studies investigating hip abductor  
16  
17 126 muscle strength in patients undergoing TKA or UKA are scarce. In addition to  
18  
19 127 outcome evaluations, quantitative assessment of muscle strength is important to  
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21 128 understanding factors influencing surgical outcome. In contrast to knee  
22  
23 129 flexor/extensor muscle strength, the impact of hip abductor muscle strength deficit in  
24  
25 130 patients with TKA/UKA is currently poorly understood. The following questions  
26  
27 131 remain unanswered:

- 28 132 • Do patients after unilateral TKA/UKA experience a muscle strength deficit in  
29 133 their operated compared to their unoperated side?
- 30 134 • How long after TKA/UKA does this deficit persist?
- 31 135 • Does the strength deficit after knee arthroplasty differ between patients with  
32 136 total versus unicompartmental arthroplasty?
- 33 137 • Are hip abductor muscle strength deficits after TKA/UKA influenced by pre-  
34 138 and postoperative knee alignment, patient characteristics or rehabilitation  
35 139 programs?

36 140 Therefore, the aim of the proposed systematic review is to synthesize the evidence of  
37 141 hip abductor muscle strength deficits in patients following TKA/UKA and to determine  
38 142 influencing factors for these deficits. The results of the proposed systematic review  
39 143 will provide extended information for physicians in the interest of improving patient  
40 144 management and outcome.

#### 41 145

#### 42 146 **METHODS AND ANALYSES:**

43 147 The protocol was developed following the Preferred Reporting Items for Systematic  
44 148 Reviews and Meta-analyses Protocols (PRISMA-P) guideline<sup>20</sup>(Supplementary a).  
45 149 Bibliographic database searching was initiated on December 19, 2019. The review  
46 150 was submitted for registration prospectively in PROSPERO on January 5<sup>th</sup>, 2020 and  
47 151 the expected completion date is July 1<sup>st</sup>, 2020.<sup>21</sup> We designed the study question

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3 152 using the PICOS (Population, Intervention, Comparison, Outcome, Study design)  
4 strategy (Table 1).<sup>22</sup>  
5 153

6 154

## 8 155 **Eligibility criteria**

### 10 156 *Inclusion criteria*

11 157 Human based clinical studies reporting on hip abductor muscle strength after primary  
12 TKA/UKA will be considered for inclusion. Case studies will not be considered for inclusion.  
13 158 No other restriction regarding the study design will be applied to broadly capture all possible  
14 appropriate studies. No restriction on operative approach, prosthesis design, age and sex of  
15 159 the patients or severity of OA/AVN will be placed. Date of publication will be limited to a time  
16 160 period from January 1, 1990 to the date of our last search. The limit of follow-up will be set to  
17 161 24 months postoperatively.  
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### 24 165 *Exclusion criteria*

25 166 Studies published before 01.01.1990 or in a language other than English or German, not  
26 167 reporting absolute values of hip abductor muscle strength or torque ratios, or reporting hip  
27 168 abductor strength measured with hand-held manometer/dynamometer or at a hip abduction  
28 169 angles other than 0° will be excluded. Articles reporting posttraumatic indications for  
29 170 TKA/UKA or reporting measurements following revision TKA/UKA will not be considered for  
30 171 inclusion.  
31 172

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### 37 173 *Methodological considerations*

38 174 Studies reporting isokinetic or isometric measurements of hip abductor muscle  
39 175 strength at a 0° hip abduction angle using a dynamometer will be considered for  
40 176 inclusion. Manual measurements are not reliable and not directly comparable with  
41 177 measurements taken by electronic dynamometers. Measurements at hip abduction  
42 178 angles other than 0° do not represent relevant muscle function/strength during  
43 179 walking and standing. Moreover, the exclusion of these studies will allow to collect  
44 180 standardized, comparable data facilitating meta-analysis.<sup>23</sup>  
45 181

46 181

## 52 182 **Information sources and search strategy**

53 183 Text word synonyms and database-specific subject headings for knee OA, knee  
54 184 arthroplasty, and hip abductor function will be used. We will search the electronic  
55 185 databases Embase via embase.com, Medline via Ovid, SportDiscus via EBSCOHost,  
56 186 the Web of Science Core Collection, and Scopus (Supplementary b). In the primary  
57 187 search no language restrictions will be applied. Time period of the search will be

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3 188 limited to articles published after January 1, 1990. References will be exported to  
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5 189 Endnote X9 (Clarivate, London, U.K.) and deduplicated. The detailed search strategy  
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7 190 can be found in the supplementary document.  
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### 192 **Study records: data management, selection process and data extraction**

193 Titles and abstracts of all retrieved references will be independently reviewed and  
194 screened by two reviewers (PK and PI) to identify studies that potentially meet the  
195 inclusion criteria. All potentially relevant references will be collected in full-text and  
196 independently assessed by two reviewers (PK and PI). Any disagreements regarding  
197 eligibility will be resolved by consensus and by necessity, a third review author (AM)  
198 will make a final decision. To find possible additional studies, we will screen the  
199 bibliographic references of all included articles as well as the citations of those that  
200 are indexed in Scopus or Web of Science. The study selection process will be  
201 presented in form of a PRISMA diagram.<sup>20</sup> Data from the full texts will be extracted  
202 and entered into a standardized excel data entry form by PK and PI based on piloting  
203 extractions. The information to be extracted can be found in Table 2. We will contact  
204 corresponding authors when the necessary data is missing or unclear. Potential  
205 conference abstracts will be considered for inclusion only if appropriate data are  
206 available for the outcomes of this study. We will contact principal investigators and/or  
207 corresponding author(s) twice by email in case of conference abstracts to collect their  
208 results. The data extraction will be cross-checked independently.  
209

### 210 **Outcomes and prioritisation**

211 The main outcomes will be:

- 212 1. Absolute values of isometric/isokinetic hip abductor torque in patients following  
213 TKA/UKA, or in asymptomatic control groups
- 214 2. Torque ratio (ipsilateral hip/contralateral hip) of hip abductors following TKA/UKA
- 215 3. Change in hip abductor torque/hip abductor torque ratio from baseline to each follow-up
- 216 4. Differences in hip abductor torque/torque ratio between patients after TKA/UKA and  
217 healthy control groups.

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219 The secondary outcomes will be:

- 220 1. Surgical approaches/methods of TKA/UKA
- 221 2. Pre- and postoperative knee alignment
- 222 3. Patient characteristics

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3 223 4. Rehabilitation programs after TKA/UKA  
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6 225 **Risk of bias in individual studies**  
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8 226 To minimise bias, articles meeting the inclusion criteria will be assessed by two  
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10 227 reviewers (PK and PI) independently using a modified version of the Newcastle-  
11 228 Ottawa Scale (NOS)<sup>24</sup> (Supplementary c). According to the modified NOS, each  
12  
13 229 study will be valued with 1 to 6 stars where higher scores indicate higher level of  
14  
15 230 quality. No separate tool will be used to assess the risk of bias of randomized control  
16  
17 231 trials because we do not extract estimates of treatment differences from RCTs but  
18 232 use these as a source for cohort data.  
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21  
22 234 **Data synthesis**

23 235 We will extract any quantitative and descriptive data from all eligible studies  
24 236 according to the main outcomes (mean, median, etc.), on the population (SD,  
25 237 interquartile ranges, percentile), on measurements (standard errors, CI, p-values,  
26  
27 238 sample size), as well as the secondary outcomes for both purposes (systematic  
28  
29 239 review and meta-analyses). Furthermore, all details specific to the review question  
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31 240 will be extracted. If the information is available for several time points, the data will be  
32  
33 241 extracted for all time points. The data will be presented in tabular format. Visual  
34  
35 242 inspection of the forest plots and I<sup>2</sup>-test will be used to assess heterogeneity between  
36  
37 243 studies. Depending on availability of appropriate data for comparable specific patient  
38  
39 244 groups with same measurement method in different studies, meta-analyses will be  
40  
41 245 performed on these data. Meta-analysis will be based on random effects and the  
42  
43 246 results will be illustrated by forest plots. Where statistical pooling is not possible, the  
44  
45 247 findings will be presented in narrative form. Meta regression and subgroup specific  
46  
47 248 meta analyses will be conducted to investigate the effect of time since TKA/UKA and  
48  
49 249 measurement type (isokinetic or isometric) on different outcomes. In case that  
50  
51 250 outcomes are not reported directly but indirect information is available on side  
52  
53 251 specific or time point specific results, the available information will be transformed  
54  
55 252 accordingly. Meta regression and subgroup specific meta analyses will be used to  
56  
57 253 investigate the influence of time since TKA/UKA and type of measurement (isokinetic  
58  
59 254 or isometric) on the different outcomes. In case of sufficient information, these  
60 255 analyses will be extended to patient characteristics, surgical approach, subtype of  
60 256 prostheses or rehabilitation program.

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3 2574  
5 **258 Meta-bias(es)**

6 259 Funnel plots will be used to assess publication bias in our meta-analysis, presenting  
7  
8 260 effect sizes plotted against their standard errors or precisions. To avoid subjective  
9  
10 261 visual inspection of the graph, Egger's regression test will be used to assess the  
11  
12 262 asymmetry. Egger's test regresses the standardized effect sizes on their precisions.  
13  
14 263 In the absence of publication bias, the regression intercept is expected to be zero.

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17 **265 Confidence in cumulative evidence**

18 266 Grading of Recommendations Assessment, Development and Evaluation system  
19  
20 267 (GRADE) will be applied.<sup>25</sup> The confidence of evidence of randomised controlled  
21  
22 268 trials can be downgraded according to the following factors: study limitations,  
23  
24 269 inconsistency of results, indirectness of evidence, imprecision, publication bias. Non-  
25  
26 270 randomised or observational studies can be upgraded for large magnitude of effect,  
27  
28 271 evidence of a dose-response effect and all possible cofounding factors taken into  
29  
30 272 account. After the grading process, the quality of evidence for each outcome will be  
31  
32 273 rated as high, moderate, low or very low.

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34 **275 Ethics and dissemination**

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36 276 This study is a protocol for a systematic review and meta-analysis. No human  
37  
38 277 participants will be recruited. No ethics approval is needed. The study results will be  
39  
40 278 published in a peer reviewed journal and as conference presentation.

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43 **280 Patient and public involvement**

44 281 There is no patient and/or public involvement planned for this review.

45 282

46  
47  
48 **283 Authors contributions**

49 284 The following work has been developed in contribution of each co-author. The  
50  
51 285 manuscript underwent several revisions with substantial contributions provided by  
52  
53 286 each co-author. PI, PK and AM will perform this systematic review and meta-  
54  
55 287 analysis. The protocol has been registered in PROSPERO by PK. The search  
56  
57 288 strategy was designed by CA. CN reviewed the protocol and was responsible for the  
58  
59 289 strategy of data synthesis. CE cooperated in study design development, as well as in

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2  
3 290 manuscript editing. All authors gave final approval of the manuscript prior to  
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5 291 submission.

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10 294 **Funding statement:**

11 295 This study will be funded by the Department of Orthopaedics and Traumatology of  
12  
13 296 the University Hospital of Basel, the Foundation for Funding Science and Education  
14  
15 297 at the Department of Surgery at the University of Basel, Swiss  
16  
17 298 Orthopaedics, Merian Iselin Foundation and Deutsche Arthrose-Hilfe e.V. The  
18  
19 299 funding sources had no involvement in any aspect of this study.

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23 302 **COMPETING INTERESTS STATEMENT**

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25 303 The authors declare no competing interest.  
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3 385 **Figures and Legends:**

4  
5 386 Table 1: The Population, Intervention, Comparison, Outcome, Study design (PICOS)  
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7 387 process<sup>22</sup>.

Item	Specification
Population, or participants and conditions of interest	Patients with OA or AVN of the knee (any age, gender and severity)
Interventions	TKA/UKA
Comparisons or control groups	For comparison between limbs of the same subject: asymptomatic contralateral hip and knee For comparison between patients and healthy individuals: asymptomatic control subjects
Outcomes of interest	Muscle strength of hip abductors
Study designs	Any study design, published studies, conference abstracts to be considered

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391 Table 2: Data that will be extracted from every study included in the review

No.	Description
1	Authors and year of publication
2	Country of origin of the study
3	Type of study
4	Study population
5	Study completion rate
6	Diagnosis
7	Surgical approach: medial parapatellar; modified medial parapatellar according to Insall; subvastus; midvastus; trivector-retaining; lateral; lateral with tuberositas osteotomy <sup>26</sup>
8	Study population demographics
9	Pre- and postoperative frontal and sagittal plane knee alignment
10	Measurement methods
10a	Isometric/isokinetic strength measurement
10b	Angle of isometric measurement/velocity of isokinetic measurement
10c	Patient position during the measurement (lying supine/side-lying/standing)
11	Comparators: healthy individuals; asymptomatic contralateral side; no comparator
12	Total duration of follow up (weeks/months after the operation)
13	Measurement stages (preoperative, follow up in weeks/months after the operation)
14	Information regarding the rehabilitation protocols
15	Outcome (mean values, standard deviations (SDs) and confidence intervals (CIs))
15a	Absolute values of hip abductor torque in patients after TKA/UKA, or in asymptomatic control groups
15b	Torque ratio (operated side/contralateral hip) of hip abductors in patients after TKA/UKA
15c	Change in hip abductor torque / hip abductor torque ratio from baseline to each follow-up
15d	Differences in hip abductor torque / torque ratios between patients after TKA/UKA and healthy control groups.
16	Authors conclusions
17	Information regarding risk of bias

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**PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol\***

Section and topic	Item No	Checklist item	Reported on Page
<b>ADMINISTRATIVE INFORMATION</b>			
Title:			
Identification	1a	Identify the report as a protocol of a systematic review	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	n.a.
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	2
Authors:			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	1
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	9
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	n.a.
Support:			
Sources	5a	Indicate sources of financial or other support for the review	9
Sponsor	5b	Provide name for the review funder and/or sponsor	9
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	9
<b>INTRODUCTION</b>			
Rationale	6	Describe the rationale for the review in the context of what is already known	4
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	5
<b>METHODS</b>			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	4
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	6
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	Supplementary file

Study records:			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	6
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	2
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	6
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	5-7
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	7
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	8
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised	8
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I <sup>2</sup> , Kendall's $\tau$ )	8
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	8
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	8
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	9
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	9

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015 Jan 2;349(jan02 1):g7647.

## ADAPTED NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE COHORT STUDIES

### Selection

1. Representativeness of the patient cohort \*
  - a) truly representative of the corresponding patient cohort in the general community (e.g. multi center trial with different types of hospitals) \*
  - b) somewhat representative of the corresponding patient cohort (e.g. single center study in only hospital of the catchment area) \*
  - c) selected group of patients
  - d) no or unclear description of the derivation of the patient cohort
2. Selection of the healthy control cohort<sup>[SEP]</sup> (if applicable)
  - a) drawn from the same community as the patient cohort \*
  - b) drawn from a different source<sup>[SEP]</sup>
  - c) no description of the derivation of the healthy cohort
3. Ascertainment of exposure<sup>[SEP]</sup> (not applicable)
4. Demonstration that outcome of interest was not present at start of study (not applicable)

### Comparability

1. Comparability of cohorts on the basis of the design or analysis<sup>[SEP]</sup> (if applicable)
  - a) study controls for age differences between cohorts (e.g. by matching or statistical adjustment for potential confounding) \*
  - b) study does not control for age differences between cohorts

### Outcome

1. Assessment of outcome
  - a) independent assessment (e.g. by nurses or researchers not involved in the study) \*
  - b) assessment by member of the research team
  - c) no information given
2. Was follow-up long enough for patients to recover?
  - a) yes (follow up at least 12 months) \*
  - b) no (follow up less than 12 months)

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2  
3 3. Adequacy of follow up of cohorts<sup>[1]</sup><sub>[SEP]</sub>

- 4 a) complete follow up - all subjects accounted for \*
- 5 b) subjects lost to follow up unlikely to introduce bias (e.g. drop out
- 6 because of medical complications) or at least 90% \*
- 7 c) follow up rate < 90 % or no description of those lost or description
- 8 suggests bias
- 9 d) no statement
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# Hip abductor muscle strength in patients after total or unicompartmental knee arthroplasty for knee osteoarthritis or avascular necrosis - Search strategy

## Appendices

### Appendix 1: Search strategies

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((('knee osteoarthritis'/de OR (((knee OR femorotibial OR patellofemoral) NEAR/5 (osteoarthriti\* OR arthriti\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR 'degenerative joint disease\*')) OR 'gonarthrosis'):ab,ti)

AND

('knee arthroplasty'/exp OR 'total knee arthroplasty'/de OR 'arthroplasty'/de OR 'total arthroplasty'/de OR 'knee prosthesis'/de OR 'femoral knee prosthesis'/de OR 'hinge knee prosthesis'/exp OR 'patella prosthesis'/de OR 'patellofemoral prosthesis'/de OR 'tibial knee prosthesis'/de OR 'total knee prosthesis'/de OR 'unicompartmental knee prosthesis'/de OR 'joint prosthesis'/de OR 'endoprosthesis'/de OR 'minimally invasive surgery'/de OR (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprosthes\* OR implant\* OR 'artificial knee\*' OR TKR OR TKA OR (('minimally invasive' OR mini-invasive OR minimal OR 'minimal access') NEAR/3 (surgery OR 'surgical method\*' OR 'surgical procedure\*' OR 'surgical technique\*' OR operation OR 'operative treatment' OR 'operative intervention' OR 'operative repair' OR 'operative restoration')) OR 'Active UKA' OR 'Advance Medial Pivot' OR 'Advantim' OR 'ALPINA PS' OR 'Anatomic Graduated Component' OR 'Ascent' OR 'ATTUNE' OR 'Bi-Surface' OR 'Duracon' OR 'EMPOWR' OR 'Genesis II' OR 'iBalance Unicondylar Knee' OR 'Insall-Burstein II' OR 'InterSpace Knee' OR 'KineMax' OR 'KineSpring' OR 'Legion' OR 'Marmor' OR 'Maxim' OR 'Maximum Congruent Knee system' OR 'Miller-Galante' OR 'Natural Knee II' OR 'Natural-Knee Flex System' OR 'NexGen' OR 'Optetrak' OR 'OrthoGlide' OR 'Oxinium' OR 'Persona Knee System' OR 'Press-Fit Condylar' OR 'Profix' OR 'Repicci' OR 'Restoris' OR 'Scorpio' OR 'Search Evolution' OR 'Segmental Knee System' OR 'Series 7000' OR 'Sigma' OR 'Triathlon' OR 'Tricon knee' OR 'UniCAP' OR 'Vanguard' OR 'Advance Total Knee' OR 'Alegretto' OR 'EIUS' OR 'UC Plus Solution' OR 'Uni-Knee' OR 'Uniglide' OR '3DKnee' OR 'Advance Stature Knee' OR 'HemiCAP' OR 'Dual Articular 2000' OR 'Endo-Model' OR 'Endo-Modell' OR 'Endomodel' OR 'EnduRo' OR 'LCS Complete' OR 'Oxford' OR 'P.F.C. Sigma' OR 'PFC Sigma' OR 'Rotaflex' OR 'S-ROM Noiles' OR 'Avon' OR 'Regenerex'):ab,ti))

OR

((('knee osteoarthritis'/de OR 'osteoarthritis'/de OR 'avascular necrosis'/de OR 'bone necrosis'/de OR (osteoarthriti\* OR arthriti\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR 'degenerative joint disease\*' OR 'gonarthrosis' OR ((avascular OR bone) NEAR/3 (necrosis OR infarction)) OR osteonecrosis OR osteoradionecrosis):ab,ti)

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4 prosthesis'/de OR 'hinge knee prosthesis'/exp OR 'patella prosthesis'/de OR 'patellofemoral  
5 prosthesis'/de OR 'tibial knee prosthesis'/de OR 'total knee prosthesis'/de OR 'unicompartmental  
6 knee prosthesis'/de OR (((knee OR femorotibial OR patella\* OR patellofemoral) NEAR/3  
7 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprosthesis\*  
8 OR implant\*)) OR 'artificial knee\*' OR TKR OR TKA OR 'Active UKA' OR 'Advance Medial Pivot' OR  
9 'Advantim' OR 'ALPINA PS' OR 'Anatomic Graduated Component' OR 'Ascent' OR 'ATTUNE' OR 'Bi-  
10 Surface' OR 'Duracon' OR 'EMPOWR' OR 'Genesis II' OR 'iBalance Unicdylar Knee' OR 'Insall-  
11 Burstein II' OR 'InterSpace Knee' OR 'KineMax' OR 'KineSpring' OR 'Legion' OR 'Marmor' OR 'Maxim'  
12 OR 'Maximum Congruent Knee system' OR 'Miller-Galante' OR 'Natural Knee II' OR 'Natural-Knee Flex  
13 System' OR 'NexGen' OR 'Optetrak' OR 'OrthoGlide' OR 'Oxinium' OR 'Persona Knee System' OR  
14 'Press-Fit Condylar' OR 'Profix' OR 'Repicci' OR 'Restoris' OR 'Scorpio' OR 'Search Evolution' OR  
15 'Segmental Knee System' OR 'Series 7000' OR 'Sigma' OR 'Triathlon' OR 'Tricon knee' OR 'UniCAP' OR  
16 'Vanguard' OR 'Advance Total Knee' OR 'Alegretto' OR 'EIUS' OR 'UC Plus Solution' OR 'Uni-Knee' OR  
17 'Uniglide' OR '3DKnee' OR 'Advance Stature Knee' OR 'HemiCAP' OR 'Dual Articular 2000' OR 'Endo-  
18 Model' OR 'Endo-Modell' OR 'Endomodel' OR 'Enduro' OR 'LCS Complete' OR 'Oxford' OR 'P.F.C.  
19 Sigma' OR 'PFC Sigma' OR 'Rotaflex' OR 'S-ROM Noiles' OR 'Avon' OR 'Regenerex'):ab,ti))

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26 ('muscle strength'/de OR 'muscle weakness'/de OR 'torque'/de OR 'hip abductor muscle'/de OR  
27 'pelvic movement'/de OR (((muscle OR muscular) NEAR/3 (strength OR power OR force OR weakness  
28 OR weakening OR insufficiency OR fatigue OR deficit\*)) OR torque OR 'torsional moment\*' OR  
29 'turning force\*' OR newton-meter\* OR 'hip abduct\*' OR gluteus OR 'gluteal muscle\*' OR 'abduction  
30 motion' OR ((pelvic OR pelvis) NEAR/3 movement\*)):ab,ti)

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36 experiment'/de))

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44 arthriti\* OR osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR  
45 degenerative joint disease\*)) OR gonarthrosis).ab,ti.)

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49 (arthroplasty, replacement, knee/ OR arthroplasty/ OR arthroplasty, replacement/ OR knee  
50 prosthesis/ OR joint prosthesis/ OR "prostheses and implants"/ OR minimally invasive surgical  
51 procedures/ OR (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\*  
52 OR endoprosthesis\* OR implant\* OR artificial knee\* OR TKR OR TKA OR ((minimally invasive OR mini-  
53 invasive OR minimal OR minimal access) ADJ3 (surgery OR surgical method\* OR surgical procedure\*  
54 OR surgical technique\* OR operation OR operative treatment OR operative intervention OR  
55 operative repair OR operative restoration)) OR Active UKA OR Advance Medial Pivot OR Advantim OR  
56 ALPINA PS OR Anatomic Graduated Component OR Ascent OR ATTUNE OR Bi-Surface OR Duracon OR  
57 EMPOWR OR Genesis II OR iBalance Unicdylar Knee OR Insall-Burstein II OR InterSpace Knee OR  
58 KineMax OR KineSpring OR Legion OR Marmor OR Maxim OR Maximum Congruent Knee system OR  
59 Miller-Galante OR Natural Knee II OR Natural-Knee Flex System OR NexGen OR Optetrak OR  
60

1  
2  
3 OrthoGlide OR Oxinium OR Persona Knee System OR Press-Fit Condylar OR Profix OR Repicci OR  
4 Restoris OR Scorpio OR Search Evolution OR Segmental Knee System OR Series 7000 OR Sigma OR  
5 Triathlon OR Tricon knee OR UniCAP OR Vanguard OR Advance Total Knee OR Alegretto OR EIUS OR  
6 UC Plus Solution OR Uni-Knee OR Uniglide OR 3DKnee OR Advance Stature Knee OR HemiCAP OR  
7 Dual Articular 2000 OR Endo-Model OR Endo-Modell OR Endomodel OR EnduRo OR LCS Complete OR  
8 Oxford OR PFC Sigma OR Rotaflex OR S-ROM Noiles OR Avon OR Regenerex).ab,ti.)

9  
10  
11 OR

12  
13 ((osteoarthritis, knee/ OR osteoarthritis/ OR osteonecrosis/ OR (osteoarthriti\* OR arthriti\* OR  
14 osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR degenerative joint  
15 disease\* OR gonarthrosis OR ((avascular OR bone) ADJ3 (necrosis OR infarction)) OR osteonecrosis  
16 OR osteoradionecrosis).ab,ti.)

17  
18 AND

19  
20 (arthroplasty, replacement, knee/ OR knee prosthesis/ OR (((knee OR femorotibial OR patella\* OR  
21 patellofemoral) ADJ3 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR  
22 arthroprosthes\* OR endoprosthes\* OR implant\*)) OR artificial knee\* OR TKR OR TKA OR Active UKA  
23 OR Advance Medial Pivot OR Advantim OR ALPINA PS OR Anatomic Graduated Component OR Ascent  
24 OR ATTUNE OR Bi-Surface OR Duracon OR EMPOWR OR Genesis II OR iBalance Unicdylar Knee OR  
25 Insall-Burstein II OR InterSpace Knee OR KineMax OR KineSpring OR Legion OR Marmor OR Maxim OR  
26 Maximum Congruent Knee system OR Miller-Galante OR Natural Knee II OR Natural-Knee Flex  
27 System OR NexGen OR Optetrak OR OrthoGlide OR Oxinium OR Persona Knee System OR Press-Fit  
28 Condylar OR Profix OR Repicci OR Restoris OR Scorpio OR Search Evolution OR Segmental Knee  
29 System OR Series 7000 OR Sigma OR Triathlon OR Tricon knee OR UniCAP OR Vanguard OR Advance  
30 Total Knee OR Alegretto OR EIUS OR UC Plus Solution OR Uni-Knee OR Uniglide OR 3DKnee OR  
31 Advance Stature Knee OR HemiCAP OR Dual Articular 2000 OR Endo-Model OR Endo-Modell OR  
32 Endomodel OR EnduRo OR LCS Complete OR Oxford OR PFC Sigma OR Rotaflex OR S-ROM Noiles OR  
33 Avon OR Regenerex).ab,ti.))

34  
35  
36  
37 AND

38  
39 (muscle strength/ OR muscle weakness/ OR torque/ OR (((muscle OR muscular) ADJ3 (strength OR  
40 power OR force OR weakness OR weakening OR insufficiency OR fatigue OR deficit\*)) OR torque OR  
41 torsional moment\* OR turning force\* OR newton-meter\* OR hip abduct\* OR gluteus OR gluteal  
42 muscle\* OR abduction motion OR ((pelvic OR pelvis) ADJ3 movement\*).ab,ti.)

43  
44  
45 NOT

46  
47 (exp animals/ NOT humans/)

48  
49  
50  
51 [SportDiscus](#)

52 (20191219; 283 hits)

53  
54 (((((((TI knee OR AB knee OR TI femorotibial OR AB femorotibial OR TI patellofemoral OR AB  
55 patellofemoral) N5 (TI osteoarthriti\* OR AB osteoarthriti\* OR TI arthriti\* OR AB arthriti\* OR TI  
56 osteoarthrosis OR AB osteoarthrosis OR TI osteoarthroses OR AB osteoarthroses OR TI arthrosis OR  
57 AB arthrosis OR TI arthroses OR AB arthroses OR TI arthropathy OR AB arthropathy OR TI  
58 "degenerative joint disease\*" OR AB "degenerative joint disease\*")) OR TI gonarthrosis OR AB  
59 gonarthrosis)) AND (DE "ARTHROPLASTY" OR DE "TOTAL knee replacement" OR DE "ARTIFICIAL  
60 joints" OR DE "PROSTHETICS" OR DE "ARTIFICIAL knees" OR (TI replacement\* OR AB replacement\*

1  
 2  
 3 OR TI reconstruct\* OR AB reconstruct\* OR TI arthroplast\* OR AB arthroplast\* OR TI prosthes\* OR AB  
 4 prosthes\* OR TI arthroprosthes\* OR AB arthroprosthes\* OR TI endoprosthesis\* OR AB endoprosthesis\*  
 5 OR TI implant\* OR AB implant\* OR TI "artificial knee\*" OR AB "artificial knee\*" OR TI TKR OR AB TKR  
 6 OR TI TKA OR AB TKA OR ((TI "minimally invasive" OR AB "minimally invasive" OR TI mini-invasive OR  
 7 AB mini-invasive OR TI minimal OR AB minimal OR TI "minimal access" OR AB "minimal access")) N3  
 8 (TI surgery OR AB surgery OR TI "surgical method\*" OR AB "surgical method\*" OR TI "surgical  
 9 procedure\*" OR AB "surgical procedure\*" OR TI "surgical technique\*" OR AB "surgical technique\*"  
 10 OR TI operation OR AB operation OR TI "operative treatment" OR AB "operative treatment" OR TI  
 11 "operative intervention" OR AB "operative intervention" OR TI "operative repair" OR AB "operative  
 12 repair" OR TI "operative restoration" OR AB "operative restoration")) OR TI "Active UKA" OR AB  
 13 "Active UKA" OR TI "Advance Medial Pivot" OR AB "Advance Medial Pivot" OR TI Advantim OR AB  
 14 Advantim OR TI "ALPINA PS" OR AB "ALPINA PS" OR TI "Anatomic Graduated Component" OR AB  
 15 "Anatomic Graduated Component" OR TI Ascent OR AB Ascent OR TI ATTUNE OR AB ATTUNE OR TI  
 16 Bi-Surface OR AB Bi-Surface OR TI Duracon OR AB Duracon OR TI EMPOWR OR AB EMPOWR OR TI  
 17 "Genesis II" OR AB "Genesis II" OR TI "iBalance Unicondylar Knee" OR AB "iBalance Unicondylar  
 18 Knee" OR TI "Insall-Burstein II" OR AB "Insall-Burstein II" OR TI "InterSpace Knee" OR AB "InterSpace  
 19 Knee" OR TI KineMax OR AB KineMax OR TI KineSpring OR AB KineSpring OR TI Legion OR AB Legion  
 20 OR TI Marmor OR AB Marmor OR TI Maxim OR AB Maxim OR TI "Maximum Congruent Knee system"  
 21 OR AB "Maximum Congruent Knee system" OR TI Miller-Galante OR AB Miller-Galante OR TI "Natural  
 22 Knee II" OR AB "Natural Knee II" OR TI "Natural-Knee Flex System" OR AB "Natural-Knee Flex System"  
 23 OR TI NexGen OR AB NexGen OR TI Optetrak OR AB Optetrak OR TI OrthoGlide OR AB OrthoGlide OR  
 24 TI Oxinium OR AB Oxinium OR TI "Persona Knee System" OR AB "Persona Knee System" OR TI "Press-  
 25 Fit Condylar" OR AB "Press-Fit Condylar" OR TI Profix OR AB Profix OR TI Repicci OR AB Repicci OR TI  
 26 Restoris OR AB Restoris OR TI Scorpio OR AB Scorpio OR TI "Search Evolution" OR AB "Search  
 27 Evolution" OR TI "Segmental Knee System" OR AB "Segmental Knee System" OR TI Series OR AB  
 28 Series OR TI Sigma OR AB Sigma OR TI Triathlon OR AB Triathlon OR TI "Tricon knee" OR AB "Tricon  
 29 knee" OR TI UniCAP OR AB UniCAP OR TI Vanguard OR AB Vanguard OR TI "Advance Total Knee" OR  
 30 AB "Advance Total Knee" OR TI Alegretto OR AB Alegretto OR TI EIUS OR AB EIUS OR TI "UC Plus  
 31 Solution" OR AB "UC Plus Solution" OR TI Uni-Knee OR AB Uni-Knee OR TI Uniglide OR AB Uniglide OR  
 32 TI DKnee OR AB DKnee OR TI "Advance Stature Knee" OR AB "Advance Stature Knee" OR TI HemiCAP  
 33 OR AB HemiCAP OR TI "Dual Articular" OR AB "Dual Articular" OR TI Endo-Model OR AB Endo-Model  
 34 OR TI Endo-Modell OR AB Endo-Modell OR TI Endomodel OR AB Endomodel OR TI Enduro OR AB  
 35 Enduro OR TI "LCS Complete" OR AB "LCS Complete" OR TI Oxford OR AB Oxford OR TI "PFC Sigma"  
 36 OR AB "PFC Sigma" OR TI Rotaflex OR AB Rotaflex OR TI "S-ROM Noiles" OR AB "S-ROM Noiles" OR TI  
 37 Avon OR AB Avon OR TI Regenerex OR AB Regenerex))) OR ((DE "OSTEOARTHRITIS" OR DE  
 38 "OSTEONECROSIS" OR DE "OSTEOCHONDROSIS" OR (TI osteoarthritis\* OR AB osteoarthritis\* OR TI  
 39 arthritis\* OR AB arthritis\* OR TI osteoarthrosis OR AB osteoarthrosis OR TI osteoarthroses OR AB  
 40 osteoarthroses OR TI arthrosis OR AB arthrosis OR TI arthroses OR AB arthroses OR TI arthropathy OR  
 41 AB arthropathy OR TI "degenerative joint disease\*" OR AB "degenerative joint disease\*" OR TI  
 42 gonarthrosis OR AB gonarthrosis OR ((TI avascular OR AB avascular OR TI bone OR AB bone) N3 (TI  
 43 necrosis OR AB necrosis OR TI infarction OR AB infarction)) OR TI osteonecrosis OR AB osteonecrosis  
 44 OR TI osteoradionecrosis OR AB osteoradionecrosis)) AND (DE "TOTAL knee replacement" OR DE  
 45 "ARTIFICIAL knees" OR (((TI knee OR AB knee OR TI femorotibial OR AB femorotibial OR TI patella\*  
 46 OR AB patella\* OR TI patellofemoral OR AB patellofemoral) N3 (TI replacement\* OR AB replacement\*  
 47 OR TI reconstruct\* OR AB reconstruct\* OR TI arthroplast\* OR AB arthroplast\* OR TI prosthes\* OR AB  
 48 prosthes\* OR TI arthroprosthes\* OR AB arthroprosthes\* OR TI endoprosthesis\* OR AB endoprosthesis\*  
 49 OR TI implant\* OR AB implant\*)) OR TI "artificial knee\*" OR AB "artificial knee\*" OR TI TKR OR AB TKR  
 50 OR TI TKA OR AB TKA OR TI "Active UKA" OR AB "Active UKA" OR TI "Advance Medial Pivot" OR AB  
 51 "Advance Medial Pivot" OR TI Advantim OR AB Advantim OR TI "ALPINA PS" OR AB "ALPINA PS" OR TI

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 3 "Anatomic Graduated Component" OR AB "Anatomic Graduated Component" OR TI Ascent OR AB  
 4 Ascent OR TI ATTUNE OR AB ATTUNE OR TI Bi-Surface OR AB Bi-Surface OR TI Duracon OR AB  
 5 Duracon OR TI EMPOWR OR AB EMPOWR OR TI "Genesis II" OR AB "Genesis II" OR TI "iBalance  
 6 Unicondylar Knee" OR AB "iBalance Unicondylar Knee" OR TI "Insall-Burstein II" OR AB "Insall-  
 7 Burstein II" OR TI "InterSpace Knee" OR AB "InterSpace Knee" OR TI KineMax OR AB KineMax OR TI  
 8 KineSpring OR AB KineSpring OR TI Legion OR AB Legion OR TI Marmor OR AB Marmor OR TI Maxim  
 9 OR AB Maxim OR TI "Maximum Congruent Knee system" OR AB "Maximum Congruent Knee system"  
 10 OR TI Miller-Galante OR AB Miller-Galante OR TI "Natural Knee II" OR AB "Natural Knee II" OR TI  
 11 "Natural-Knee Flex System" OR AB "Natural-Knee Flex System" OR TI NexGen OR AB NexGen OR TI  
 12 Optetrak OR AB Optetrak OR TI OrthoGlide OR AB OrthoGlide OR TI Oxinium OR AB Oxinium OR TI  
 13 "Persona Knee System" OR AB "Persona Knee System" OR TI "Press-Fit Condylar" OR AB "Press-Fit  
 14 Condylar" OR TI Profix OR AB Profix OR TI Repicci OR AB Repicci OR TI Restoris OR AB Restoris OR TI  
 15 Scorpio OR AB Scorpio OR TI "Search Evolution" OR AB "Search Evolution" OR TI "Segmental Knee  
 16 System" OR AB "Segmental Knee System" OR TI Series OR AB Series OR TI Sigma OR AB Sigma OR TI  
 17 Triathlon OR AB Triathlon OR TI "Tricon knee" OR AB "Tricon knee" OR TI UniCAP OR AB UniCAP OR TI  
 18 Vanguard OR AB Vanguard OR TI "Advance Total Knee" OR AB "Advance Total Knee" OR TI Alegretto  
 19 OR AB Alegretto OR TI EIUS OR AB EIUS OR TI "UC Plus Solution" OR AB "UC Plus Solution" OR TI Uni-  
 20 Knee OR AB Uni-Knee OR TI Uniglide OR AB Uniglide OR TI DKnee OR AB DKnee OR TI "Advance  
 21 Stature Knee" OR AB "Advance Stature Knee" OR TI HemiCAP OR AB HemiCAP OR TI "Dual Articular"  
 22 OR AB "Dual Articular" OR TI Endo-Model OR AB Endo-Model OR TI Endo-Modell OR AB Endo-Modell  
 23 OR TI Endomodel OR AB Endomodel OR TI EnduRo OR AB EnduRo OR TI "LCS Complete" OR AB "LCS  
 24 Complete" OR TI Oxford OR AB Oxford OR TI "PFC Sigma" OR AB "PFC Sigma" OR TI Rotaflex OR AB  
 25 Rotaflex OR TI "S-ROM Noiles" OR AB "S-ROM Noiles" OR TI Avon OR AB Avon OR TI Regenerex OR AB  
 26 Regenerex)))) AND (DE "MUSCLE strength" OR DE "MUSCLE weakness" OR DE "TORQUE" OR DE  
 27 "GLUTEAL muscles" OR DE "GLUTEUS medius" OR DE "GLUTEUS minimus" OR DE "PIRIFORMIS  
 28 muscle" OR (((TI muscle OR AB muscle OR TI muscular OR AB muscular) N3 (TI strength OR AB  
 29 strength OR TI power OR AB power OR TI force OR AB force OR TI weakness OR AB weakness OR TI  
 30 weakening OR AB weakening OR TI insufficiency OR AB insufficiency OR TI fatigue OR AB fatigue OR  
 31 TI deficit\* OR AB deficit\*)) OR TI torque OR AB torque OR TI "torsional moment\*" OR AB "torsional  
 32 moment\*" OR TI "turning force\*" OR AB "turning force\*" OR TI newton-meter\* OR AB newton-  
 33 meter\* OR TI "hip abduct\*" OR AB "hip abduct\*" OR TI gluteus OR AB gluteus OR TI "gluteal muscle\*" OR AB "gluteal muscle\*" OR TI "abduction motion" OR AB "abduction motion" OR ((TI pelvic OR AB pelvic OR TI pelvis OR AB pelvis) N3 TI movement\* OR AB movement\*)))))

### Web of Science Core Collection

(20191219; 662 hits)

43  
 44  
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 49 TS=((((((knee OR femorotibial OR patellofemoral) NEAR/5 (osteoarthriti\* OR arthriti\* OR  
 50 osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR "degenerative joint  
 51 disease\*")) OR "gonarthrosis")) AND (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\*  
 52 OR arthroprosthes\* OR endoprothes\* OR implant\* OR "artificial knee\*" OR TKR OR TKA OR  
 53 ("minimally invasive" OR mini-invasive OR minimal OR "minimal access") NEAR/2 (surgery OR  
 54 "surgical method\*" OR "surgical procedure\*" OR "surgical technique\*" OR operation OR "operative  
 55 treatment" OR "operative intervention" OR "operative repair" OR "operative restoration")) OR  
 56 "Active UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
 57 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
 58 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
 59 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR

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2  
3 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
4 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
5 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
6 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
7 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
8 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
9 Modell" OR "Endomodel" OR "Enduro" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
10 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) OR ((osteoarthritis\* OR  
11 arthritis\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR  
12 "degenerative joint disease\*" OR "gonarthrosis" OR ((avascular OR bone) NEAR/2 (necrosis OR  
13 infarction)) OR osteonecrosis OR osteoradionecrosis) AND (((knee OR femorotibial OR patella\* OR  
14 patellofemoral) NEAR/2 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR  
15 arthroprosthes\* OR endoprosthesis\* OR implant\*)) OR "artificial knee\*" OR TKR OR TKA OR "Active  
16 UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
17 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
18 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
19 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR  
20 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
21 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
22 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
23 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
24 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
25 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
26 Modell" OR "Endomodel" OR "Enduro" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
27 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) AND (((muscle OR muscular)  
28 NEAR/2 (strength OR power OR force OR weakness OR weakening OR insufficiency OR fatigue OR  
29 deficit\*)) OR torque OR "torsional moment\*" OR "turning force\*" OR newton-meter\* OR "hip  
30 abduct\*" OR gluteus OR "gluteal muscle\*" OR "abduction motion" OR ((pelvic OR pelvis) NEAR/2  
31 movement\*))

## Scopus

(20191219; 993 hits)

44 TITLE-ABS-KEY((((knee OR femorotibial OR patellofemoral) W/5 (osteoarthritis\* OR arthritis\* OR  
45 osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR "degenerative joint  
46 disease\*")) OR "gonarthrosis") AND (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\*  
47 OR arthroprosthes\* OR endoprosthesis\* OR implant\* OR "artificial knee\*" OR TKR OR TKA OR  
48 ("minimally invasive" OR mini-invasive OR minimal OR "minimal access") W/2 (surgery OR "surgical  
49 method\*" OR "surgical procedure\*" OR "surgical technique\*" OR operation OR "operative  
50 treatment" OR "operative intervention" OR "operative repair" OR "operative restoration")) OR  
51 "Active UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
52 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
53 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
54 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR  
55 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
56 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
57 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
58 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
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3 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
4 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
5 Modell" OR "Endomodel" OR "EnduRo" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
6 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) OR ((osteoarthritis\* OR  
7 arthritis\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR  
8 "degenerative joint disease\*" OR "gonarthrosis" OR ((avascular OR bone) W/2 (necrosis OR  
9 infarction)) OR osteonecrosis OR osteoradionecrosis) AND (((knee OR femorotibial OR patella\* OR  
10 patellofemoral) W/2 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR  
11 arthroprosthes\* OR endoprosthesis\* OR implant\*)) OR "artificial knee\*" OR TKR OR TKA OR "Active  
12 UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
13 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
14 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
15 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR  
16 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
17 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
18 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
19 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
20 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
21 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
22 Modell" OR "Endomodel" OR "EnduRo" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
23 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) AND (((muscle OR muscular)  
24 W/2 (strength OR power OR force OR weakness OR weakening OR insufficiency OR fatigue OR  
25 deficit\*)) OR torque OR "torsional moment\*" OR "turning force\*" OR newton-meter\* OR "hip  
26 abduct\*" OR gluteus OR "gluteal muscle\*" OR "abduction motion" OR ((pelvic OR pelvis) W/2  
27 movement\*))

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# BMJ Open

## Hip abductor muscle strength in patients after total or unicompartmental knee arthroplasty for knee osteoarthritis or avascular necrosis: a systematic review and meta-analysis protocol

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-038770.R2
Article Type:	Protocol
Date Submitted by the Author:	30-Jun-2020
Complete List of Authors:	Kvarda, Peter; University Hospital Basel, Orthopaedics and Traumatology,; Kantonsspital Baselland, Department of Orthopaedic Surgery and Traumatology Nüesch, Corina; University of Basel, Department of Clinical Research Egloff, Christian; University of Basel, Department of Orthopaedics and Traumatology Appenzeller-Herzog, Christian ; University of Basel, University Medical Library, Basel, Spiegelgasse 5, 4051 Basel, Switzerland Mündermann, Annegret ; University Hospital Basel, Orthopaedics and Traumatology; University of Basel, Department of Clinical Research Ismailidis, Petros; University Hospital Basel, Orthopaedics and Traumatology
<b>Primary Subject Heading</b>:	Surgery
Secondary Subject Heading:	Rehabilitation medicine, Evidence based practice
Keywords:	Knee < ORTHOPAEDIC & TRAUMA SURGERY, Hip < ORTHOPAEDIC & TRAUMA SURGERY, Adult orthopaedics < ORTHOPAEDIC & TRAUMA SURGERY, REHABILITATION MEDICINE

SCHOLARONE™  
Manuscripts



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5 2 **Hip abductor muscle strength in patients after total or unicompartmental knee**  
6 3 **arthroplasty for knee osteoarthritis or avascular necrosis: a systematic review**  
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## and meta-analysis protocol

6 Peter Kvarda<sup>1,6</sup>, Corina Nüesch<sup>1,2,3,4</sup>, Christian Egloff<sup>1</sup>, Christian Appenzeller-  
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18 Protocol manuscript

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20 June 2020

21  
22 Submitted to: BMJ Open

23  
24 Manuscript # bmjopen-2020-038770

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3 36 **ABSTRACT**  
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6 38 **Introduction:**  
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9 39 Reduced hip abductor strength may indirectly lead to changes in knee kinematics  
10 40 and functional impairment and has been reported in patients with patellofemoral pain  
11 41 and knee osteoarthritis (OA). Limited information is available regarding hip abductor  
12 42 strength following total or unicompartmental knee arthroplasty (TKA/UKA). The aims  
13 43 of this systematic review are to synthesize the evidence of hip abductor muscle  
14 44 strength deficits in patients following TKA/UKA and to determine influencing factors  
15 45 for these deficits.  
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22 47 **Methods and analysis:**  
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25 48 Embase, Medline, SportDiscus, the Web of Science Core Collection and Scopus will  
26 49 be searched for human based clinical studies investigating hip abductor muscle  
27 50 strength after TKA/UKA for knee OA or avascular necrosis (AVN). Articles studying  
28 51 hip abductor strength after knee arthroplasty for posttraumatic OA will not be  
29 52 considered. No restriction on study design, prosthesis design, surgical approach,  
30 53 patient characteristics or severity of OA/AVN will be applied. We will search articles  
31 54 published between January 1, 1990 and the date of our last search. Only articles in  
32 55 English or German language will be considered for inclusion. Studies reporting  
33 56 manually measured muscle strength or measurements performed at hip abduction  
34 57 angles other than 0° will be excluded. References will be screened by two reviewers  
35 58 independently. Where necessary, a third author will make the final decision. The  
36 59 assessment of quality and risk of bias will be performed with the modified Newcastle-  
37 60 Ottawa scale (NOS). Data will be extracted and presented in a tabular form.  
38 61 Depending on availability, comparable subgroup and meta-analyses will be  
39 62 conducted. Patient characteristics such as age, sex and surgical approach or  
40 63 rehabilitation program will be analysed, if sufficient data are available.  
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54 65 **Ethics and dissemination:**  
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56 66 No ethics approval is required. The results will be published in a peer reviewed  
57 67 journal and as conference presentation.  
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3 69 **Registration details:**

4  
5 70 Registered in PROSPERO, acknowledgement of receipt Nr. 164339.  
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7 71

8 72 **Keywords:** abductor muscle strength, hip abductor, knee replacement, knee  
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10 73 arthroplasty knee osteoarthritis, knee avascular necrosis  
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15 76 **Strengths and limitations of this study:**

- 16  
17 77 - To our knowledge, there is no published systematic review investigating hip abductor  
18 78 muscle strength following TKA/UKA.  
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20 79 - The subject and inclusion/exclusion criteria are clearly stated to obtain and present  
21 80 comparable data.  
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23 81 - Possible limitations are the restricted time period of publication and language  
24 82 restriction to English or German.  
25  
26 83 - Possibility of limited and heterogenous data availability to perform a meta-analysis.  
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## 85 INTRODUCTION:

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87 Degenerative diseases of the musculoskeletal system such as osteoarthritis are one  
88 of the leading burdens on the health care system, social security system and  
89 certainly on individuals. Prevalence of knee osteoarthritis (OA) is estimated to be  
90 approximately 10% in men and 13% in women at the age of 60 years or older.<sup>1</sup> OA is  
91 estimated to be the fourth leading cause of disability by the year of 2020, and the  
92 most common indication for performing knee arthroplasty.<sup>2,3</sup>

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94 Different static and dynamic biomechanical components influence the functional knee  
95 mechanics. Static elements are alignment and bony geometry. A neutral mechanical  
96 axis of the lower limb during standing passes through the centre of the tibial plateau  
97 in the frontal plane. This axis is altered in valgus or varus deformity.<sup>4,5</sup>

98 Physiologically, during the stance phase of walking, the centre of load is located over  
99 the medial condyle creating an external knee adduction moment.<sup>6,7</sup> Ligaments and  
100 muscles of the joint form the group of dynamic stabilizers and mainly resist the  
101 adduction moment.<sup>7</sup>

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103 As the adjacent proximal articulation, the hip joint contributes to knee biomechanics.  
104 The hip abductor muscles abduct the femur, facilitate pelvic stability during single leg  
105 stance and walking, and directly affect the tibiofemoral and patellofemoral joint  
106 kinematics. Moreover, the hip abductor muscle group controls the internal rotation of  
107 the femur.<sup>8</sup> In case of hip abductor muscle strength deficit, the contralateral pelvic  
108 side drops while walking, a condition known as “Trendelenburg gait”<sup>9</sup> because the  
109 external hip adduction moment cannot be sufficiently balanced by the internal hip  
110 abduction moment primarily generated by hip abductor muscles. This can be  
111 compensated by leaning the trunk toward the support limb and shifting the centre of  
112 mass over the support limb and reduce the hip adduction moment.<sup>8</sup> The protective  
113 effect of greater internal hip abduction moment has also been reported in terms of  
114 reduced medial tibiofemoral OA progression.<sup>10</sup> Moreover, patellar tracking can be  
115 also altered and cause knee pain.<sup>11,12,13</sup> Isokinetic measurements have shown that  
116 hip abductor muscle weakness is present in patients with knee OA.<sup>14,15</sup> In a recent  
117 systematic review, Deasy et al. reported hip abductor weakness in patients with knee  
118 OA.<sup>16</sup>

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5 120 Current non-surgical treatment modalities aiming alleviate and control symptoms,  
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7 121 nonetheless today the only treatment for severe knee OA is total and  
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9 122 unicompartmental knee arthroplasty (TKA/UKA).<sup>17,18</sup> Reduced hip abductor muscle  
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11 123 strength can implicate compromised functional and performance-based outcome  
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13 124 after TKA/UKA, and hence maintaining and strengthening of the hip abductor  
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15 125 muscles are clinically relevant factors in patients undergoing TKA or UKA.<sup>19,20,21,</sup>  
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17 126 However, to date studies investigating hip abductor muscle strength in patients  
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19 127 undergoing TKA or UKA are scarce. In addition to outcome evaluations, quantitative  
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21 128 assessment of muscle strength is important to understanding factors influencing  
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23 129 surgical outcome. In contrast to knee flexor/extensor muscle strength, the impact of  
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25 130 hip abductor muscle strength deficit in patients with TKA/UKA is currently poorly  
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27 131 understood. The following questions remain unanswered:

- 28 132 • Do patients after unilateral TKA/UKA experience a muscle strength deficit in  
29 133 their operated compared to their unoperated side?
- 30 134 • How long after TKA/UKA does this deficit persist?
- 31 135 • Does the strength deficit after knee arthroplasty differ between patients with  
32 136 total versus unicompartmental arthroplasty?
- 33 137 • Are hip abductor muscle strength deficits after TKA/UKA influenced by pre-  
34 138 and postoperative knee alignment, patient characteristics or rehabilitation  
35 139 programs?

36 140 Therefore, the aim of the proposed systematic review is to synthesize the evidence of  
37 141 hip abductor muscle strength deficits in patients following TKA/UKA and to determine  
38 142 influencing factors for these deficits. The results of the proposed systematic review  
39 143 will provide extended information for physicians in the interest of improving patient  
40 144 management and outcome.

#### 41 145

#### 42 146 **METHODS AND ANALYSES:**

43 147 The protocol was developed following the Preferred Reporting Items for Systematic  
44 148 Reviews and Meta-analyses Protocols (PRISMA-P) guideline<sup>22</sup>(Supplementary a).  
45 149 Bibliographic database searching was initiated on December 19, 2019. The review  
46 150 was submitted for registration prospectively in PROSPERO on January 5<sup>th</sup>, 2020 and  
47 151 the expected completion date is July 1<sup>st</sup>, 2020.<sup>23</sup> We designed the study question

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3 152 using the PICOS (Population, Intervention, Comparison, Outcome, Study design)  
4 strategy (Table 1).<sup>24</sup>  
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## 8 155 **Eligibility criteria**

### 9 156 *Inclusion criteria*

10 157 Human based clinical studies reporting on hip abductor muscle strength after primary  
11 TKA/UKA will be considered for inclusion. Case studies will not be considered for  
12 inclusion. No other restriction regarding the study design will be applied to broadly  
13 capture all possible appropriate studies. No restriction on operative approach,  
14 prosthesis design, age and sex of the patients or severity of OA/AVN will be placed.  
15 In order to avoid capturing irrelevant, methodologically inappropriate studies the date  
16 of publication will be limited to a time period from January 1, 1990 to the date of our  
17 last search. The limit of follow-up will be set to 24 months postoperatively.  
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### 21 164 *Exclusion criteria*

22 165  
23 166 Studies published before 01.01.1990 or in a language other than English or German,  
24 not reporting absolute values of hip abductor muscle strength or torque ratios or  
25 reporting hip abductor strength measured with hand-held manometer/dynamometer  
26 or at a hip abduction angles other than 0° will be excluded. Articles reporting  
27 posttraumatic indications for TKA/UKA or reporting measurements following revision  
28 TKA/UKA will not be considered for inclusion.  
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### 31 174 *Methodological considerations*

32 175 Studies reporting isokinetic or isometric measurements of hip abductor muscle  
33 strength at a 0° hip abduction angle using a dynamometer will be considered for  
34 inclusion. Manual measurements are not reliable and not directly comparable with  
35 measurements taken by electronic dynamometers. Measurements at hip abduction  
36 angles other than 0° do not represent relevant muscle function/strength during  
37 walking and standing. Moreover, the exclusion of these studies will allow to collect  
38 standardized, comparable data facilitating meta-analysis.<sup>25</sup>  
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## 41 183 **Information sources and search strategy**

42 184 Text word synonyms and database-specific subject headings for knee OA, knee  
43 arthroplasty, and hip abductor function will be used. We will search the electronic  
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3 186 databases Embase via embase.com, Medline via Ovid, SportDiscus via EBSCOHost,  
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5 187 the Web of Science Core Collection, and Scopus (Supplementary b). In the primary  
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7 188 search no language restrictions will be applied. Time period of the search will be  
8  
9 189 limited to articles published after January 1, 1990. References will be exported to  
10  
11 190 Endnote X9 (Clarivate, London, U.K.) and deduplicated. The detailed search strategy  
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13 191 can be found in the supplementary document.  
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### 15 193 **Study records: data management, selection process and data extraction**

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17 194 Titles and abstracts of all retrieved references will be independently reviewed and  
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19 195 screened by two reviewers (PK and PI) to identify studies that potentially meet the  
20  
21 196 inclusion criteria. All potentially relevant references will be collected in full-text and  
22  
23 197 independently assessed by two reviewers (PK and PI). Any disagreements regarding  
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25 198 eligibility will be resolved by consensus and by necessity, a third review author (AM)  
26  
27 199 will make a final decision. To find possible additional studies, we will screen the  
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29 200 bibliographic references of all included articles as well as the citations of those that  
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31 201 are indexed in Scopus or Web of Science. The study selection process will be  
32  
33 202 presented in form of a PRISMA diagram.<sup>22</sup> Data from the full texts will be extracted  
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35 203 and entered into a standardized excel data entry form by PK and PI based on piloting  
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37 204 extractions. The information to be extracted can be found in Table 2. We will contact  
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39 205 corresponding authors when the necessary data is missing or unclear. Potential  
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41 206 conference abstracts will be considered for inclusion only if appropriate data are  
42  
43 207 available for the outcomes of this study. We will contact principal investigators and/or  
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45 208 corresponding author(s) twice by email in case of conference abstracts to collect their  
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47 209 results. The data extraction will be cross-checked independently.  
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### 49 211 **Outcomes and prioritisation**

50 212 The main outcomes will be:

- 51 213 1. Absolute values of isometric/isokinetic hip abductor torque in patients following  
52 214 TKA/UKA, or in asymptomatic control groups
- 53 215 2. Torque ratio (ipsilateral hip/contralateral hip) of hip abductors following TKA/UKA
- 54 216 3. Change in hip abductor torque/hip abductor torque ratio from baseline to each follow-up
- 55 217 4. Differences in hip abductor torque/torque ratio between patients after TKA/UKA and  
56 218 healthy control groups.

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58 220 The secondary outcomes will be:

- 221 1. Surgical approaches/methods of TKA/UKA
- 222 2. Pre- and postoperative knee alignment
- 223 3. Patient characteristics
- 224 4. Rehabilitation programs after TKA/UKA

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### 226 **Risk of bias in individual studies**

227 To minimise bias, articles meeting the inclusion criteria will be assessed by two  
228 reviewers (PK and PI) independently using a modified version of the Newcaste-  
229 Ottawa Scale (NOS)<sup>26</sup> (Supplementary c). According to the modified NOS, each  
230 study will be valued with 1 to 6 stars where higher scores indicate higher level of  
231 quality. No separate tool will be used to assess the risk of bias of randomized control  
232 trials because we do not extract estimates of treatment differences from RCTs but  
233 use these as a source for cohort data.

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### 235 **Data synthesis**

236 We will extract any quantitative and descriptive data from all eligible studies  
237 according to the main outcomes (mean, median, etc.), on the population (SD,  
238 interquartile ranges, percentile), on measurements (standard errors, CI, p-values,  
239 sample size), as well as the secondary outcomes for both purposes (systematic  
240 review and meta-analyses). Furthermore, all details specific to the review question  
241 will be extracted. If the information is available for several time points, the data will be  
242 extracted for all time points. The data will be presented in tabular format. Visual  
243 inspection of the forest plots and I<sup>2</sup>-test will be used to assess heterogeneity between  
244 studies. Depending on availability of appropriate data for comparable specific patient  
245 groups with same measurement method in different studies, meta-analyses will be  
246 performed on these data. Meta-analysis will be based on random effects and the  
247 results will be illustrated by forest plots. Where statistical pooling is not possible, the  
248 findings will be presented in narrative form. Meta regression and subgroup specific  
249 meta analyses will be conducted to investigate the effect of time since TKA/UKA and  
250 measurement type (isokinetic or isometric) on different outcomes. In case that  
251 outcomes are not reported directly but indirect information is available on side  
252 specific or time point specific results, the available information will be transformed  
253 accordingly. Meta regression and subgroup specific meta analyses will be used to  
254 investigate the influence of time since TKA/UKA and type of measurement (isokinetic  
255 or isometric) on the different outcomes. In case of sufficient information, these



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3 256 analyses will be extended to patient characteristics, surgical approach, subtype of  
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5 257 prostheses or rehabilitation program.

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### 8 259 **Meta-bias(es)**

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10 260 Funnel plots will be used to assess publication bias in our meta-analysis, presenting  
11 261 effect sizes plotted against their standard errors or precisions. To avoid subjective  
12 262 visual inspection of the graph, Egger's regression test will be used to assess the  
13 263 asymmetry. Egger's test regresses the standardized effect sizes on their precisions.  
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15 264 In the absence of publication bias, the regression intercept is expected to be zero.  
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### 20 266 **Confidence in cumulative evidence**

21 267 Grading of Recommendations Assessment, Development and Evaluation system  
22 268 (GRADE) will be applied.<sup>27</sup> The confidence of evidence of the investigated study can  
23 269 be downgraded according to the following factors: study limitations, inconsistency of  
24 270 results, indirectness of evidence, imprecision, publication bias. Criteria for upgrading  
25 271 are the following: large magnitude of effect, evidence of a dose-response effect and  
26 272 all possible confounding factors taken into account. After the grading process, the  
27 273 quality of evidence for each outcome will be rated as high, moderate, low or very low.  
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### 36 275 **Ethics and dissemination**

37 276 This study is a protocol for a systematic review and meta-analysis. No human  
38 277 participants will be recruited. No ethics approval is needed. The study results will be  
39 278 published in a peer reviewed journal and as conference presentation.  
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### 44 280 **Patient and public involvement**

45 281 There is no patient and/or public involvement planned for this review.  
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### 49 283 **Authors contributions**

50 284 The following work has been developed in contribution of each co-author. The  
51 285 manuscript underwent several revisions with substantial contributions provided by  
52 286 each co-author. PI, PK and AM will perform this systematic review and meta-  
53 287 analysis. The protocol has been registered in PROSPERO by PK. The search  
54 288 strategy was designed by CA. CN reviewed the protocol and was responsible for the  
55 289 strategy of data synthesis. CE cooperated in study design development, as well as in

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2  
3 290 manuscript editing. All authors gave final approval of the manuscript prior to  
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5 291 submission.

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10 294 **Funding statement:**

11 295 This study will be funded by the Department of Orthopaedics and Traumatology of  
12  
13 296 the University Hospital of Basel, the Foundation for Funding Science and Education  
14  
15 297 at the Department of Surgery at the University of Basel, Swiss  
16  
17 298 Orthopaedics, Merian Iselin Foundation and Deutsche Arthrose-Hilfe e.V. The  
18  
19 299 funding sources had no involvement in any aspect of this study.

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23 302 **COMPETING INTERESTS STATEMENT**

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25 303 The authors declare no competing interest.  
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393 **Figures and Legends:**

394 Table 1: The Population, Intervention, Comparison, Outcome, Study design (PICOS)  
 395 process<sup>24</sup>.

Item	Specification
Population, or participants and conditions of interest	Patients with OA or AVN of the knee (any age, gender and severity)
Interventions	TKA/UKA
Comparisons or control groups	For comparison between limbs of the same subject: asymptomatic contralateral hip and knee For comparison between patients and healthy individuals: asymptomatic control subjects
Outcomes of interest	Muscle strength of hip abductors
Study designs	Any study design, published studies, conference abstracts to be considered

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399 Table 2: Data that will be extracted from every study included in the review

No.	Description
1	Authors and year of publication
2	Country of origin of the study
3	Type of study
4	Study population
5	Study completion rate
6	Diagnosis
7	Surgical approach: medial parapatellar; modified medial parapatellar according to Insall; subvastus; midvastus; trivector-retaining; lateral; lateral with tuberositas osteotomy <sup>28</sup>
8	Study population demographics
9	Pre- and postoperative frontal and sagittal plane knee alignment
10	Measurement methods
10a	Isometric/isokinetic strength measurement
10b	Angle of isometric measurement/velocity of isokinetic measurement
10c	Patient position during the measurement (lying supine/side-lying/standing)
11	Comparators: healthy individuals; asymptomatic contralateral side; no comparator
12	Total duration of follow up (weeks/months after the operation)
13	Measurement stages (preoperative, follow up in weeks/months after the operation)
14	Information regarding the rehabilitation protocols
15	Outcome (mean values, standard deviations (SDs) and confidence intervals (CIs))
15a	Absolute values of hip abductor torque in patients after TKA/UKA, or in asymptomatic control groups
15b	Torque ratio (operated side/contralateral hip) of hip abductors in patients after TKA/UKA
15c	Change in hip abductor torque / hip abductor torque ratio from baseline to each follow-up
15d	Differences in hip abductor torque / torque ratios between patients after TKA/UKA and healthy control groups.
16	Authors conclusions
17	Information regarding risk of bias

400

**PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol\***

Section and topic	Item No	Checklist item	Reported on Page
<b>ADMINISTRATIVE INFORMATION</b>			
Title:			
Identification	1a	Identify the report as a protocol of a systematic review	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	n.a.
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	2
Authors:			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	1
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	9
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	n.a.
Support:			
Sources	5a	Indicate sources of financial or other support for the review	9
Sponsor	5b	Provide name for the review funder and/or sponsor	9
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	9
<b>INTRODUCTION</b>			
Rationale	6	Describe the rationale for the review in the context of what is already known	4
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	5
<b>METHODS</b>			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	4
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	6
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	Supplementary file



Study records:			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	6
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	2
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	6
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	5-7
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	7
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	8
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised	8
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I <sup>2</sup> , Kendall's $\tau$ )	8
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	8
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	8
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	9
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	9

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015 Jan 2;349(jan02 1):g7647.

# Hip abductor muscle strength in patients after total or unicompartmental knee arthroplasty for knee osteoarthritis or avascular necrosis - Search strategy

## Appendices

### Appendix 1: Search strategies

Embase.com

(20191219; 860 hits)

((('knee osteoarthritis'/de OR (((knee OR femorotibial OR patellofemoral) NEAR/5 (osteoarthriti\* OR arthriti\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR 'degenerative joint disease\*')) OR 'gonarthrosis'):ab,ti)

AND

('knee arthroplasty'/exp OR 'total knee arthroplasty'/de OR 'arthroplasty'/de OR 'total arthroplasty'/de OR 'knee prosthesis'/de OR 'femoral knee prosthesis'/de OR 'hinge knee prosthesis'/exp OR 'patella prosthesis'/de OR 'patellofemoral prosthesis'/de OR 'tibial knee prosthesis'/de OR 'total knee prosthesis'/de OR 'unicompartmental knee prosthesis'/de OR 'joint prosthesis'/de OR 'endoprosthesis'/de OR 'minimally invasive surgery'/de OR (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprosthes\* OR implant\* OR 'artificial knee\*' OR TKR OR TKA OR (('minimally invasive' OR mini-invasive OR minimal OR 'minimal access') NEAR/3 (surgery OR 'surgical method\*' OR 'surgical procedure\*' OR 'surgical technique\*' OR operation OR 'operative treatment' OR 'operative intervention' OR 'operative repair' OR 'operative restoration')) OR 'Active UKA' OR 'Advance Medial Pivot' OR 'Advantim' OR 'ALPINA PS' OR 'Anatomic Graduated Component' OR 'Ascent' OR 'ATTUNE' OR 'Bi-Surface' OR 'Duracon' OR 'EMPOWR' OR 'Genesis II' OR 'iBalance Unicdylar Knee' OR 'Insall-Burstein II' OR 'InterSpace Knee' OR 'KineMax' OR 'KineSpring' OR 'Legion' OR 'Marmor' OR 'Maxim' OR 'Maximum Congruent Knee system' OR 'Miller-Galante' OR 'Natural Knee II' OR 'Natural-Knee Flex System' OR 'NexGen' OR 'Optetrak' OR 'OrthoGlide' OR 'Oxinium' OR 'Persona Knee System' OR 'Press-Fit Condylar' OR 'Profix' OR 'Repicci' OR 'Restoris' OR 'Scorpio' OR 'Search Evolution' OR 'Segmental Knee System' OR 'Series 7000' OR 'Sigma' OR 'Triathlon' OR 'Tricon knee' OR 'UniCAP' OR 'Vanguard' OR 'Advance Total Knee' OR 'Alegretto' OR 'EIUS' OR 'UC Plus Solution' OR 'Uni-Knee' OR 'Uniglide' OR '3DKnee' OR 'Advance Stature Knee' OR 'HemiCAP' OR 'Dual Articular 2000' OR 'Endo-Model' OR 'Endo-Modell' OR 'Endomodel' OR 'EnduRo' OR 'LCS Complete' OR 'Oxford' OR 'P.F.C. Sigma' OR 'PFC Sigma' OR 'Rotaflex' OR 'S-ROM Noiles' OR 'Avon' OR 'Regenerex'):ab,ti))

OR

((('knee osteoarthritis'/de OR 'osteoarthritis'/de OR 'avascular necrosis'/de OR 'bone necrosis'/de OR (osteoarthriti\* OR arthriti\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR 'degenerative joint disease\*' OR 'gonarthrosis' OR ((avascular OR bone) NEAR/3 (necrosis OR infarction)) OR osteonecrosis OR osteoradionecrosis):ab,ti)

AND

1  
2  
3 ('knee arthroplasty'/exp OR 'total knee arthroplasty'/de OR 'knee prosthesis'/de OR 'femoral knee  
4 prosthesis'/de OR 'hinge knee prosthesis'/exp OR 'patella prosthesis'/de OR 'patellofemoral  
5 prosthesis'/de OR 'tibial knee prosthesis'/de OR 'total knee prosthesis'/de OR 'unicompartmental  
6 knee prosthesis'/de OR (((knee OR femorotibial OR patella\* OR patellofemoral) NEAR/3  
7 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\* OR endoprosthesis\*  
8 OR implant\*)) OR 'artificial knee\*' OR TKR OR TKA OR 'Active UKA' OR 'Advance Medial Pivot' OR  
9 'Advantim' OR 'ALPINA PS' OR 'Anatomic Graduated Component' OR 'Ascent' OR 'ATTUNE' OR 'Bi-  
10 Surface' OR 'Duracon' OR 'EMPOWR' OR 'Genesis II' OR 'iBalance Unicdylar Knee' OR 'Insall-  
11 Burstein II' OR 'InterSpace Knee' OR 'KineMax' OR 'KineSpring' OR 'Legion' OR 'Marmor' OR 'Maxim'  
12 OR 'Maximum Congruent Knee system' OR 'Miller-Galante' OR 'Natural Knee II' OR 'Natural-Knee Flex  
13 System' OR 'NexGen' OR 'Optetrak' OR 'OrthoGlide' OR 'Oxinium' OR 'Persona Knee System' OR  
14 'Press-Fit Condylar' OR 'Profix' OR 'Repicci' OR 'Restoris' OR 'Scorpio' OR 'Search Evolution' OR  
15 'Segmental Knee System' OR 'Series 7000' OR 'Sigma' OR 'Triathlon' OR 'Tricon knee' OR 'UniCAP' OR  
16 'Vanguard' OR 'Advance Total Knee' OR 'Alegretto' OR 'EIUS' OR 'UC Plus Solution' OR 'Uni-Knee' OR  
17 'Uniglide' OR '3DKnee' OR 'Advance Stature Knee' OR 'HemiCAP' OR 'Dual Articular 2000' OR 'Endo-  
18 Model' OR 'Endo-Modell' OR 'Endomodel' OR 'EnduRo' OR 'LCS Complete' OR 'Oxford' OR 'P.F.C.  
19 Sigma' OR 'PFC Sigma' OR 'Rotaflex' OR 'S-ROM Noiles' OR 'Avon' OR 'Regenerex'):ab,ti))

20  
21  
22  
23  
24 AND

25  
26 ('muscle strength'/de OR 'muscle weakness'/de OR 'torque'/de OR 'hip abductor muscle'/de OR  
27 'pelvic movement'/de OR (((muscle OR muscular) NEAR/3 (strength OR power OR force OR weakness  
28 OR weakening OR insufficiency OR fatigue OR deficit\*)) OR torque OR 'torsional moment\*' OR  
29 'turning force\*' OR newton-meter\* OR 'hip abduct\*' OR gluteus OR 'gluteal muscle\*' OR 'abduction  
30 motion' OR ((pelvic OR pelvis) NEAR/3 movement\*)):ab,ti)

31  
32  
33 NOT

34  
35 (('animal'/de OR 'animal experiment'/exp OR 'nonhuman'/de) NOT ('human'/exp OR 'human  
36 experiment'/de))

37  
38  
39  
40 Ovid Medline

41 (20191219; 449 hits)

42  
43 (((osteoarthritis, knee/ OR (((knee OR femorotibial OR patellofemoral) ADJ5 (osteoarthriti\* OR  
44 arthriti\* OR osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR  
45 degenerative joint disease\*)) OR gonarthrosis).ab,ti.)

46  
47 AND

48  
49 (arthroplasty, replacement, knee/ OR arthroplasty/ OR arthroplasty, replacement/ OR knee  
50 prosthesis/ OR joint prosthesis/ OR "prostheses and implants"/ OR minimally invasive surgical  
51 procedures/ OR (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR arthroprosthes\*  
52 OR endoprosthesis\* OR implant\* OR artificial knee\* OR TKR OR TKA OR ((minimally invasive OR mini-  
53 invasive OR minimal OR minimal access) ADJ3 (surgery OR surgical method\* OR surgical procedure\*  
54 OR surgical technique\* OR operation OR operative treatment OR operative intervention OR  
55 operative repair OR operative restoration)) OR Active UKA OR Advance Medial Pivot OR Advantim OR  
56 ALPINA PS OR Anatomic Graduated Component OR Ascent OR ATTUNE OR Bi-Surface OR Duracon OR  
57 EMPOWR OR Genesis II OR iBalance Unicdylar Knee OR Insall-Burstein II OR InterSpace Knee OR  
58 KineMax OR KineSpring OR Legion OR Marmor OR Maxim OR Maximum Congruent Knee system OR  
59 Miller-Galante OR Natural Knee II OR Natural-Knee Flex System OR NexGen OR Optetrak OR  
60

1  
2  
3 OrthoGlide OR Oxinium OR Persona Knee System OR Press-Fit Condylar OR Profix OR Repicci OR  
4 Restoris OR Scorpio OR Search Evolution OR Segmental Knee System OR Series 7000 OR Sigma OR  
5 Triathlon OR Tricon knee OR UniCAP OR Vanguard OR Advance Total Knee OR Alegretto OR EIUS OR  
6 UC Plus Solution OR Uni-Knee OR Uniglide OR 3DKnee OR Advance Stature Knee OR HemiCAP OR  
7 Dual Articular 2000 OR Endo-Model OR Endo-Modell OR Endomodel OR EnduRo OR LCS Complete OR  
8 Oxford OR PFC Sigma OR Rotaflex OR S-ROM Noiles OR Avon OR Regenerex).ab,ti.)

9  
10  
11 OR

12  
13 ((osteoarthritis, knee/ OR osteoarthritis/ OR osteonecrosis/ OR (osteoarthriti\* OR arthriti\* OR  
14 osteoarthrosis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR degenerative joint  
15 disease\* OR gonarthrosis OR ((avascular OR bone) ADJ3 (necrosis OR infarction)) OR osteonecrosis  
16 OR osteoradionecrosis).ab,ti.)

17  
18 AND

19  
20 (arthroplasty, replacement, knee/ OR knee prosthesis/ OR (((knee OR femorotibial OR patella\* OR  
21 patellofemoral) ADJ3 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR  
22 arthroprosthes\* OR endoprosthes\* OR implant\*)) OR artificial knee\* OR TKR OR TKA OR Active UKA  
23 OR Advance Medial Pivot OR Advantim OR ALPINA PS OR Anatomic Graduated Component OR Ascent  
24 OR ATTUNE OR Bi-Surface OR Duracon OR EMPOWR OR Genesis II OR iBalance Unicdylar Knee OR  
25 Insall-Burstein II OR InterSpace Knee OR KineMax OR KineSpring OR Legion OR Marmor OR Maxim OR  
26 Maximum Congruent Knee system OR Miller-Galante OR Natural Knee II OR Natural-Knee Flex  
27 System OR NexGen OR Optetrak OR OrthoGlide OR Oxinium OR Persona Knee System OR Press-Fit  
28 Condylar OR Profix OR Repicci OR Restoris OR Scorpio OR Search Evolution OR Segmental Knee  
29 System OR Series 7000 OR Sigma OR Triathlon OR Tricon knee OR UniCAP OR Vanguard OR Advance  
30 Total Knee OR Alegretto OR EIUS OR UC Plus Solution OR Uni-Knee OR Uniglide OR 3DKnee OR  
31 Advance Stature Knee OR HemiCAP OR Dual Articular 2000 OR Endo-Model OR Endo-Modell OR  
32 Endomodel OR EnduRo OR LCS Complete OR Oxford OR PFC Sigma OR Rotaflex OR S-ROM Noiles OR  
33 Avon OR Regenerex).ab,ti.))

34  
35  
36  
37 AND

38  
39 (muscle strength/ OR muscle weakness/ OR torque/ OR (((muscle OR muscular) ADJ3 (strength OR  
40 power OR force OR weakness OR weakening OR insufficiency OR fatigue OR deficit\*)) OR torque OR  
41 torsional moment\* OR turning force\* OR newton-meter\* OR hip abduct\* OR gluteus OR gluteal  
42 muscle\* OR abduction motion OR ((pelvic OR pelvis) ADJ3 movement\*).ab,ti.)

43  
44  
45 NOT

46  
47 (exp animals/ NOT humans/)

48  
49  
50  
51 [SportDiscus](#)

52 (20191219; 283 hits)

53  
54 (((((((TI knee OR AB knee OR TI femorotibial OR AB femorotibial OR TI patellofemoral OR AB  
55 patellofemoral) N5 (TI osteoarthriti\* OR AB osteoarthriti\* OR TI arthriti\* OR AB arthriti\* OR TI  
56 osteoarthrosis OR AB osteoarthrosis OR TI osteoarthroses OR AB osteoarthroses OR TI arthrosis OR  
57 AB arthrosis OR TI arthroses OR AB arthroses OR TI arthropathy OR AB arthropathy OR TI  
58 "degenerative joint disease\*" OR AB "degenerative joint disease\*")) OR TI gonarthrosis OR AB  
59 gonarthrosis)) AND (DE "ARTHROPLASTY" OR DE "TOTAL knee replacement" OR DE "ARTIFICIAL  
60 joints" OR DE "PROSTHETICS" OR DE "ARTIFICIAL knees" OR (TI replacement\* OR AB replacement\*

1  
 2  
 3 OR TI reconstruct\* OR AB reconstruct\* OR TI arthroplast\* OR AB arthroplast\* OR TI prosthes\* OR AB  
 4 prosthes\* OR TI arthroprosthes\* OR AB arthroprosthes\* OR TI endoprothes\* OR AB endoprothes\*  
 5 OR TI implant\* OR AB implant\* OR TI "artificial knee\*" OR AB "artificial knee\*" OR TI TKR OR AB TKR  
 6 OR TI TKA OR AB TKA OR ((TI "minimally invasive" OR AB "minimally invasive" OR TI mini-invasive OR  
 7 AB mini-invasive OR TI minimal OR AB minimal OR TI "minimal access" OR AB "minimal access")) N3  
 8 (TI surgery OR AB surgery OR TI "surgical method\*" OR AB "surgical method\*" OR TI "surgical  
 9 procedure\*" OR AB "surgical procedure\*" OR TI "surgical technique\*" OR AB "surgical technique\*"  
 10 OR TI operation OR AB operation OR TI "operative treatment" OR AB "operative treatment" OR TI  
 11 "operative intervention" OR AB "operative intervention" OR TI "operative repair" OR AB "operative  
 12 repair" OR TI "operative restoration" OR AB "operative restoration")) OR TI "Active UKA" OR AB  
 13 "Active UKA" OR TI "Advance Medial Pivot" OR AB "Advance Medial Pivot" OR TI Advantim OR AB  
 14 Advantim OR TI "ALPINA PS" OR AB "ALPINA PS" OR TI "Anatomic Graduated Component" OR AB  
 15 "Anatomic Graduated Component" OR TI Ascent OR AB Ascent OR TI ATTUNE OR AB ATTUNE OR TI  
 16 Bi-Surface OR AB Bi-Surface OR TI Duracon OR AB Duracon OR TI EMPOWR OR AB EMPOWR OR TI  
 17 "Genesis II" OR AB "Genesis II" OR TI "iBalance Unicondylar Knee" OR AB "iBalance Unicondylar  
 18 Knee" OR TI "Insall-Burstein II" OR AB "Insall-Burstein II" OR TI "InterSpace Knee" OR AB "InterSpace  
 19 Knee" OR TI KineMax OR AB KineMax OR TI KineSpring OR AB KineSpring OR TI Legion OR AB Legion  
 20 OR TI Marmor OR AB Marmor OR TI Maxim OR AB Maxim OR TI "Maximum Congruent Knee system"  
 21 OR AB "Maximum Congruent Knee system" OR TI Miller-Galante OR AB Miller-Galante OR TI "Natural  
 22 Knee II" OR AB "Natural Knee II" OR TI "Natural-Knee Flex System" OR AB "Natural-Knee Flex System"  
 23 OR TI NexGen OR AB NexGen OR TI Optetrak OR AB Optetrak OR TI OrthoGlide OR AB OrthoGlide OR  
 24 TI Oxinium OR AB Oxinium OR TI "Persona Knee System" OR AB "Persona Knee System" OR TI "Press-  
 25 Fit Condylar" OR AB "Press-Fit Condylar" OR TI Profix OR AB Profix OR TI Repicci OR AB Repicci OR TI  
 26 Restoris OR AB Restoris OR TI Scorpio OR AB Scorpio OR TI "Search Evolution" OR AB "Search  
 27 Evolution" OR TI "Segmental Knee System" OR AB "Segmental Knee System" OR TI Series OR AB  
 28 Series OR TI Sigma OR AB Sigma OR TI Triathlon OR AB Triathlon OR TI "Tricon knee" OR AB "Tricon  
 29 knee" OR TI UniCAP OR AB UniCAP OR TI Vanguard OR AB Vanguard OR TI "Advance Total Knee" OR  
 30 AB "Advance Total Knee" OR TI Alegretto OR AB Alegretto OR TI EIUS OR AB EIUS OR TI "UC Plus  
 31 Solution" OR AB "UC Plus Solution" OR TI Uni-Knee OR AB Uni-Knee OR TI Uniglide OR AB Uniglide OR  
 32 TI DKnee OR AB DKnee OR TI "Advance Stature Knee" OR AB "Advance Stature Knee" OR TI HemiCAP  
 33 OR AB HemiCAP OR TI "Dual Articular" OR AB "Dual Articular" OR TI Endo-Model OR AB Endo-Model  
 34 OR TI Endo-Modell OR AB Endo-Modell OR TI Endomodel OR AB Endomodel OR TI EnduRo OR AB  
 35 EnduRo OR TI "LCS Complete" OR AB "LCS Complete" OR TI Oxford OR AB Oxford OR TI "PFC Sigma"  
 36 OR AB "PFC Sigma" OR TI Rotaflex OR AB Rotaflex OR TI "S-ROM Noiles" OR AB "S-ROM Noiles" OR TI  
 37 Avon OR AB Avon OR TI Regenerex OR AB Regenerex))) OR ((DE "OSTEOARTHRITIS" OR DE  
 38 "OSTEONECROSIS" OR DE "OSTEOCHONDROSIS" OR (TI osteoarthriti\* OR AB osteoarthriti\* OR TI  
 39 arthriti\* OR AB arthriti\* OR TI osteoarthrosis OR AB osteoarthrosis OR TI osteoarthroses OR AB  
 40 osteoarthroses OR TI arthrosis OR AB arthrosis OR TI arthroses OR AB arthroses OR TI arthropathy OR  
 41 AB arthropathy OR TI "degenerative joint disease\*" OR AB "degenerative joint disease\*" OR TI  
 42 gonarthrosis OR AB gonarthrosis OR ((TI avascular OR AB avascular OR TI bone OR AB bone) N3 (TI  
 43 necrosis OR AB necrosis OR TI infarction OR AB infarction)) OR TI osteonecrosis OR AB osteonecrosis  
 44 OR TI osteoradionecrosis OR AB osteoradionecrosis)) AND (DE "TOTAL knee replacement" OR DE  
 45 "ARTIFICIAL knees" OR (((TI knee OR AB knee OR TI femorotibial OR AB femorotibial OR TI patella\*  
 46 OR AB patella\* OR TI patellofemoral OR AB patellofemoral) N3 (TI replacement\* OR AB replacement\*  
 47 OR TI reconstruct\* OR AB reconstruct\* OR TI arthroplast\* OR AB arthroplast\* OR TI prosthes\* OR AB  
 48 prosthes\* OR TI arthroprosthes\* OR AB arthroprosthes\* OR TI endoprothes\* OR AB endoprothes\*  
 49 OR TI implant\* OR AB implant\*)) OR TI "artificial knee\*" OR AB "artificial knee\*" OR TI TKR OR AB TKR  
 50 OR TI TKA OR AB TKA OR TI "Active UKA" OR AB "Active UKA" OR TI "Advance Medial Pivot" OR AB  
 51 "Advance Medial Pivot" OR TI Advantim OR AB Advantim OR TI "ALPINA PS" OR AB "ALPINA PS" OR TI

1  
2  
3 "Anatomic Graduated Component" OR AB "Anatomic Graduated Component" OR TI Ascent OR AB  
4 Ascent OR TI ATTUNE OR AB ATTUNE OR TI Bi-Surface OR AB Bi-Surface OR TI Duracon OR AB  
5 Duracon OR TI EMPOWR OR AB EMPOWR OR TI "Genesis II" OR AB "Genesis II" OR TI "iBalance  
6 Unicondylar Knee" OR AB "iBalance Unicondylar Knee" OR TI "Insall-Burstein II" OR AB "Insall-  
7 Burstein II" OR TI "InterSpace Knee" OR AB "InterSpace Knee" OR TI KineMax OR AB KineMax OR TI  
8 KineSpring OR AB KineSpring OR TI Legion OR AB Legion OR TI Marmor OR AB Marmor OR TI Maxim  
9 OR AB Maxim OR TI "Maximum Congruent Knee system" OR AB "Maximum Congruent Knee system"  
10 OR TI Miller-Galante OR AB Miller-Galante OR TI "Natural Knee II" OR AB "Natural Knee II" OR TI  
11 "Natural-Knee Flex System" OR AB "Natural-Knee Flex System" OR TI NexGen OR AB NexGen OR TI  
12 Optetrak OR AB Optetrak OR TI OrthoGlide OR AB OrthoGlide OR TI Oxinium OR AB Oxinium OR TI  
13 "Persona Knee System" OR AB "Persona Knee System" OR TI "Press-Fit Condylar" OR AB "Press-Fit  
14 Condylar" OR TI Profix OR AB Profix OR TI Repicci OR AB Repicci OR TI Restoris OR AB Restoris OR TI  
15 Scorpio OR AB Scorpio OR TI "Search Evolution" OR AB "Search Evolution" OR TI "Segmental Knee  
16 System" OR AB "Segmental Knee System" OR TI Series OR AB Series OR TI Sigma OR AB Sigma OR TI  
17 Triathlon OR AB Triathlon OR TI "Tricon knee" OR AB "Tricon knee" OR TI UniCAP OR AB UniCAP OR TI  
18 Vanguard OR AB Vanguard OR TI "Advance Total Knee" OR AB "Advance Total Knee" OR TI Alegretto  
19 OR AB Alegretto OR TI EIUS OR AB EIUS OR TI "UC Plus Solution" OR AB "UC Plus Solution" OR TI Uni-  
20 Knee OR AB Uni-Knee OR TI Uniglide OR AB Uniglide OR TI DKnee OR AB DKnee OR TI "Advance  
21 Stature Knee" OR AB "Advance Stature Knee" OR TI HemiCAP OR AB HemiCAP OR TI "Dual Articular"  
22 OR AB "Dual Articular" OR TI Endo-Model OR AB Endo-Model OR TI Endo-Modell OR AB Endo-Modell  
23 OR TI Endomodel OR AB Endomodel OR TI EnduRo OR AB EnduRo OR TI "LCS Complete" OR AB "LCS  
24 Complete" OR TI Oxford OR AB Oxford OR TI "PFC Sigma" OR AB "PFC Sigma" OR TI Rotaflex OR AB  
25 Rotaflex OR TI "S-ROM Noiles" OR AB "S-ROM Noiles" OR TI Avon OR AB Avon OR TI Regenerex OR AB  
26 Regenerex)))) AND (DE "MUSCLE strength" OR DE "MUSCLE weakness" OR DE "TORQUE" OR DE  
27 "GLUTEAL muscles" OR DE "GLUTEUS medius" OR DE "GLUTEUS minimus" OR DE "PIRIFORMIS  
28 muscle" OR (((TI muscle OR AB muscle OR TI muscular OR AB muscular) N3 (TI strength OR AB  
29 strength OR TI power OR AB power OR TI force OR AB force OR TI weakness OR AB weakness OR TI  
30 weakening OR AB weakening OR TI insufficiency OR AB insufficiency OR TI fatigue OR AB fatigue OR  
31 TI deficit\* OR AB deficit\*)) OR TI torque OR AB torque OR TI "torsional moment\*" OR AB "torsional  
32 moment\*" OR TI "turning force\*" OR AB "turning force\*" OR TI newton-meter\* OR AB newton-  
33 meter\* OR TI "hip abduct\*" OR AB "hip abduct\*" OR TI gluteus OR AB gluteus OR TI "gluteal muscle\*" OR AB "gluteal muscle\*" OR TI "abduction motion" OR AB "abduction motion" OR ((TI pelvic OR AB pelvic OR TI pelvis OR AB pelvis) N3 TI movement\* OR AB movement\*)))))

### Web of Science Core Collection

(20191219; 662 hits)

43  
44  
45  
46  
47  
48  
49 TS=((((((knee OR femorotibial OR patellofemoral) NEAR/5 (osteoarthritis\* OR arthritis\* OR  
50 osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR "degenerative joint  
51 disease\*")) OR "gonarthrosis") AND (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\*  
52 OR arthroprosthes\* OR endoprothes\* OR implant\* OR "artificial knee\*" OR TKR OR TKA OR  
53 ("minimally invasive" OR mini-invasive OR minimal OR "minimal access") NEAR/2 (surgery OR  
54 "surgical method\*" OR "surgical procedure\*" OR "surgical technique\*" OR operation OR "operative  
55 treatment" OR "operative intervention" OR "operative repair" OR "operative restoration")) OR  
56 "Active UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
57 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
58 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
59 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR

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3 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
4 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
5 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
6 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
7 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
8 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
9 Modell" OR "Endomodel" OR "Enduro" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
10 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) OR ((osteoarthritis\* OR  
11 arthritis\* OR osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR  
12 "degenerative joint disease\*" OR "gonarthrosis" OR ((avascular OR bone) NEAR/2 (necrosis OR  
13 infarction)) OR osteonecrosis OR osteoradionecrosis) AND (((knee OR femorotibial OR patella\* OR  
14 patellofemoral) NEAR/2 (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\* OR  
15 arthroprosthes\* OR endoprosthesis\* OR implant\*)) OR "artificial knee\*" OR TKR OR TKA OR "Active  
16 UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
17 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
18 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
19 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR  
20 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
21 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
22 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
23 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
24 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
25 "Advance Stature Knee" OR "HemiCAP" OR "Dual Articular 2000" OR "Endo-Model" OR "Endo-  
26 Modell" OR "Endomodel" OR "Enduro" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
27 Sigma" OR "Rotaflex" OR "S-ROM Noiles" OR "Avon" OR "Regenerex")) AND (((muscle OR muscular)  
28 NEAR/2 (strength OR power OR force OR weakness OR weakening OR insufficiency OR fatigue OR  
29 deficit\*)) OR torque OR "torsional moment\*" OR "turning force\*" OR newton-meter\* OR "hip  
30 abduct\*" OR gluteus OR "gluteal muscle\*" OR "abduction motion" OR ((pelvic OR pelvis) NEAR/2  
31 movement\*))

## Scopus

(20191219; 993 hits)

44 TITLE-ABS-KEY((((knee OR femorotibial OR patellofemoral) W/5 (osteoarthritis\* OR arthritis\* OR  
45 osteoarthritis OR osteoarthroses OR arthrosis OR arthroses OR arthropathy OR "degenerative joint  
46 disease\*")) OR "gonarthrosis") AND (replacement\* OR reconstruct\* OR arthroplast\* OR prosthes\*  
47 OR arthroprosthes\* OR endoprosthesis\* OR implant\* OR "artificial knee\*" OR TKR OR TKA OR  
48 ("minimally invasive" OR mini-invasive OR minimal OR "minimal access") W/2 (surgery OR "surgical  
49 method\*" OR "surgical procedure\*" OR "surgical technique\*" OR operation OR "operative  
50 treatment" OR "operative intervention" OR "operative repair" OR "operative restoration")) OR  
51 "Active UKA" OR "Advance Medial Pivot" OR "Advantim" OR "ALPINA PS" OR "Anatomic Graduated  
52 Component" OR "Ascent" OR "ATTUNE" OR "Bi-Surface" OR "Duracon" OR "EMPOWR" OR "Genesis  
53 II" OR "iBalance Unicondylar Knee" OR "Insall-Burstein II" OR "InterSpace Knee" OR "KineMax" OR  
54 "KineSpring" OR "Legion" OR "Marmor" OR "Maxim" OR "Maximum Congruent Knee system" OR  
55 "Miller-Galante" OR "Natural Knee II" OR "Natural-Knee Flex System" OR "NexGen" OR "Optetrak"  
56 OR "OrthoGlide" OR "Oxinium" OR "Persona Knee System" OR "Press-Fit Condylar" OR "Profix" OR  
57 "Repicci" OR "Restoris" OR "Scorpio" OR "Search Evolution" OR "Segmental Knee System" OR "Series  
58 7000" OR "Sigma" OR "Triathlon" OR "Tricon knee" OR "UniCAP" OR "Vanguard" OR "Advance Total  
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3 Knee" OR "Alegretto" OR "EIUS" OR "UC Plus Solution" OR "Uni-Knee" OR "Uniglide" OR "3DKnee" OR  
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22 Modell" OR "Endomodel" OR "EnduRo" OR "LCS Complete" OR "Oxford" OR "P.F.C. Sigma" OR "PFC  
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26 abduct\*" OR gluteus OR "gluteal muscle\*" OR "abduction motion" OR ((pelvic OR pelvis) W/2  
27 movement\*))

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## ADAPTED NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE COHORT STUDIES

### Selection

1. Representativeness of the patient cohort \*
  - a) truly representative of the corresponding patient cohort in the general community (e.g. multi center trial with different types of hospitals) \*
  - b) somewhat representative of the corresponding patient cohort (e.g. single center study in only hospital of the catchment area) \*
  - c) selected group of patients
  - d) no or unclear description of the derivation of the patient cohort
2. Selection of the healthy control cohort<sup>[[SEP]]</sup> (if applicable)
  - a) drawn from the same community as the patient cohort \*
  - b) drawn from a different source<sup>[[SEP]]</sup>
  - c) no description of the derivation of the healthy cohort
3. Ascertainment of exposure<sup>[[SEP]]</sup> (not applicable)
4. Demonstration that outcome of interest was not present at start of study (not applicable)

### Comparability

1. Comparability of cohorts on the basis of the design or analysis<sup>[[SEP]]</sup> (if applicable)
  - a) study controls for age differences between cohorts (e.g. by matching or statistical adjustment for potential confounding) \*
  - b) study does not control for age differences between cohorts

### Outcome

1. Assessment of outcome
  - a) independent assessment (e.g. by nurses or researchers not involved in the study) \*
  - b) assessment by member of the research team
  - c) no information given
2. Was follow-up long enough for patients to recover?
  - a) yes (follow up at least 12 months) \*
  - b) no (follow up less than 12 months)

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2  
3 3. Adequacy of follow up of cohorts<sup>[1]</sup><sub>SEP</sub>  
4  
5 a) complete follow up - all subjects accounted for \*  
6 b) subjects lost to follow up unlikely to introduce bias (e.g. drop out  
7 because of medical complications) or at least 90% \*  
8  
9 c) follow up rate < 90 % or no description of those lost or description  
10 suggests bias  
11  
12 d) no statement  
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