International Orthopaedics (SICOT) (2015) 39:1405–1410
DOI 10.1007/s00264-014-2663-9

ORIGINAL PAPER

The influence of pre-existing radiographic osteoarthritis on functional outcome after trochanteric fracture

Christoph Kolja Boese · Benjamin Buecking · Tim Schwarting · Florian Debus · Steffen Ruchholtz · Christoph Bliemel · Michael Frink · Philipp Lechler

Received: 14 December 2014 / Accepted: 29 December 2014 / Published online: 21 January 2015

Abstract
Purpose It is crucially important to optimise functional outcome after fixation of trochanteric femoral fractures. While a number of risk factors that predict a poor clinical course have been identified, the influence of pre-existing radiographic osteoarthritis (OA) of the hip is unclear.
Methods The influence of pre-existing radiographic OA of the hip on short- to mid-term functional outcome was prospectively analysed in a cohort of patients undergoing proximal femoral nailing for trochanteric fracture. OA was graded according to Kellgren and Lawrence; functional outcome was assessed at six and 12 months by the Harris hip score (HHS), the timed up and go (TUG) test and the Barthel Index.
Results Our cohort comprised 188 patients (58 were male and 130 female), with a mean age of 82 years. At six and 12 months postoperatively, the HHS ($p<0.001$ and $p=0.008$, respectively) and Barthel Index ($p<0.001$ and $p=0.02$, respectively) correlated significantly with the grade of pre-existing OA. After adjustment for confounding variables, there was a significant association between the grade of pre-existing OA and the HHS at six months ($p=0.02$). Although we observed trends suggestive of other relationships, none reached statistical significance.
Conclusions Pre-existing radiographic OA of the hip is an important determinant of clinical outcome in elderly patients with a trochanteric femoral fracture. Further studies will be needed to establish the most effective means of restoring hip function after trochanteric femoral fracture in patients with radiographic OA of the hip.

Keywords Hip fracture · Osteoarthritis · Proximal femoral fracture · Proximal femoral nailing · Trochanteric fracture

Abbreviations

ASA	American Society of Anesthesiologists
FU	Follow-up
HSS	Harris hip score
MMSE	Mini-Mental State Examination
NSA	Neck shaft angle
OA	Osteoarthritis
PFF	Proximal femoral fracture
SD	Standard deviation
TUG	Timed up and go

Introduction

As the proportion of elderly people increases in global populations, there has been an increase in the incidence of proximal femoral fracture [1]. The majority of previously published studies have focused on improving patient survival [2–4], but the identification and modification of risk factors predicting incomplete recovery and loss of autonomy are of growing interest due to the immense socioeconomic burden resulting from the need to care for this population [5].

Extra- and intramedullary fixation are widely accepted as the therapeutic standards for the surgical treatment of trochanteric fracture, combining stable anatomic reconstruction with a minimally invasive approach [6]. In patients with pre-existing radiological signs of osteoarthritis (OA) of the affected hip, the effectiveness of internal fixation has been challenged and

C. K. Boese
Department of Orthopaedic and Trauma Surgery, University Hospital of Cologne, Cologne, Germany

B. Buecking · T. Schwarting · F. Debus · S. Ruchholtz · C. Bliemel · M. Frink · P. Lechler (✉)
Department of Trauma, Hand and Reconstructive Surgery, University of Giessen and Marburg, Marburg, Germany
e-mail: lechler@med.uni-marburg.de

it has been suggested that in these circumstances primary total hip arthroplasty would be more effective [7]. Nonetheless, the influence of pre-existing OA on the functional outcome after fixation of trochanteric fractures has not yet been studied in depth, and there is little evidence upon which to base recommendations regarding the optimal operative strategy.

To address this question, we analysed the impact of pre-existing radiographic OA on the functional outcome in a prospectively observed cohort of elderly patients undergoing proximal femoral nailing for trochanteric fracture.

Patients and methods

We enrolled all consecutive patients undergoing proximal femoral nailing for trochanteric femoral fracture at our level one trauma centre (University Hospital) between 1 April 2009 and 30 September 2011 (Fig. 1). The analysed population was part of a larger cohort of patients with a proximal femoral fracture. Patients presenting with multiple trauma or malignancy-associated fracture were excluded from the analysis.

The extent of pre-existing OA of the affected hip was categorised according to the criteria proposed by Kellgren and Lawrence [8] into grades 0–4 on standardised anteroposterior radiographs of the pelvis independently by two orthopaedic surgeons (CKB and PL); disagreement was resolved through consensus. Radiographs were stored in an archiving and communication system (IMPAX, AGFA HealthCare GmbH, Bonn, Germany) and analysed using IMPAX EE (AGFA HealthCare GmbH). The pre-fracture Barthel Index, Mini-Mental State Examination (MMSE) and American Society of Anesthesiologists (ASA) physical status score were also recorded on admission.

Operative treatment was performed under general anaesthesia on traction tables (Maquet, Rastatt, Germany) with the patient supine. Proximal femoral nails with a neck shaft angle of 130° (Zimmer Natural Nail System, Cephalomedullary Nail, Zimmer, Inc., Warsaw, IN, USA) were used in 153 cases; 35 patients received intramedullary implants with a neck shaft angle of 125° (Trochanteric Gamma3™ Locking Nail, Stryker Corporate, Kalamazoo, MI, USA). Patients were mobilised with full weight-bearing on the first postoperative day, drains were removed 48 hours after the operation and further rehabilitation followed a standardised protocol, including daily locomotor training by a physiotherapist, mobilisation with crutches or walking frame, deep breathing exercises and manual lymphatic drainage. Deep venous thrombosis prophylaxis with low molecular weight heparin was maintained until patients recovered sufficient ambulation. Finally, patients were transferred either to specialised geriatric rehabilitation centres or nursing homes.

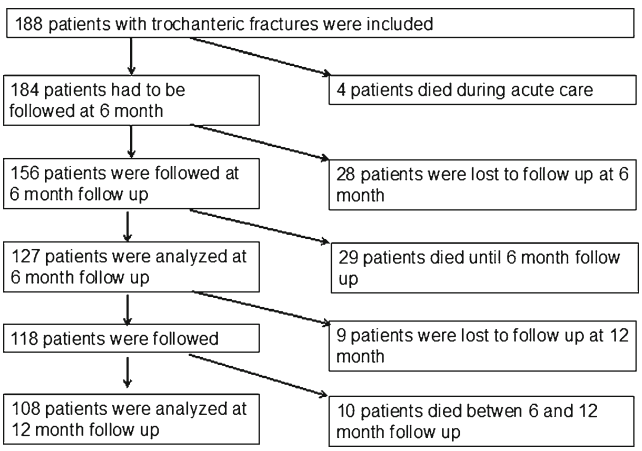

Fig. 1 Follow-up of 188 patients with trochanteric femoral fractures

At six and 12 months postoperatively, the Harris hip score (HHS), timed up and go (TUG) test and Barthel Index were recorded. Surgical complications and revisions that occurred during the follow-up period were also recorded.

Statistical analysis

For descriptive analysis, absolute mean values, standard deviations, medians and ranges are reported. Data were tested for normality using the Kolmogorov-Smirnov test. Age-dependent distribution of the grade of OA was depicted using a scatter plot including a linear regression trend line and the corresponding correlation coefficient, R^2. The correlation between the grade of OA and the outcome measures was assessed by means of Spearman's correlation coefficient. Additionally, a multivariate regression analysis to adjust for confounding variables was performed that included the grade of OA, sex, age, ASA physical status score, MMSE on admission and pre-fracture Barthel Index.

The significance level was set at a p value <0.05. Data were stored in a database (FileMaker Inc., Santa Clara, CA, USA) and statistical analyses performed using Statistical Package for the Social Sciences (SPSS version 22, IBM Corporation, Armonk, NY, USA) and Excel 2010 (Microsoft Corporation, Redmond, WA, USA).

Ethics

The study design was approved by the local Ethics Committee (registration number AZ 175/08).

Results

Clinico-demographic characteristics, pre-existing OA of the hip and functional outcome

During the study period, we treated 188 patients with a trochanteric femoral fracture by proximal femoral nailing. Their

mean age was 82 years; a more detailed description of their demographic and clinical characteristics is given in Table 1. Pre- and postoperative functional assessment scores are provided. The median grade of pre-existing radiographic OA of the affected hip was 2: 14 patients were graded 0 (7 %), 65 graded 1 (35 %), 54 graded 2 (29 %), 30 graded 3 (16 %) and 25 graded 4 (13 %). Figure 2 shows a scatter plot demonstrating the relationship between age and grade of OA. Surgical complications leading to revision surgery occurred in nine patients, including cutting out (n=3), tractus iliotibialis irritation (n=2), peri-implant fracture (n=2), haematoma (n=2) and infection (n=1). During the follow-up period, a total of three patients were revised to total hip arthroplasty. No patient was revised for progressive OA. Four patients died during the hospital stay. Six- and 12-month mortality was 18 % (n=33) and 23 % (n=43), respectively.

Table 1 Clinico-demographic characteristics, pre-existing OA of the hip and functional outcome

Characteristic	Value
Age in years (mean±SD)	82±8; median 83; range 60–99
Gender	
Female	130 (69 %)
Male	58 (31 %)
ASA score	2.9±0.6; median 3; range 1–4
1	2 (1 %)
2	32 (17 %)
3	136 (72 %)
4	18 (10 %)
Pre-fracture Barthel Index	82±23; median 90; range 0–100
MMSE on admission	21±9.0; median 24; range 0–30
27–30 (normal)	61 (33 %)
20–26 (mild dementia)	70 (37 %)
10–19 (moderate dementia)	29 (15 %)
<10 (severe dementia)	28 (15 %)
HHS	
6-month FU	64±19; median 64; range 8–100
12-month FU	68±18; median 67; range 8–99
HHS pain subscale	
6-month FU	33±11; median 40; range 0–44
12-month FU	35±10; median 40; range 0–44
TUG test in seconds	
6-month FU[a]	27±17; median 22; range 8–109
12-month FU[b]	28±20; median 25; range 8–120
Barthel Index	
6-month FU	69±30; median 80; range 0–100
12-month FU	70±32; median 80; range 0–100

SD standard deviation, *ASA* American Society of Anesthesiologists, *MMSE* Mini-Mental State Examination, *HHS* Harris hip score, *FU* follow-up, *TUG* timed up and go

[a] Possible in 98 patients (79 %)

[b] Possible in 87 patients (81 %)

Correlation between grade of pre-existing radiographic OA and functional outcome

We found a statistically significant correlation between the grade of pre-existing radiographic OA of the affected hip and hip-specific functional outcome at six and 12 months postoperatively, as assessed by the HHS (Table 2). Furthermore, the performance in activities of daily living (Barthel Index) correlated significantly with the grade of OA at six (p<0.001) and 12 months (p=0.02). There was a nonsignificant trend suggesting possible associations between the extent of OA and the HHS pain subscale, and between OA and the TUG test. These findings are further supported by the analysis of functional outcome relative to the grade of OA (Table 3).

Adjustment for confounding variables

Adjustment for confounding variables revealed a significant association between the grade of OA and the HSS at six months postoperatively (p=0.002, Table 4).

Discussion

The clinical and socioeconomic benefits of optimising functional outcome in elderly patients with a trochanteric femoral fracture are indisputable [9]. Internal fixation by intra- and extramedullary implants is the current standard of surgical treatment [10], but it has been proposed that primary total hip arthroplasty may have additional benefits in patients with signs of joint degeneration [7, 11]. However, in their prospective randomised trial Kim et al. reported that patients "with proximal femoral nail had a shorter operative time, less blood loss, fewer units of blood transfused, a lower mortality rate, and lower hospital costs compared with those treated with the long-stem cementless calcar-replacement prosthesis" [12], thus emphasising potentially higher risks of primary arthroplasty in patients with intertrochanteric fractures. These results were confirmed in the cohort of Shen et al. [13]. Based on their recent literature review, Hoffmann et al. proposed the Hamburg Per- and Intertrochanteric Fracture Score to guide treatment decisions in this fragile elderly population [11]. Here, the existence of significant OA has been included as a parameter indicating advantages of arthroplasty over internal fixation.

However, to the best of our knowledge, there has been no systematic analysis of the influence of pre-existing radiographic OA on the functional outcome in elderly patients who have sustained a trochanteric femoral fracture. This

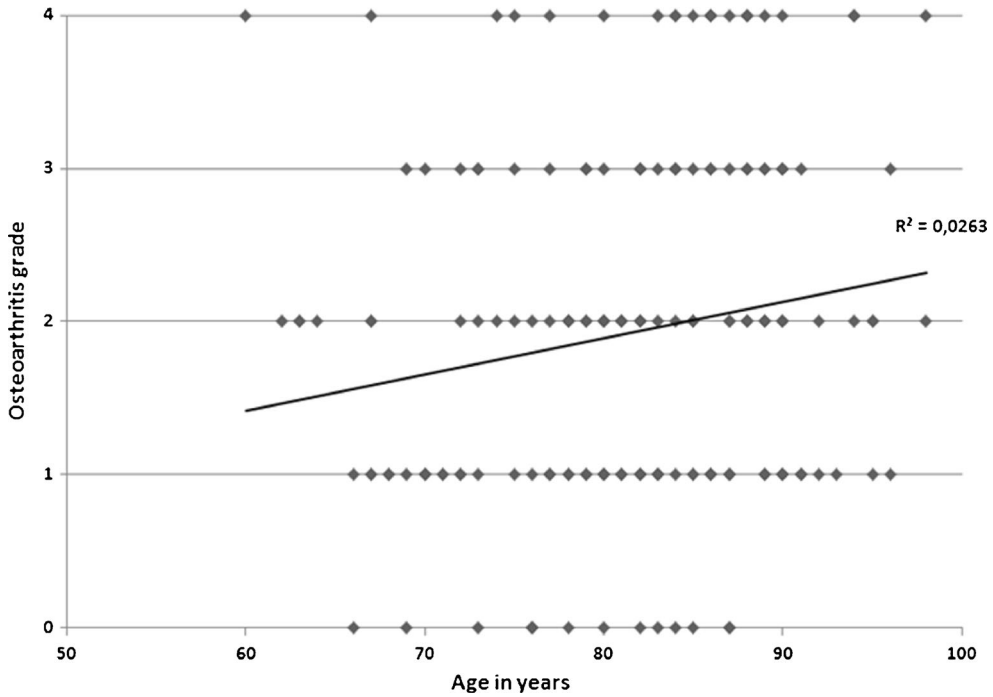

Fig. 2 Scatter plot of patient age and grade of OA according to Kellgren and Lawrence. The trend is characterised by the linear regression trend line and the corresponding correlation coefficient, R^2

prospective observational study revealed inferior functional outcome and higher pain scores in patients with pre-existing radiographic OA at six months postoperatively, and a trend towards an inverse association between functional outcome and the grade of OA was observed at 12 months.

The clinical relevance of our study question and findings is underlined by the high prevalence of osteoarthritic degeneration of the lower extremities reported in large epidemiological studies of elderly populations [14], which is further highlighted by the incidence of OA in the analysed cohort (Fig. 2).

Table 2 Correlation between OA and functional outcome and pain at 6 and 12 months postoperatively

	OA	
Patients' functional outcome	Spearman's coefficient	*p* value
HHS		
6-month FU	−0.352	<0.001
12-month FU	−0.260	0.008
HHS pain subscale		
6-month FU	−0.217	0.016
12-month FU	−0.134	0.176
TUG test		
6-month FU	0.196	0.053
12-month FU	0.175	0.108
Barthel Index		
6-month FU	−0.340	<0.001
12-month FU	−0.291	0.02

HHS Harris hip score, *FU* follow-up, *TUG* timed up and go

While there is little evidence of an inverse relationship between the incidence of hip fracture and OA, Calderazzi et al. reported that the existence of OA affects the anatomic location, potentially increasing the risk of trochanteric fracture [15].

Studying specific determinants of the clinical outcome in elderly patients with a proximal femoral fracture is complicated by the high prevalence of comorbidities in this population

Table 3 OA grade-specific functional outcome at 6 and 12 months postoperatively

	Grade of OA					
Patients' functional outcome and pain (mean and SD)	0	1	2	3	4	*p* value
HHS						
6-month FU	76±14	70±16	59±20	66±14	46±19	<0.001
12-month FU	73±17	73±17	61±17	72±17	56±18	0.008
HHS pain subscale						
6-month FU	36±9	36±8	30±12	34±10	27±12	0.066
12-month FU	37±9	37±9	31±12	36±9	32±12	0.276
TUG test						
6-month FU	21±17	27±16	31±22	26±14	34±8	0.146
12-month FU	27±21	23±12	32±23	39±20	39±36	0.433
Barthel Index						
6-month FU	85±16	78±27	63±32	72±24	47±32	0.001
12-month FU	74±33	80±27	63±33	69±30	50±37	0.012

SD standard deviation, *HHS* Harris hip score, *FU* follow-up, *TUG* timed up and go

Table 4 Influence of OA on functional outcome and pain adjusted for gender, age, ASA score, MMSE and pre-fracture Barthel Index

	Grade of OA			
Patients' functional outcome	B	β	95 % CI of B	*p* value
HHS				
6-month FU	−4.593	0.270	−7.435; −1.751	0.002
12-month FU	−1.427	−0.089	−4.298; 1.445	0.326
HHS pain subscale				
6-month FU	−2.299	−0.244	−4.147: −0.452	0.015
12-month FU	−1.095	−0.121	−2.995; 0.804	0.255
TUG test				
6-month FU	0.652	0.039	−2.815; 4.120	0.709
12-month FU	1.199	0.065	−2.984; 5.382	0.570
Barthel Index				
6-month FU	−2.880	−0.192	−6.214; 0.453	0.090
12-month FU	−1.942	−0.069	−6.098; 2.213	0.356

ASA American Society of Anesthesiologists, *MMSE* Mini-Mental State Examination, *CI* confidence interval, *HHS* Harris hip score, *FU* follow-up, *TUG* timed up and go

[16], as underlined by the mean ASA physical status and pre-fracture Barthel Index scores of our cohort. We addressed the influence of confounding variables by adjusting for pre-fracture Barthel Index, MMSE, ASA physical status score, sex and age in a multivariate regression analysis. However, this approach does not account for all confounding factors, such as patient motivation and compliance with treatment, or variation in post-traumatic hip anatomy and joint biomechanics [17]. Here, beneficial effects of femoral shaft medialisation and a slight valgisation during the reconstruction of the neck shaft angle had been reported previously [18, 19].

The measurement of outcome of elderly patients with a proximal femoral fracture is not straightforward. In their recent review, Hutchings et al. recommended the use of different scales from more than one outcome category [16]. To maximise the interpretability of our results, three independent functional measures were acquired: (1) the HHS, assessing hip-specific functional outcome; (2) the Barthel Index, as a measure of performance in activities of daily living; and (3) the TUG test analysing overall mobility.

Our study had some limitations. First, we assessed the grade of pre-operative radiographic OA on standard radiographs according to the classification proposed by Kellgren and Lawrence. While the relatively low sensitivity of the method has been highlighted before, a comparison with other assessment tools conducted by Reijman et al. concluded that the Kellgren and Lawrence grade remains a useful representation of the extent of radiographic OA of the hip [20]. Second, our study was limited to a one year follow-up period and does not provide long-term functional results. Furthermore, no radiological follow-up was undertaken; thus, we are not able to comment on the dynamics of cartilage degeneration or the subsequent radiological signs of OA following trochanteric fracture. Finally, our study does not allow conclusions to be drawn that could offer therapeutic guidance to those managing patients with pre-existing OA and trochanteric fracture. Further studies will be needed to assess the impact of intensified non-operative measures such as early mobilisation, interdisciplinary pain management and improved care of the elderly on postoperative functional outcome. Surgical alternatives would be primary total hip arthroplasty [7, 11] or secondary joint replacement following consolidation of the fracture.

Conclusions

We found that radiographic OA was a clinically relevant risk factor for inferior mid-term functional outcome in elderly patients with a trochanteric femoral fracture. Future interventional studies aiming to optimise operative and non-operative therapeutic protocols should account for the influence of pre-existing radiographic OA of the hip on outcomes in this population.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Rosengren BE, Karlsson MK (2014) The annual number of hip fractures in Sweden will double from year 2002 to 2050: projections based on local and nationwide data. Acta Orthop 85(3):234–237
2. Kannegaard PN, van der Mark S, Eiken P, Abrahamsen B (2010) Excess mortality in men compared with women following a hip fracture. National analysis of comedications, comorbidity and survival. Age Ageing 39(2):203–209
3. Khan MA, Hossain FS, Ahmed I, Muthukumar N, Mohsen A (2013) Predictors of early mortality after hip fracture surgery. Int Orthop 37 (11):2119–2124
4. Talsnes O, Hjelmstedt F, Dahl OE, Pripp AH, Reikerås O (2011) Clinical and biochemical prediction of early fatal outcome following hip fracture in the elderly. Int Orthop 35(6):903–907
5. Giessauf C, Glehr M, Bernhardt GA, Seibert FJ, Gruber K, Sadoghi P, Leithner A, Gruber G (2012) Quality of life after pertrochanteric femoral fractures treated with a γ nail: a single center study of 62 patients. BMC Musculoskelet Disord 13:214
6. Radcliff TA, Regan E, Cowper Ripley DC, Hutt E (2012) Increased use of intramedullary nails for intertrochanteric proximal femoral fractures in veterans affairs hospitals: a comparative effectiveness study. J Bone Joint Surg Am 94(9):833–840
7. Bonnaire F, Lein T, Bula P (2011) Trochanteric femoral fractures: anatomy, biomechanics and choice of implants. Unfallchirurg 114 (6):491–500
8. Kellgren JH, Lawrence JS (1957) Radiological assessment of osteo-arthrosis. Ann Rheum Dis 16(4):494–502

9. Roth T, Kammerlander C, Gosch M, Luger TJ, Blauth M (2010) Outcome in geriatric fracture patients and how it can be improved. Osteoporos Int 21:S615–S619
10. Matre K, Vinje T, Havelin LI, Gjertsen JE, Furnes O, Espehaug B, Kjellevold SH, Fevang JM (2013) TRIGEN INTERTAN intramedullary nail versus sliding hip screw: a prospective, randomized multicenter study on pain, function, and complications in 684 patients with an intertrochanteric or subtrochanteric fracture and one year of follow-up. J Bone Joint Surg Am 95(3):200–208
11. Hoffmann M, Hartel M, Rueger JM, Lehmann W (2014) Primary prosthetic replacement in per- and intertrochanteric fractures. Eur J Trauma Emerg Surg 40(3):273–277
12. Kim SY, Kim YG, Hwang JK (2005) Cementless calcar-replacement hemiarthroplasty compared with intramedullary fixation of unstable intertrochanteric fractures. A prospective, randomized study. J Bone Joint Surg Am 87(10):2186–2192
13. Shen J, Wang DL, Chen GX, Yang HL, Li L, Wei MX, Cai XQ, Yu ZH, Cheng L, Zhang XX, Zou TM (2012) Bipolar hemiarthroplasty compared with internal fixation for unstable intertrochanteric fractures in elderly patients. J Orthop Sci 17(6):722–729
14. Kim C, Linsenmeyer KD, Vlad S, Guermazi A, Clancy MM, Niu J, Felson DT (2014) Prevalence of radiographic and symptomatic hip osteoarthritis in an urban United States community: the Framingham osteoarthritis study. Arthritis Rheumatol 66(11):3013–3017. doi:10.1002/art.38795
15. Calderazzi F, Groppi G, Ricotta A, Ceccarelli F (2014) Does hip osteoarthritis have a protective effect against proximal femoral fractures? A retrospective study. Hip Int 24(3):231–236
16. Hutchings L, Fox R, Chesser T (2011) Proximal femoral fractures in the elderly: how are we measuring outcome? Injury 42(11):1205–1213
17. Lechler P, Frink M, Gulati A, Murray D, Renkawitz T, Bücking B, Ruchholtz S, Boese CK (2014) The influence of hip rotation on femoral offset in plain radiographs. Acta Orthop 85(4):389–395
18. Pajarinen J, Lindahl J, Savolainen V, Michelsson O, Hirvensalo E (2004) Femoral shaft medialisation and neck-shaft angle in unstable pertrochanteric femoral fractures. Int Orthop 28(6):347–353
19. Andruszkow H, Frink M, Frömke C, Matityahu A, Zeckey C, Mommsen P, Suntardjo S, Krettek C, Hildebrand F (2012) Tip apex distance, hip screw placement, and neck shaft angle as potential risk factors for cut-out failure of hip screws after surgical treatment of intertrochanteric fractures. Int Orthop 36(11):2347–2354
20. Reijman M, Hazes JM, Koes BW, Verhagen AP, Bierma-Zeinstra SM (2004) Validity, reliability, and applicability of seven definitions of hip osteoarthritis used in epidemiological studies: a systematic appraisal. Ann Rheum Dis 63(3):226–232