The Effect of Disease Severity and Comorbidity on Length of Stay for Orthopedic Surgery in Rheumatoid Arthritis: Results from 2 UK Inception Cohorts, 1986–2012

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ABSTRACT. ***Objective.*** To examine factors predicting length of stay (LoS) for orthopedic intervention in rheumatoid arthritis (RA).

Methods. LoS for orthopedic intervention was examined in 2 consecutive, multicenter inception cohorts: the Early RA Study (n = 1465, 9 centers) and the Early RA Network (n = 1236, 23 centers). Date, type of orthopedic procedure, and LoS were recorded and validated against national data, the UK National Joint Registry, and the UK Hospital Episode Statistics database. Clinical, laboratory, and radiographic measures and comorbidity recorded at baseline and annually were examined for their predictive power on LoS using regression analysis.

Results. A total of 770 of 2701 patients (28.5%) had 1602 orthopedic interventions: 40% major (mainly total hip/knee replacements), 24% intermediate (mainly hand/wrist and ankle/foot surgery), and 16% minor (mainly soft tissue surgery). Median (interquartile range) LoS was 8 (5–13), 3 (1–5), and 1 (0–2) days for major, intermediate, and minor interventions, respectively. Older age predicted longer LoS ($p < 0.001$) whereas a more recent operation year predicted shorter LoS ($p < 0.001$). Markers of active disease, namely low hemoglobin, high Health Assessment Questionnaire, and high Disease Activity Scores in the first year all predicted longer LoS for all types of surgery ($p = 0.001$, $p < 0.001$, $p = 0.05$, respectively). Presence of 1 or more major comorbidities predicted longer LoS ($p < 0.001$).

Conclusion. Comorbidity and standard clinical and laboratory markers of disease activity affect the LoS for orthopedic surgery in RA, which has important clinical and economic implications, providing a target for improving patient outcomes. (J Rheumatol First Release April 1 2015; doi:10.3899/jrheum.141049)

Key Indexing Terms:
RHEUMATOID ARTHRITIS — ORTHOPEDIC SURGERY — LENGTH OF STAY
TOTAL JOINT REPLACEMENT — DISEASE MARKERS — HEMOGLOBIN

The substantial economic effect of rheumatoid arthritis (RA) has been the subject of several health economic studies[1,2,3,4,5]. Inpatient admission and specifically the patient's length of stay (LoS) in hospital is considered one of the most important components affecting costs of treatment and quality of life in RA[6]. Hospital admissions for orthopedic surgery are frequent, but data on LoS for RA-related orthopedic surgery and factors influencing this are limited. In a

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UK longitudinal prospective study, inpatient and day-unit stays accounted for 33% of the National Health Service (NHS) costs. Although this cost was incurred by a minority of the study population (6%), it was the largest proportion of costs incurred by the NHS[5], similar to other diseases including asthma[7] and multiple sclerosis[8].

Benefits of reducing LoS are well described and include releasing capacity in the system of care provision, including beds and staff time, helping to minimize waiting times, maximize productivity, and improve patient care (Institute for Innovation and Improvement, 2012). UK national data also suggest a reduction in hospital infection rates by reducing LoS.

Most evidence on orthopedic outcomes in RA comes from continental European and American studies, with few reports coming from the United Kingdom. Yet few of these studies report on the predictive power of routinely used clinical and laboratory or radiological tests and the effect of comorbidity on longterm outcomes in RA, including orthopedic surgery and its LoS.

Our study aimed to evaluate the LoS for orthopedic intervention and its predictive factors in 2 sequential, multicenter inception cohorts of RA in the UK designed to assess RA outcomes using standard measures. The identification of reliable prognostic factors for variables like orthopedic surgery and its LoS could help provide targeted treatment and consequently better patient and economic outcomes.

MATERIALS AND METHODS

Clinical databases. The Early RA Study (ERAS) and Early RA Network (ERAN) are multicenter-inception cohorts of early RA [< 2 and < 3 yrs of disease duration, no prior disease-modifying antirheumatic drug (DMARD) therapy] formed from collaborations between, respectively, 9 rheumatology centers in England recruiting from 1986–1999 and 23 centers in England, Wales, and Ireland from 2002–2012. Standard clinical and laboratory features were recorded at baseline and yearly in both cohorts. Comorbidity details included standard clinical terms and year of diagnosis, and were based on patient self-report, clinical assessment, and medical records recorded on a standard form, and then coded using the *International Classification of Diseases*, 10th ed. into organ systems (chapters) as previously described[9]. All centers followed the framework of published UK guidelines for the management of RA as described[10]. In ERAS, this included mainly sequential use of DMARD that was standard practice for early RA in the UK in the 1980s and 1990s. “Step-up” (or “add-on”) and combination therapies were initially reserved for more severe RA only, but gradually became more common[10]. In ERAN, combination DMARD therapies and biologics were used more frequently and earlier, in line with contemporary UK guidelines[11].

At the time of this analysis, recruitment numbers and median followup for ERAS and ERAN were 1465 and 10 years (maximum 25 yrs) and 1236 and 6 years (maximum 10 yrs), respectively.

National databases. Patients included in the clinical databases were identified in the National Joint Registry (NJR) and Hospital Episode Statistics (HES) as previously described[12]. Each HES record represented 1 complete hospital episode and contained information on the type of orthopedic intervention, start and end date for each episode, and site.

Data linkage, orthopedic interventions, and LoS. The methodology for matching and cross-checking episodes obtained from HES and NJR with the clinical database had been previously described in detail[12]. Followup and patient-tracking was based on the Medical Research Information Service. Orthopedic interventions were categorized based on joint type and procedure as previously described[13]: (1) “major” representing mainly primary or secondary large joint replacement surgery; (2) “intermediate” representing mainly wrist, hand, and hind/forefoot joint reconstructive procedures (excision arthroplasty, synovectomy, arthrodesis); and (3) “minor” representing mainly soft tissue procedures (e.g., carpal tunnel decompression). ERAS also included reasons for orthopedic surgery (RA, osteoarthritis, or fracture)[13].

Cross-validation of LoS between clinical and national data. Where there was overlap between ERAS and ERAN orthopedic episodes and HES or NJR, LoS from HES was assumed to be more accurate and used in the analysis. Cross-validation was undertaken in these cases to determine the accuracy of LoS data from the clinical datasets since LoS was not available from HES prior to 1997, and the method for obtaining LoS was different in the clinical datasets (patient self-reported) and was potentially less accurate. LoS recorded in both HES and ERAS (episodes post-1997) were compared and a strong correlation was found (Spearman ρ 0.924, 2-tailed significance, $p < 0.001$) that was confirmed on analysis of LoS as a categorical variable consisting of 4 groups: LoS 0–1 days, 2–5, 6–10, or ≥ 11 (measure of agreement: $\kappa = 0.712$, $p < 0.001$). These results suggested that the LoS data in the clinical datasets were robust and that therefore, pre-HES LoS data from the clinical datasets were accurate enough to be included in the final database. Validation of the ERAS and HES orthopedic data recording revealed an 89% match in procedure coding.

LoS variable. The LoS variable was measured as a continuous variable, calculated as discharge date minus admission date measured in days. A value of 0 for LoS indicated a day case (0 for no overnight stay), a value of 1 indicated 1 overnight stay, and so on.

Independent variables. Health Assessment Questionnaire (HAQ) score, Disease Activity Score (DAS), erythrocyte sedimentation rate (ESR), and hemoglobin (HB) at baseline and 1 year were the main clinical and laboratory variables investigated for their predictive value as independent variables on LoS. These disease markers were converted into dichotomous variables to indicate mild/inactive or severe/active disease (Table 1). A DAS cutoff ≤ 3.2 has been used to separate those with low versus high disease activity as per the European League Against Rheumatism response criteria[14]. HB cutoffs for men/women were based on the World Health Organization criteria[15] to distinguish between anemia-range HB versus normal HB. In our study, only the normocytic normochromic anemia typical of active or chronic inflammatory disease was included. ESR and HAQ cutoffs were chosen based on median values. The age variable was dichotomized based on the median age at the time of surgery.

Clinical and laboratory variables were recorded as part of the study only at baseline and yearly intervals after the first year. These variables were not routinely collected near or at the time of operation as part of the study. However, the variables nearest to the time of surgery were identified and examined (e.g., operation DAS, operation HAQ), keeping in mind that these could be recorded up to 12 months earlier.

Other independent variables tested in regression models included age at operation, sex, operation year period, and center (hospital), which were included in every model. The number of all major or minor comorbidities by the time of a major or intermediate surgery was recorded and used for subsequent analysis.

Statistical analysis. Year of operation was grouped into 4 time periods: 1986–1994, 1995–1999, 2000–2004, and 2005–2012. The first and last periods were longer than the 2 middle ones to make the time periods comparable by accommodating varying recruitment that was slow initially and diminished gradually toward the end. The Mann-Whitney U and Kruskal-Wallis tests were used to test differences in LoS between time periods. Overall, the extent of missing data was low (around 5%) and unlikely to introduce bias. LoS was regressed against the independent variables in multivariate analyses using both linear regression [ordinary least squares (OLS)] and negative binomial regression[16,17]. For the linear regression models, we present coefficients that show the change in LoS in

Table 1. Dichotomization of clinical and disease variables based on clinically accepted cutoffs.

Variable	Category Labels 1	0
DAS	High DAS > 3.2, active disease	Low DAS ≤ 3.2
HAQ	High HAQ ≥ 1, worse HAQ	Low HAQ < 1
ESR	High ESR ≥ 33 mm/h, high inflammation	Low ESR < 33 mm/h
HB	Low HB < 12 g/dl (F) / < 13 g/dl (M), low HB	Normal HB ≥ 12 g/dl (F) / ≥ 13 g/dl (M)

DAS: Disease Activity Score; HAQ: Health Assessment Questionnaire; ESR: erythrocyte sedimentation rate; HB: hemoglobin; F: females; M: males.

days for a 1-unit change in the independent variable. The logged dependent variable is also used in the OLS regression models to further account for skews of the data[17]. The exponential of the log transformed coefficient (also presented in the analysis) represents the relative effect of the independent variables tested in the models. For the negative binomial regression models, we present coefficients and incidence rate ratios (IRR). All statistical analyses were conducted using SPSS, version 21 (IBM SPSS Inc.).

RESULTS

LoS for different types of orthopedic interventions. There were 1602 orthopedic interventions undertaken in 770 patients (cumulative incidence 24.6%) with LoS recorded in 1426 procedures (89%). There were 263 day cases (16.4%, LoS 0 days), 185 overnight stays (11%, 1 day), and the rest of the episodes had an LoS of 2 or more days. Median and mean LoS in the combined cohorts were 3 days [interquartile range (IQR) 1–8] and 6 days (SD 7.96), respectively (range 0–89 days). There were 30 episodes with LoS of 30 days or more. The majority of procedures with prolonged LoS (≥ 30 days) were for fracture-related procedures of the hips [e.g., dynamic hip screw procedure or partial/total hip replacement (THR)] or knees. Greater LoS variation was observed in the fracture-related surgical group (mainly hip-related), and in view of the different pathology, the nature of the damage leading to the procedure being outside the joint itself, and the small numbers, the fracture-related surgical group was treated as a separate group from the major category. As expected, LoS was longer for major compared with intermediate or minor interventions (Table 2).

Disease, clinical, and laboratory variables. A total of 1247 procedures were undergone by women (78%) and 355 by men (22%). The mean, median, SD, and IQR for the main clinical and laboratory variables used in this analysis are summarized in Table 3.

The presence of 1 major comorbid condition only was recorded in 474 patients (30%) undergoing orthopedic intervention; in 28%, 2 or more were recorded at the time of surgery. There were 592 patients (37%) who had a record of 1 minor comorbidity at the time of surgery, whereas in 38%, 2 or more were recorded.

Predictors of LoS: Changes in LoS over time by age and clinical and laboratory variables. Age at intervention was examined for the main types of procedures. Figure 1 demonstrates the changing LoS across the time periods in the 2 age categories. First, the graph shows a higher median LoS for older patients. Second, the graph depicts a decreasing LoS over time for all ages ($p < 0.001$).

Figure 2 shows the changes in LoS over the 4 time periods for baseline and 1-year DAS. Again, the trends were significant ($p < 0.001$), with higher DAS categories (> 3.2) predicting longer LoS for all types of surgery.

In further analysis of other clinical and laboratory variables (HAQ, ESR, and HB), values indicative of worse disease showed significant trends toward longer LoS ($p < 0.05$), and an overall decrease in LoS over time ($p < 0.05$) within each category of disease activity (results not shown).

Predictors of LoS: multivariate regression analysis. Models were built on clinical/laboratory variables at baseline and 1 year of disease, and the number of comorbidities by the first major or intermediate surgery. Variables near the time of surgery were only present in small numbers, and because of

Table 2. Differences in LoS between various intervention categories and commonly undertaken procedures.

Variable	Major TJR Total	THR	TKR	THR# and TKR#	Other	Intermediate Total	H/W	A/F	Other	Minor Total
n	477	189	232	55	56	351	149	162	40	484
Mean, days	10.26	11.79	9.94	15.60	6.41	4.04	2.91	4.52	6.30	2.06
SD	7.01	7.98	6.2	14.18	4.56	6.69	2.44	8.21	9.43	4.87
Median, days	8	10	8.5	9	6	3	2	3	3	1
IQR	5–13	6–14	6–13	7–22	4–8	1–5	1–4	1–5	1–6	0–2

LoS: length of stay; TJR: total joint replacement; THR: total hip replacement; TKR: total knee replacement; THR# and TKR#: fracture-related THR or TKR; H/W: hand/wrist interventions; A/F: ankle/foot interventions; IQR: interquartile range.

Table 3. Summary statistics of clinical and laboratory variables.

Variable	Valid, n	Missing, n	Mean	Median	SD	IQR
Age at operation, yrs	1599	3	62	63	13	53–72
DAS baseline	1580	22	5.08	5.22	1.32	4.1–6.1
DAS 1 yr	1412	190	4.24	4.29	1.52	3.2–5.3
HAQ baseline	1595	7	1.22	1.13	0.78	0.63–1.75
HAQ 1yr	1429	173	1.02	0.88	0.78	0.38–1.63
ESR baseline	1547	55	40.09	33.00	28.19	17.00–58.00
ESR 1 yr	1408	194	30.24	21.00	24.54	10.00–45.00
HB baseline	1594	8	12.74	12.50	5.52	11.50–13.33
HB 1 yr	1446	156	12.49	12.40	2.72	11.50–13.43

IQR: interquartile range; DAS: Disease Activity Score; HAQ: Health Assessment Questionnaire; ESR: erythrocyte sedimentation rate; HB: hemoglobin.

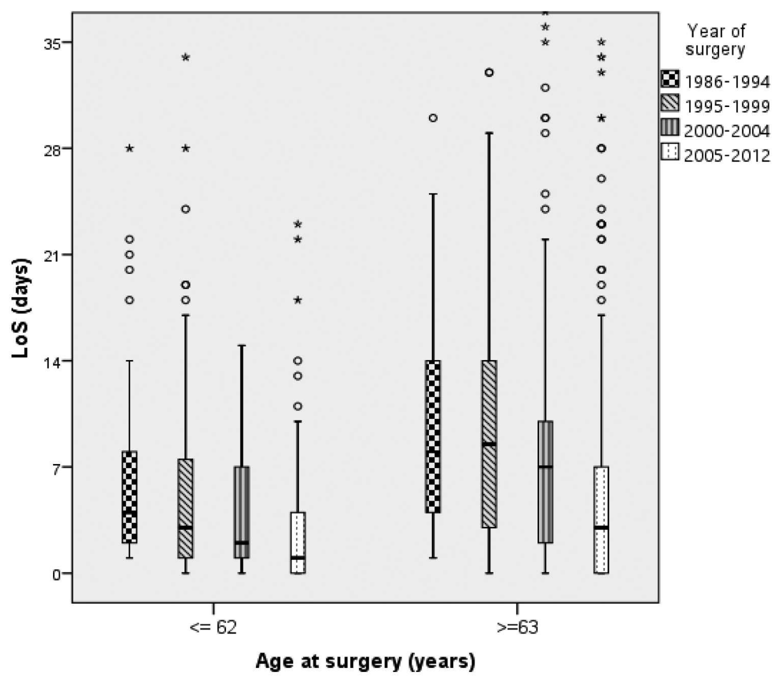

Figure 1. Changing LoS across the 4 study time periods in 2 age category groups. The horizontal lines in the boxes represent the median values for LoS, and the bottom and top parts of the box represent the 25th and 75th centiles of the sample. The length of the box represents the IQR. Whiskers coming out of the box represent the minimum and maximum values of the sample, and the circles and asterisks represent outliers and extreme values, respectively. LoS: length of stay; IQR: interquartile range.

insufficient power, these were excluded from the final regression models. Further, because they could be recorded with anything up to 12 months before the time of surgery, they were not truly representative of the disease state of the patient at the time of surgery and were therefore considered inappropriate for inclusion in the analysis.

Table 4 presents the results of the OLS and negative binomial regression analysis in a model that includes both major and intermediate joint categories, specifically THR, total knee replacements (TKR), hand/wrist operations, ankle/feet operations, and "other". The results from the OLS log scale models and the negative binomial models were

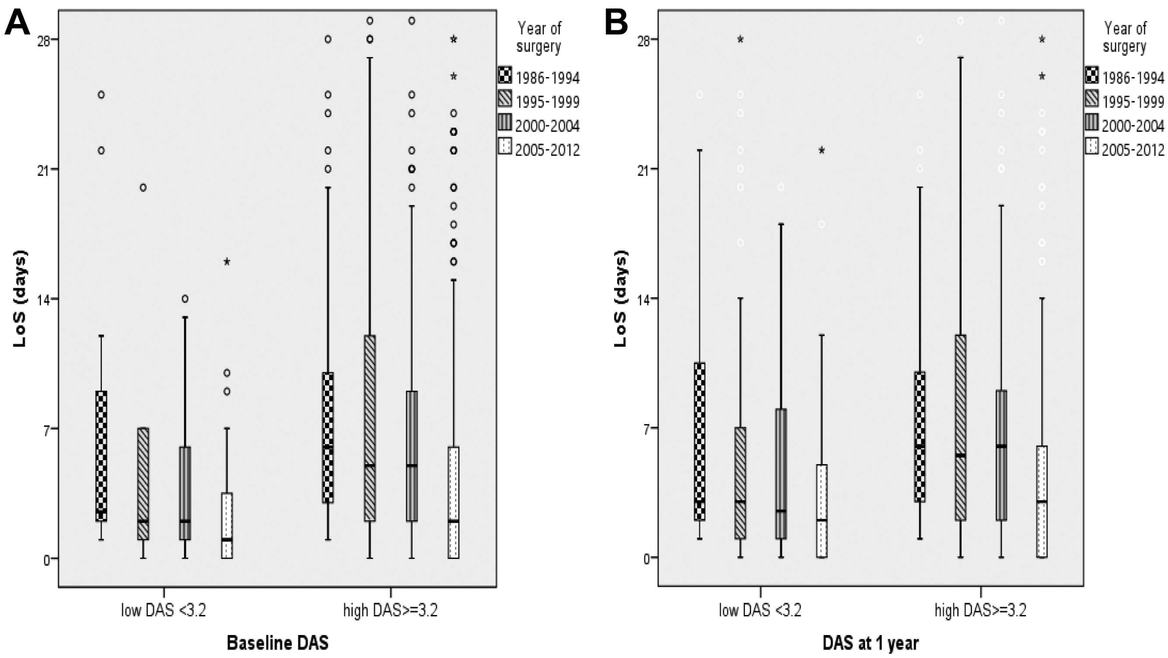

Figure 2. (A) Changing LoS in baseline and (B) 1-year DAS groups indicating low and high disease activity and comparison across the 4 time periods. The horizontal lines in the boxes represent the median values for LoS, and the bottom and top parts of the box represent the 25th and 75th centiles of the sample. The length of the box represents the IQR. Whiskers coming out of the box represent the minimum and maximum values of the sample, and the circles and asterisks represent outliers and extreme values, respectively. LoS: length of stay; DAS: Disease Activity Score; IQR: interquartile range.

Table 4. Regression analysis indicating covariates tested in a combined major and intermediate joint model.

Covariate	OLS Raw Scale			OLS Log Scale			Negative Binomial			
	B	CI	p	B (exp B)	CI	p	IRR	B	CI	p
Constant/intercept	2.331	0.266–4.396	0.027	0.634 (1.89)	0.376–0.893	< 0.001	2.186	0.782	0.485–1.079	**< 0.001**
Age at operation	2.629	1.724–3.535	< 0.001	0.312 (1.37)	0.197–0.428	< 0.001	1.632	0.490	0.363–0.616	**< 0.001**
Male	–0.745	–1.796–0.305	0.164	–0.014 (0.99)	–0.147 to –0.120	0.842	0.869	–0.141	–0.286–0.005	0.058
Type of procedure[1]										
THR	5.636	4.313–6.959	< 0.001	0.966 (2.63)	0.806–1.127	< 0.001	2.196	0.786	0.613–0.960	**< 0.001**
TKR	4.984	3.739–6.229	< 0.001	0.946 (2.58)	0.796–1.095	< 0.001	2.179	0.779	0.615–0.942	**< 0.001**
Hand/wrist operations	–2.100	–3.499 to –0.700	0.003	–0.105 (0.90)	–0.280–0.131	0.243	0.704	–0.351	–0.559 to –0.143	**0.001**
Ankle/foot operations	0.792	–2.174–0.590	0.261	–0.044 (0.96)	0.093–0.346	0.622	0.963	–0.038	–0.238–0.162	0.711
Comorbidity										
Major comorbidities	1.620	0.631–2.608	0.001	0.220 (1.25)	0.093–0.346	0.001	1.416	0.348	0.207–0.489	**< 0.001**
Clinical/laboratory variables										
DAS, baseline	0.622	–0.925–2.170	0.430	0.198 (1.22)	–0.007–0.404	0.058	1.270	0.239	0.002–0.476	**0.048**
HAQ, 1yr	1.424	0.515–2.333	0.002	0.225 (1.25)	0.111–0.339	< 0.001	1.344	0.296	0.166–0.425	**< 0.001**
ESR, baseline	0.403	–0.501–1.308	0.382	0.119 (1.13)	0.005–0.232	0.041	1.097	0.093	–0.033–0.218	0.149
HB, 1 yr	1.320	0.412–2.229	0.004	0.163 (1.18)	0.049–0.277	0.005	1.250	0.224	0.096–0.351	**0.001**
Yr of operation[2]										
2005–2012	–3.468	–5.043 to –1.892	< 0.001	–0.422 (0.66)	–0.618 to –0.227	< 0.001	0.564	–0.572	–0.793 to –0.352	**< 0.001**
2000–2004	–2.850	–4.328 to –1.371	< 0.001	–0.295 (0.74)	–0.472 to –0.119	0.001	0.639	–0.447	–0.652 to –0.243	**< 0.001**
1995–1999	–1.049	–2.463 to –0.366	0.416	–0.183 (0.83)	–0.349 to –0.017	0.031	0.797	–0.227	–0.418 to –0.036	**0.020**
Total n		1590							1590	
Adjusted R^2		0.249					AIC		6590.504	
F-tests of joint significance,										
p value	Center	0.057								
	Yr of operation	**< 0.001**								

Significant data are in bold face. Types of surgery incorporated in the model: THR, TKR, and hand/wrist and ankle/feet operations. [1] The omitted category is all other types of major (including large TJR and large joint fracture-related procedures) and intermediate surgery (including elbow/shoulder/knee surgery other than total joint replacements, excision arthrodeses, or synovectomies). [2] The omitted category is 1986–1994. OLS: ordinary least squares; IRR: incidence rate ratio; THR: total hip replacements; TKR: total knee replacements; HAQ: Health Assessment Questionnaire; ESR: erythrocyte sedimentation rate; HB: hemoglobin; TJR: total joint replacements; AIC: Akaike information criterion.

consistent with one another with only a few exceptions, and qualitatively the same in terms of sign and statistical significance. The exponentiated coefficients from the OLS log scale models were similar in magnitude to the IRR from the negative binomial models.

Fracture-related surgery was excluded as a category on its own from the multivariate regression models because of the different pathology (as described above) and also because of the small numbers. When included in the major joint surgery group, no differences were seen in the LoS trends or significance levels. Additionally, minor surgery was largely undertaken as a day case and thus was not included. Trends were similar using both types of regression models, with a significant higher increase in LoS for THR and TKR compared to all other types of procedures and a shorter LoS for hand/wrist operations ($p < 0.001$). LoS declined significantly by year of operation ($p < 0.001$). HB and HAQ at 1 year remained significant in both types of regression, whereas baseline DAS was significant in negative binomial regression, but not OLS. The presence of 1 or more major comorbidities significantly increased LoS by a rate of 42% ($p < 0.001$); 1 or more minor comorbidities only had no significant effect on LoS ($p = 0.775$) and was dropped from the model. Controlling for the other variables, LoS did not vary significantly by center ($p = 0.057$).

The examination of the effect on LoS in patients having had more than orthopedic intervention revealed no significant trends. Specifically, comparing either those with 2 or more surgeries to patients having undergone 1 surgery only, or those with 3 or more surgeries compared to those who had 1 or 2 surgeries only (as independent covariates in the regression models) revealed no significant differences ($p = 0.662$ and $p = 0.740$, respectively).

DISCUSSION

Orthopedic surgery in RA is a medium to longterm outcome of disease and a surrogate marker of joint destruction[18]. It may be that other major surgery is associated with longer LoS in RA compared to non-RA populations because of issues such as rehabilitation needs. Hospital admissions for this intervention are frequent events as shown in a report by our group[19], and owing mainly to the inflammatory process leading to joint destruction and/or secondary degenerative changes. Several studies have examined LoS for the most commonly undertaken orthopedic interventions (THR and TKR), but not specifically in the RA population[20,21,22,23,24]. Examining LoS in the RA population is highly relevant because this patient group tends to have lower functional independence. Our study shows that potentially modifiable baseline factors and the presence of comorbid diseases predict LoS in patients with RA undergoing orthopedic surgery.

Variation by type of procedure. The initial analysis demonstrates that LoS varies by type of intervention, with major interventions having a longer median LoS compared to intermediate and minor interventions (8, 3, and 1 days, respectively). Multivariate regression analysis confirmed their independent effects ($p < 0.001$). This suggests greater recovery time and/or complications associated with the complexity of large joint surgery in RA. Studies of LoS for THR vary partly because some reports include THR being undertaken as day cases[25], although the majority of studies (similar to ours) reports longer LoS, some supporting a link with lower provider volumes[26,27]. In a Danish study examining LoS for hip or knee surgery, 92% of the patients were discharged to their homes within 5 days, and 41% were discharged within 3 days[23].

Predictors of LoS. Our study supports the findings of others reporting longer LoS with increasing age[21,28,29]. The need for multiple and longer hospitalizations in elderly people, for reasons including complex disease status and multiple comorbidities, was also alluded to by other investigators[30]. However, the sex effect seen in our study does not entirely agree with the existing literature, which has reported that men have shorter stays than women[20,21,29]. Although in our study regression analysis supported a trend toward shorter LoS for men, this was not quite significant ($p = 0.058$).

In the study by Husted, *et al*[23], preoperative and postoperative HB levels were also examined and found to have predictive value for LoS, a finding similar to our results for HB levels at both baseline and 1 year. Examining these variables close to the time of procedure did not give significantly different results or improve predictive power, although this could be because of the small numbers. The anemia of chronic disease is normocytic normochromic and is recognized as a marker of severity of inflammatory activity in conditions such as RA. We had previously reported its prognostic use in the ERAS cohort[13] and with ERAN in 2014[12]. Other reasons for low HB predicting longer LoS could include an increased risk of postoperative complications as a result of a higher severity of inflammatory disease and slow healing because of less optimal hemodynamic states[31].

The regression models in our study indicated the powerful effect of year of operation on LoS, which is not surprising given improvements in elective surgery in recent years. As in many countries, in the United Kingdom there have been constant efforts to reduce LoS with the aim of releasing capacity in the system. As part of the modernization of the NHS in the UK, among the "10 High Impact Changes for Service Improvement and Delivery" is the reduction in LoS, to improve the patient experience and healthcare use and economy[32].

The effect of comorbidity. Major comorbidities were present in 58% of surgery patients and included cardiovascular, respiratory, and gastrointestinal diseases, solid tumors, and hematological malignancies. The presence of 1 or more major comorbid conditions by the first surgery significantly increased LoS by 42% ($p < 0.001$), whereas the presence of minor comorbidities alone did not. Minor comorbidities affecting 75% of surgery patients referred mainly to modifiable conditions such as chest infections and hypertension. LoS and orthopedic surgery have important clinical, economic, and policy implications in healthcare, but there is a general lack of data on the effect of comorbidity. In a Spanish study examining hospitalization costs in patients with RA who were admitted for various reasons, among them surgery[33], the presence of cardiovascular disease was the most important determinant of high costs ($p < 0.01$).

Comorbidity in RA is associated with risk of both all-cause and cardiovascular mortality and increased rates of functional decline over 10 years in an earlier report based on ERAS data[9]. Our results support previous studies emphasizing the importance of addressing comorbidity in RA because this can affect LoS and consequently costs and patient outcomes. Screening for comorbidity should be part of routine RA management, especially with evidence suggesting that the average patient with RA has 1.6 comorbid conditions[34].

The importance of reducing LoS. It is possible that surgery is associated with longer LoS in RA compared to non-RA populations because of issues such as rehabilitation needs, highlighting the importance of LoS in terms of the health economic effect of RA. Shorter LoS translates into more effective use of hospital resources and improved patient satisfaction. The UK National Audit Office estimates that a reduction in LoS of between 2 and 6 days could lead to a cost saving for the NHS Trusts of between £15.5 million and £46.5 million each year, releasing resources[35].

Clinical implications, strengths, and weaknesses of our study. Identifying and targeting factors that could result in reduced LoS could translate into improved patient experiences and outcomes, as well as better healthcare use planning. Reducing LoS has been one of the key goals over the years as part of an initiative to modernize and improve the NHS in the United Kingdom and in other countries.

The major strengths of our study are the real-life settings of the ERAS and ERAN, reflecting the treatment practices of the time, the length of study followup, and the low attrition rates for orthopedic data through HES. In addition, accuracy has been strengthened by corroboration of source data by linkage of clinical and national datasets. This makes the dataset unique for the study of predictive factors for the LoS of patients with RA who are having orthopedic surgery.

The identification of patient and disease features in the first year of RA that can affect LoS up to 25 years later provides an invaluable tool for targeted treatments and the real possibility of a greater influence on patient and economic outcomes. The observational study design has allowed the identification of baseline/1-year variables related to orthopedic interventions, but these potentially modifiable factors should be tested in interventional studies. We included 1-year predictors in the analysis because recent studies have reported greater prognostic value of variables examined within the first year of disease than at baseline alone[13,36]. Analysis of disease markers recorded closer to the time of orthopedic intervention revealed generally nonsignificant data, with possible reasons including more controlled disease in patients at the time of major surgery, reduced power because of small samples, and methodological flaws because of variable measurements of up to 12 months prior to surgery.

Finally, although our study is based on data from the United Kingdom, the findings could be generalized to many other European and non-European countries with similar healthcare systems.

Our study is unique because it focuses on the LoS for orthopedic surgery as an outcome measure, one that has been generally poorly studied in RA but that has important patient, economic, and healthcare policy implications. Increased age at time of surgery, the presence of major comorbidities, and standard clinical and laboratory markers indicative of active disease result in longer LoS. In line with other studies, the findings emphasize the importance of addressing modifiable factors to improve longterm outcomes.

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