Appendix E-1: Piecewise General Linear Mixed Model (GLMM)

A specific application of the general linear mixed model (GLMM), the piecewise GLMM, was used to model functional improvement following revision total knee arthroplasty and to identify significant predictors of such improvement[18]. This approach has two main advantages over conventional regression methods. First, the piecewise GLMM adjusts for the correlation between repeated measures of the same subject. Conventional regression analyses, which are conducted separately for each time point, evaluate the effect of predictors on functional status at a given time point (that is, a cross-sectional evaluation). Repeated-measures data analysis with GLMM simultaneously evaluates the effects of two factors, individual predictors and time, on functional status. In addition, the piecewise GLMM tests the presence of nonlinear patterns of improvement of functional status by allowing a change in slope for different time periods (Fig. E-1). The conventional GLMM assumes a linear change in function across follow-up periods, which is likely not the case. We hypothesized that patients treated with revision arthroplasty, like those treated with primary total knee arthroplasty, would continue to have improvement during the first year following the surgery, with a peak in the functional status at one year and a plateau thereafter[4,12,13]. We therefore estimated two slopes: baseline to twelve months (slope 1) and twelve to twenty-four months (slope 2). We tested whether this assumption held true by estimating other models in which values peaked at six or eighteen months. The conventional Akaike information criteria (AIC) values were utilized to compare model specifications and judge the best fit of the models to the data. The lower the AIC value, the better the fit of the model to the data. However, AIC values were very similar for all three model specifications; thus, we were not able to

determine a best fit of the model to the data solely on the basis of the AIC values. We chose the GLMM with a twelve-month inflection point for two main reasons. First, previous literature on total knee arthroplasty supports a two-period functional recovery: an improvement period that extends up to one year and a stability period thereafter. Second, a GLMM with a twelve-month inflection point is more balanced in its assumptions than is a GLMM with a six or eighteen-month inflection point. A GLMM with a six-month inflection point assumes linearity in the period between six and twenty-four months. A consequence of this assumption is that the slope is estimated with use of scores for improvement and stability and will be overly positive. On the other hand, a GLMM with an eighteen-month inflection point assumes linearity in the period between baseline and eighteen months, which is not supported by any literature.

This piecewise model was estimated for each of the six functional measures: the SF-36 PCS and MCS; the WOMAC stiffness, pain, and difficulty-of-function scores; and the LEAS. Each measure was regressed on baseline factors, including age, sex, number of comorbidities, body mass index, side operated on, preoperative flexion contracture and extension contracture angles, reasons for failure of the primary total knee arthroplasty, techniques of the revision (use of cement in fixation, use of stems, use of augments for the femur or tibia, and whether one or two components were revised), and two time variables to estimate the two piecewise linear slopes. The F-statistic was used to test the predictive significance of the two piecewise linear slopes and the independent variables ($p < 0.05$). Additional models, including several prespecified interactions of interest, were also estimated. P values were not corrected to account for multiple testing.

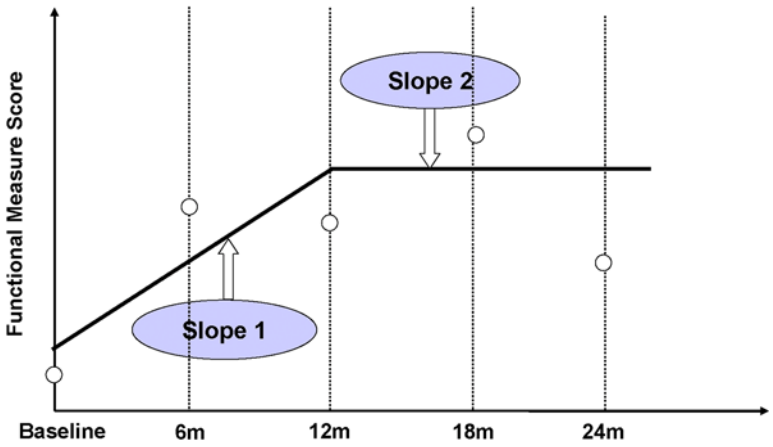

Fig. E-1
An illustration of the piecewise general linear mixed model. The open circles indicate data from one patient, and the solid lines indicate the model predicted slopes.