The goals of this study were to examine the improvement in quality of life achieved after open surgical treatment of elbow stiffness and to verify the cost/utility ratio of surgery. Thirty-three patients (22 men and 11 women) underwent surgery. The etiologies of elbow stiffness were posttraumatic conditions (n = 26), primary osteoarthritis (n = 5), and rheumatoid arthritis (n = 2). Surgery included 14 ulnohumeral arthroplasties, 6 ulnohumeral arthroplasties associated with radiocapitellar replacement, 5 ulnohumeral arthroplasties associated with radial head replacement, and 8 total elbow arthroplasties. All patients were evaluated pre- and postoperatively with the Mayo Elbow Performance Score, the Mayo Elbow Performance Index, the modified American Shoulder and Elbow Surgeons score, the Quick Disabilities of the Arm, Shoulder and Hand score, and the Short Form 36 after a mean follow-up of 26 months. Possible variables affecting clinical outcome and quality of life improvement were assessed. The cost/utility ratio was evaluated as diagnosis-related group reimbursement per quality-adjusted life year. Mayo Elbow Performance Scores and modified American Shoulder and Elbow Surgeons scores increased, on average, by 43 and 41 points, respectively (P < .0001). Quick Disabilities of the Arm, Shoulder and Hand scores decreased, on average, by 44 points (P < .0001). The improvement in the SF-36 physical and mental component summary score was 7.6 and 7, respectively (P = .0001 and .0018). The cost/utility ratio ranged between 670 and 817 Euro/quality-adjusted life year. A significant correlation was found between pain score and quality of life improvement. An inverse correlation emerged between pre- and postoperative quality of life score. The current study shows that open surgery significantly improves quality of life and elbow function. Selecting the surgical procedure that most effectively reduces pain appears to be the most relevant variable responsible for quality of life improvement. Surgery shows a satisfactory cost/utility ratio, justifying a health spending increase to reduce the social costs resulting from lingering elbow stiffness.
Primary and secondary osteoarthritis represent one of the leading causes of chronic pain and disability in the elderly population, as well as one of the main sources of health spending. Nevertheless, in terms of quality of life and cost/utility ratio, the efficacy of treatment, whether conservative or surgical, has been poorly investigated.2,13 Furthermore, most previous studies focused on quality of life in hip and knee osteoarthritis,2,3,7,10-12 whereas little is known about patients with degenerative conditions of the upper limb, particularly the elbow joint.4,6,8,13,14 However, elbow stiffness is one of the conditions most frequently associated with significant limitations of hand function in activities of daily living and working.4,6,8,14 The goals of this study were to evaluate whether open stage-related surgical treatment for elbow stiffness improves quality of life and elbow function and to analyze the cost/utility ratio of surgery.

MATERIALS AND METHODS
Patient Characteristics and Treatment
Between 2007 and 2010, thirty-three patients underwent surgery for elbow stiffness, including 22 men and 11 women, with an average age of 49 years (range, 17-80 years). The causes of elbow stiffness were posttraumatic (n=26), primary osteoarthritis (n=5), and rheumatoid arthritis (n=2). Elbow stiffness was due to both intrinsic and extrinsic factors in 19 patients and only extrinsic factors in 14 patients, according to Morrey’s classification.15 Sixteen patients showed clinical and electromyographic signs of ulnar neuropathy: 12 with isolated sensory dysfunction and 4 with motor and sensory dysfunction. Preoperatively, all patients underwent conservative treatment for 4 to 6 months, including physiotherapy and use of non-steroidal anti-inflammatory drugs, without any improvements. Preoperatively, elbow stiffness had occurred for an average of 53 months (range, 4-300 months).

Preoperative radiographic and computed tomography evaluations were performed for all patients. All surgeries were performed by the same surgeon (G.G.) and included ulnohumeral arthroplasty (n=14), total elbow arthroplasty (n=8), ulnohumeral arthroplasties associated with radiocapitellar replacement (n=6), and ulnohumeral arthroplasties associated with radial head replacement (n=5) (Table 1).

Postoperative Treatment
For all patients, the elbow was placed in full extension with a plaster cast, and cryotherapy was applied for 48 hours. Intravenous analgesic drugs (elastometric pump with 0.8 mg/kg of ketorolac and 0.3 mg/kg of morphine) for the first 30 hours and indomethacin per os for heterotopic ossification prophylaxis (100 mg per day) for 4 weeks were administered in all patients. On the second postoperative day, patients were encouraged to perform self-managed active and passive flexion-extension and supination-pronation exercises several times per day. On average, patients were discharged on the third postoperative day (range, 2-5 days). The resumption of most activities of daily living, including sedentary work activities, was allowed beginning the second postoperative month, whereas more demanding physical tasks were permitted subsequently, depending on the type of surgery performed.

Clinical Assessment
Pre- and postoperative clinical assessment included the Mayo Elbow Performance Score (MEPS), the Mayo Elbow Performance Index (MEPI), the modified American Shoulder and Elbow Surgeons (m-ASES) score, and the Quick Disabilities of the Arm, Shoulder and Hand (Q-DASH) score.16-18 The Short Form 36 (SF-36) questionnaire was used to assess quality of life. The SF-36 is a widely used general health status questionnaire consisting of a physical component summary score and a mental component summary score.19 In addition, all patients were asked about their clinical history, their job status pre- and postoperatively, and to what extent stiffness affected their work and economic status (Table 2). Patients underwent clinical evaluation every 3 weeks in the first 3 months, every 3 months during the first year, and then annually until the last follow-up, which occurred at a mean of 26 months (range, 12-48 months) postoperatively.
**Cost/Utility Analysis of Surgical Procedures**

A quality-adjusted life year (QALY) calculation was performed to evaluate the cost/utility ratio of surgery.\(^{20}\) Quality-adjusted life year measures both the quantitative and qualitative aspect of life created by a specific health care treatment. Quality-adjusted life year values were calculated using SF-6D, extrapolated from the administered SF-36 questionnaire through 4 different procedures (standard gamble health state valuation, ordinal health state valuation, parametric mean, posterior mean).\(^{21,23}\) The expected annual per capita QALY gained was computed as the difference between the pre-and postoperative SF-6D scores. The expected QALY gain over the course of the patient’s life was estimated as a product of the annual gain in QALY and the expected remaining lifespan. This lifespan was calculated as a difference between the patients’ average expected lifespans (78.7 years for men and 84 years for women, according to the most recent estimates of the National Central Statistical Office) and their ages at the time of surgery.\(^{24}\) It was assumed that patients would have the same life expectancy as the general population and that surgery would not increase their length of life.

In this study, only direct costs related to the surgical treatment were estimated using the average diagnosis-related group value. The cost/utility ratio was calculated with 2 different procedures. In the first, the 4 cost/utility ratios of the surgical procedures were calculated, taking the average QALY gains of the whole sample (including 0 and negative values) and multiplying them by the average life expectancy of the whole sample. The same procedure was repeated for cost analysis. In the second, for each patient showing an increase in the quality of life and QALYs, the 4 cost/utility ratios and the global average of cost/utility ratios were calculated. In this second procedure, the results were also stratified by sex.

The monetary value of a QALY was calculated assuming an average QALY value of €40,000,\(^{25}\) which allowed the authors to treat the utility as a monetary benefit and compute simple differences between monetary benefits and costs.

**Statistical Analysis**

Improvements in the average pre- and postoperative values of MEPS, m-ASES, Q-DASH, and SF-36 were assessed using paired Student’s \(t\) tests. The Pearson correlation index was initially used to assess whether pain relief or other variables affected quality of life scores. Next, a multivariate analysis was performed by means of a backward stepwise regression analysis (cutting probability 0.05). Dependent variables were various measures of quality of life improvement (gain in SF-6D or SF-36 scores), whereas explanatory variables included those that could theoretically affect the result (ie, age, sex, etiology, previous surgeries, operated side, pain, range of motion, instability, ulnar neuropathy, type of surgery, continuous passive motion, complications). The discrete variables were treated as dummy variables (if binary) or as indicator variables (if multiple values). Moreover, the preoperative quality of life values were considered to be among the independent variables, assuming that a negative association existed between the amount of improvement and the initial conditions of patient quality of life. Because multicollinearity was expected, the authors tested for multicollinearity with the variance inflation factor (VIF), using the rule of a value 7 representing damaging multicollinearity levels and re-defined models, to solve multicollinearity problems. The final strategy consisted of running separate regression analyses including either all of the variables other than pain or range of motion improvements (specification 1: max VIF = 2.57) or both the single factor affecting pain and range of motion improvements (specification 2: max VIF = 6.98; if arc motility is excluded: max VIF = 2.89).

**RESULTS**

The pre- and postoperative clinical results are reported in Table 3. A significant improvement was observed between pre- and postoperative scores and range of motion. At last follow-up, according to the MEPI, 30 (91%) of the 33 patients had satisfactory results (21 excellent and 9 good) and 3 (9%) had fair results. Of the 3 fair results, 1 patient with a psychiatric disturbance related to chronic alcoholism developed recurrent stiffness due to a periprosthetic fracture 7 months postoperatively, and the other 2 patients developed postoperative ulnar neuropathy with sen-
Table 3

Results of Preoperative and Postoperative Evaluation

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Gain</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion, deg</td>
<td>103.6 (45-140)</td>
<td>133.3 (115-150)</td>
<td>29.7</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Extension, deg</td>
<td>38.3 (90-5)</td>
<td>15 (70-0)</td>
<td>23.3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Arc of movement, deg</td>
<td>68.03 (0-130)</td>
<td>119.09 (70-150)</td>
<td>51.06</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Pronation, deg</td>
<td>66 (0-90)</td>
<td>81.36 (40-85)</td>
<td>15.36</td>
<td>.0008</td>
</tr>
<tr>
<td>Supination, deg</td>
<td>68.18 (0-85)</td>
<td>81.82 (50-85)</td>
<td>13.64</td>
<td>.0030</td>
</tr>
<tr>
<td>MEPS score</td>
<td>49.39 (15-100)</td>
<td>92.42 (65-100)</td>
<td>43.03</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Q-DASH score</td>
<td>58.6 (4.5-95.5)</td>
<td>14.93 (0-70.5)</td>
<td>43.67</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>m-ASES score</td>
<td>43.6 (0-98)</td>
<td>85.09 (51-99)</td>
<td>41.49</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Pain m-ASES score</td>
<td>21.1 (0-50)</td>
<td>42.5 (21-50)</td>
<td>21.4</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>SF-36 PCS score</td>
<td>38.76 (20.38-56.63)</td>
<td>46.37 (23.16-59.88)</td>
<td>7.61</td>
<td>.0001</td>
</tr>
<tr>
<td>SF-36 MCS score</td>
<td>43.86 (13.44-67.68)</td>
<td>50.87 (30.52-67.50)</td>
<td>7.01</td>
<td>.0018</td>
</tr>
</tbody>
</table>

Abbreviations: m-ASES, modified American Society Elbow Surgery; MEPS, Mayo Elbow Performance Score; Q-DASH, Quick Disabilities of the Arm, Shoulder and Hand; SF-36 MCS, Short Form-36 mental component summary; SF-36 PCS, Short Form-36 physical component summary.

Table 4

Type of Comorbidities

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>Preop, No.</th>
<th>Postop, No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low back and sciatic pain</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>Polyarticular rheumatoid arthritis</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>Polyarticular arthritis</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Posttraumatic dysmetria of the lower limbs with significant limp</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Psychiatric disorders</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Obliterative arteriopathy of the lower limbs</td>
<td>–</td>
<td>1</td>
</tr>
</tbody>
</table>

Abbreviations: postop, postoperative; preop, preoperative.

sory loss and pain. One other patient developed a postoperative recurrent extrinsic stiffness due to heterotopic ossification and was reoperated on, with satisfactory results seen at last follow-up.

Of the total sample, 5 (15%) patients were unemployed and 28 (85%) were employed before elbow stiffness. As joint stiffness occurred, 6 (21%) of the employed patients had to change their work duty and 6 (21%) were laid off. These 12 patients were manual workers and the dominant arm was involved in 9 (75%) patients; at last follow-up, none had resumed their original work. A satisfactory clinical result and a significant improvement in quality of life were observed in 9 (75%) and 7 (58%) patients, respectively. Seven (58%) of these 12 patients reported medical litigation related to the causes of stiffness. Two (20%) patients who had both psychiatric condition. Three (30%) of the 10 patients were involved in medical litigation preoperatively. Of the 23 (70%) patients with significant improvement in quality of life, none had comorbidities. In 7 (30%) patients, medical litigation was underway.

Pearson correlation analysis between functional scores and quality of life scores is reported in Table 5. The significant results of multivariate analysis are reported in Table 6. Backward stepwise selection showed a strong inverse correlation between pre- and postoperative quality of life values (i.e., the gain in quality of life postoperatively was greater in patients with a lower preoperative quality of life and vice versa) (Student’s t=5.15; significance >99%). The m-ASES pain variable was the only variable significantly different from 0 and had a Student’s t equal to 2.90 (significance >99%) in the regression analysis based on SF-6D measured with standard gamble (R²=0.55) (Figure). However, the effect of the m-ASES pain variable lost significance when regression analysis was based on SF-36 physical component summary or SF-36 mental component summary scores. None of the variables indicating an improvement in joint mobility or the other variables examined had a significant effect on the improvement in quality of life assessed with SF-36.

The cost of the surgical procedures resulting from the reimbursed diagnosis-related group was equal to €117,649, with a per capita average of €3565 (range, €1916-€5061). The value of lifetime QALYs for all patients ranged from €5,615,830 to €6,716,680 (with a per
capita average of €170,177 to €203,536) according to different SF-6D measures. Table 7 shows the average cost/utility ratio for all patients; Table 8 shows the average cost/utility ratio, divided by sex and based on the abovementioned second procedure that was conducted individually.

DISCUSSION

The goal of this study was to assess whether open stage-related surgical treatment of elbow stiffness yielded a significant improvement in quality of life and a good cost/utility ratio. The results showed a significant improvement in functional scores and quality of life values; in addition, a satisfactory cost/utility ratio was found.

Although elbow stiffness is one of the most frequent conditions leading to significant limitation of hand function in common activities of daily living, to the authors’ knowledge, only 1 study has analyzed quality of life improvement after open surgery for elbow stiffness. However, the study did not include patients with intrinsic elbow stiffness, nor did the authors assess the cost/utility ratio of the surgical treatment. The current study results showed a significant improvement in functional scores with a significant reduction in pain and recovery of elbow motion and function. A concomitant improvement in quality of life, whether in the psychosocial or functional area, was also noted. Linear regression analysis showed that the preoperative quality of life score and the improvement of pain score were the only 2 variables that significantly affected quality of life.

In particular, a greater quality of life increase was found in patients with a lower preoperative quality of life and in those showing marked improvement between pre- and postoperative pain scores; a 10-point gain in the pain score element of m-ASES led to a 4% improvement in quality of life value. However, the influence of pain on quality of life was found only on the SF-6D assessment, whereas preoperative quality of life values were found to affect both SF-36 and SF-6D evaluations. It may be that by increasing the Short Form dimensions and by splitting them into their physical and mental components, the importance of pain score decreases and becomes less significant.

Because the current bivariate analysis showed the close relationship between quality of life and elbow function scores, including MEPS and DASH, the authors wondered why elbow function did not affect quality of life in multivariate analysis. A possible explanation is that general purpose questionnaires and scores, such as SF-36 and SF-6D, allow comparability between the effects of different health care interventions. However, they are weak in terms of sensitivity to specific aspects of health, with the results only being affected by strong factors such as pain score. However, specific questionnaires (ie, Q-DASH, MEPS, m-ASES) that are more sensitive to each aspect of upper limb function are not exportable for quality of life evaluation. The authors believe that the estimates of quality of life improvements that may be achieved postoperatively probably underestimate the true effect on health status. As a result, the cost/utility ratios are conservative and probably overestimate true ratios.

These results suggest that surgical treatment should be aimed not only at recovering elbow motion, but also at relieving pain and improving quality of life.
Linear regression analysis showing Short Form 6D (SF-6D) and modified-American Society Elbow Surgery (M-ASES) pain index improvement pre- and postoperatively. Fitted values-linear interpolation of scatter values ($P=.007$; $R^2=0.55$).

Figure: Linear regression analysis showing Short Form 6D (SF-6D) and modified-American Society Elbow Surgery (M-ASES) pain index improvement pre- and postoperatively. Fitted values-linear interpolation of scatter values ($P=.007$; $R^2=0.55$).

...ing pain. In this regard, any intervention should be designed in such a way as to remove any cause of pain, not only those that impair range of motion. An accurate evaluation of the different tissues involved in each patient (i.e., articular surface, bone, capsuloligamentous, and nervous structures) is needed to be able to select the most appropriate surgical technique. For these reasons, in the current series the authors adopted a range of custom surgical procedures to achieve this goal.

These results are of interest because the majority of patients were young, full-time workers. One-third of the patients, who had a preoperative poor socioeconomic status due to elbow stiffness, did not resume their work postoperatively, and only half of them showed a quality of life improvement; this group of patients consisted exclusively of manual workers whose dominant arm was involved. These results may be due to the long period away from work preoperatively, which was reported by most patients, and to the high percentage of medical litigation in this group of patients. These findings may explain the direct or indirect increase in social costs and public health costs, in terms of sick days, absenteeism, and disability pension and in terms of medical treatment and physical therapy associated with elbow stiffness. The authors believe that early treatment for elbow stiffness may be useful in reducing public health costs and in improving quality of life.

The current study showed that approximately one-third of patients did not obtain significant improvement in quality of life, despite the significant increase in functional scores. In keeping with other investigations, the current authors found that all patients who did not obtain significant quality of life improvement had comorbidities. Conversely, no patients with postoperative increases in the SF-36 score had other diseases. This finding may suggest a multidisciplinary treatment approach in patients with significant comorbidities to obtain improvement in quality of life.

The second part of the study was aimed at analyzing the cost/utility ratio of the surgical procedures performed. It was found that the improvement in quality of life, expressed in QALY, was approximately €6000 per capita per year. This result is of interest, especially if related to the average value of diagnosis-related group of €3500, which indirectly represents the estimate of cost. Even if the cost assessment performed through the reimbursement of the diagnosis-related group is an approximate value, this analysis highlights the positive cost/utility ratio of these surgical procedures. The evaluation of expected gains over the course of the rest of each patient’s life confirms this result. The authors found an average quantitative improvement in remaining life expectancy in quality of life of approximately €200,000 per capita, with a significant difference in favor of women. The cost/utility ratio, in the 4 different measurements performed, was found to be highly advantageous because it ranged between €670 and €817 per QALY.

Limitations of this study include its relative heterogeneous case series and the low number of patients analyzed. This is due to the low prevalence of this condition, which makes it difficult to examine, with strong statistical power, a broad range of patient case histories with similar etiology and treatment. In addition, the diagnosis-related group represents cost estimates, taking into account current health policy, which do not necessarily correspond with the real cost for each patient. In this regard, the current study takes the perspective of the national health system, disregarding indirect costs and their social effects.

**Conclusion**

This study indicates that open stage-related surgery for elbow stiffness leads to significant improvement in quality of life, particularly in patients with low preoperative quality of life and reduced comorbidities. Pain reduction was the most important factor affecting quality of life improvement. The surgical treatment of elbow joint stiffness shows a satisfactory
cost/utility ratio, which may justify an increase in health spending in this area to reduce the social costs of lingering elbow stiffness.

**References**