# PATIENT VARIABLES DETERMINING TREATMENT PROTOCOL AND RELATED ECONOMICAL IMPACT IN OCCUPATIONAL ROTATOR CUFF TEARS

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*Abstract:* Rotator cuff tears occur in almost three percent of all industrial accidents in Belgium. There are two treatment options for this type of injury: the non-surgical or 'conservative' option and the considerably more expensive surgical option. As the total cost associated with the treatment of rotator cuff tears has, over the past ten years, risen considerably in Belgium, we tried to identify variables that are related to an increased risk for need of such surgical treatment.

The objective of this study is to evaluate the use of different treatment options and their economic impact following rotator cuff tearing resulting from an occupational accident in the Belgian context.

Patient age and rupture size were interrelated and both significantly associated with need for surgical treatment and prolonged temporarily and even permanent disability with increasing social and medical costs. Occupation type, although itself a risk factor for the development of rotator cuff tears, was not significantly associated with increased need for surgical treatment.

*Key-Words:* Rotator cuff rupture, economic evaluation, conservative treatment, surgical treatment, cost modelling of medical treatments

## 1 Introduction

Tears of the rotator cuff tendons, a tendineous tissue envelope surrounding the glenohumeral joint, are one of the most common causes of pain and disability in the upper extremity [1]. The so-called rotator cuff is made up of four muscles and their tendons: the infraspinatus, teres major, subscapular and supraspinatus muscle. Those who suffer from this condition range from athletes and workers with repetitive microtrauma due to overhead activities, to the elderly with degenerative tears through years of use. A cuff tear may also coincide with

other injuries to the shoulder, such as a fracture or dislocation.

Two options exist for treating rotator cuff tears: non-surgical treatment, also referred to as conservative treatment, and surgical rotator cuff repair. Conservative treatments that have been advocated include nonsteroidal-anti-inflammatory drugs (NSAIDs), injections, physiotherapy and activity modification, i.e. avoidance of activities that cause symptoms, while surgery is usually reserved for those who fail to respond. Evidenced based medicine provides minor evidence that for rotator cuff disease, corticosteroid injections and NSAIDs have a small benefit over placebo [2]. Combining mobilisation with exercise provides an additional benefit when compared to exercise alone [3].

Surgical treatment may include removing bone decrease pressure on the rotator cuff tendons (acromioplasty), removing any swollen or inflamed bursa (the small sack of fluid around the joint), and removing any damaged tissue to help heal the remaining tissue. This is called a 'decompression'. If a significant partial or full thickness tear is present in the cuff this can be stitched This is called a 'repair'. Often a combination of procedures is performed.

According to the Cochrane review database on the treatment for rotator cuff tears, there is little evidence to support or refute the efficacy of common interventions for tears of rotator cuff in adults and insufficient evidence to define the optimal treatment strategy within the broad spectrum of surgical and non-surgical treatments available [4,5]. Parameters that may be assumed to have relevance to the need or choice for or early conversion to surgical treatment are age and rupture size [6,7].

The objective of this paper is to evaluate the use of different treatment options and there economical impact following rotator cuff tearing resulting from an occupational accident in the Belgian situation. The impact of patient variables on the treatment type and related course of recovery of the victim as well as on the associated accident costs is analyzed. The primary variables of interest are age, physical intensity of occupation and size of the rupture. Based on retrospectively acquired data from health insurance databases, we strive to acquire insight into the impact of these parameters on the choice of rotator cuff tear treatment and related economic impact.

# 2 Material and Methods

*Composition of the population studied*

The rotator cuff tear "victim" database consists of 112 cases and was provided by the health insurance companies Fortis AG(Brussels, Belgium) and AXA (Antwerp, Charleroi, Belgium). The database consists of occupational accidents which happened between 1998 and 2006. The theoretical costs and compensations were adjusted with the consumer price index (CPI) to be comparable with the costs of 2007 [8].

Relevant demographical, clinical and economical data retained included gender, age, occupation type, rupture size, treatment protocol and compensation for unemployment costs.

Subsequently, we looked at the number of days that patients were temporarily and/or permanently incapacitated for work as a result of their injury. A cost analysis will be performed for the various treatment options and correlations with patient variables were established through regression analysis.

*Cost analysis*

The research relates to accidents having taken place in different years. This implies that the payouts by the insurance companies are also spread out over a considerable period of time. In the cost analysis, we must therefore take due account of inflation and the time-dependence of money value. In this study, all financial data are calculated back to the chosen reference year 2006. To this end, we make use of the Consumer Price Index (CPI), resulting in the following conversion table (table 1).

To account for the time-dependence of money value, a growth percentage of 3% is assumed. One can interpret the costs as the budget required in the year of the accident (expressed in prices for 2006) in order to pay all present (year of accident) and future bills.

Subsequently, an assessment was made of the impact of individual costs on the total cost for the different groups. Medical costs and costs associated with the number of days of temporary disability (TD) are similar for the conservative and the surgical treatments. This is not the case for the cost associated with the permanent disability (PD) percentage. Comparison among the conservative group of the medical costs incurred by patients with and without a PD percentage shows these costs to be considerable lower for cases with a PD percentage. This is explained by the great impact of the PD cost on total costs. The observed effect is even stronger among surgically treated patients.

| | 2006 | /100 |
|---|---|---|
| 1998 | 117.204 | 1.172.039.561 |
| 1999 | 1.159.048 | 115.904.828 |
| 2000 | 1.130.287 | 1.130.287.236 |
| 2001 | 110.302 | 1.103.020.171 |
| 2002 | 1.085.202 | 1.085.202.229 |
| 2003 | 1.068.235 | 10.682.354 |
| 2004 | 104.63 | 10.463 |
| 2005 | 1.017.957 | 1.017.956.988 |
| 2006 | 100 | 1 |
| 2007 | 989.409 | 0.989408983 |

Table 1: Conversion table based on the CPI

Further, a regression analysis is performed to gain insight into the extent that the different parameters contribute to total cost.

*Regression analysis*

To determine the independent variables $(x_1, x_2, ..., x_k)$ explaining the dependent total cost ($Y$), a linear regression analysis is performed. This leads to the following model:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k + \varepsilon$$

where ε is a very small constant that may be discarded.

The intercept is $\beta_0$ and the linear constants are called $\beta_i$ (with i= 1, …, k).

The number of days of TD, the PD percentage and the basic daily wage (BDW) of the patient determine the level of compensation, and hence are incorporated into the model. These variables are expected to have the largest impact on total cost. The medical cost is integrated as an independent variable, as is the age of the victim. Table 2 shows the course of the algorithm of the stepped linear regression. It emerges that the variables with the highest t-value and $p = 0.00 < 0.05$ (and, among these, the variables with the highest partial correlations) are incorporated into the model. The distinction conservative / surgical was initially not incorporated into the model, as it impacts strongly on the number of days of TD and ultimately on the PD percentage as well.[9-14]

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Tolerance | VIF | Minimum Tolerance |
| 1 | Age | .060(a) | 1.074 | .286 | .126 | .984 | 1.017 | .984 |
| | % of PD | .142(a) | 2.265 | .027 | .258 | .729 | 1.373 | .729 |
| | Rest / immobility | .057(a) | .969 | .336 | .113 | .884 | 1.131 | .884 |
| | Infiltration | .119(a) | 2.214 | .030 | .252 | .995 | 1.005 | .995 |
| | Physio | .062(a) | 1.080 | .284 | .126 | .930 | 1.075 | .930 |
| | Surgery | .125(a) | 1.973 | .052 | .227 | .728 | 1.373 | .728 |
| | BDW TD | .162(a) | 3.085 | .003 | .342 | .987 | 1.013 | .987 |
| | Hospitalisation days | .025(a) | .385 | .702 | .045 | .745 | 1.343 | .745 |

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics | | |
|---|---|---|---|---|---|---|---|---|
| 2 | Age | .046(b) | .870 | .387 | .103 | .976 | 1.024 | .974 |
| | % of PD | .145(b) | 2.449 | .017 | .279 | .728 | 1.373 | .721 |
| | Rest / immobility | .026(b) | .450 | .654 | .053 | .853 | 1.173 | .853 |
| | Infiltration | .098(b) | 1.897 | .062 | .220 | .976 | 1.025 | .968 |
| | physio | .087(b) | 1.609 | .112 | .188 | .911 | 1.097 | .910 |
| | Surgery | .105(b) | 1.730 | .088 | .201 | .719 | 1.391 | .719 |
| | Hospitalisation days | .013(b) | .215 | .830 | .026 | .742 | 1.348 | .742 |
| 3 | Age | -.006(c) | -.100 | .920 | -.012 | .816 | 1.226 | .609 |
| | Rest / immobility | .042(c) | .758 | .451 | .090 | .841 | 1.189 | .639 |
| | Infiltration | .071(c) | 1.356 | .179 | .160 | .912 | 1.096 | .681 |
| | Physio | .083(c) | 1.581 | .118 | .186 | .910 | 1.098 | .684 |
| | Surgery | .114(c) | 1.945 | .056 | .226 | .717 | 1.395 | .557 |
| | Hospitalisation days | .027(c) | .460 | .647 | .055 | .735 | 1.361 | .556 |

a Predictors in the Model: (Constant), days of TD
b Predictors in the Model: (Constant), days of TD, BDW TD
c Predictors in the Model: (Constant), days of TD, BDW TD, % PD
d Dependent Variable: Total cost

Table 2 Excluded Variables(d) in respect of total cost

Table 3 provides an indication of the model's explanatory power. A model with multiple independent variables typically produces a higher R-square, but it is also more complex. A criterion that weighs up complexity against explanatory power is the so-called adjusted R-square. In our case, the adjusted R-square remains very high: 81% of the variance in total cost is explained by the variance in the number of days of TD, the PD percentage and the basic daily wage. The p-value = 0.000 < 0.05 for the F-value for the three variables shows that the variance explained by the model is not attributable to chance. This result may be seen to correspond with our assumption that disability costs impact strongly on total cost.

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .882(a) | .778 | .775 | 5.681.000 |
| 2 | .897(b) | .804 | .799 | 5.375.974 |
| 3 | .905(c) | .819 | .812 | 5.198.512 |

a Predictors: (Constant), Days of TD
b Predictors: (Constant), Days of TD, BDW TD
c Predictors: (Constant), Days of TD, BDW TD, % of PD
d Dependent Variable: Total cost

Table 3 Model Summary(d) in respect of regression of total cost

Table 4 shows that the model adequately explains total cost on the basis of days of TD, PD percentage and basic daily wage without problems of multicollinearity (as none of the eigenvalues is very close to zero and the condition indices are all below 15).

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions (Constant) | Days of TD | BDW TD | PD % |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.692 | 1.000 | .15 | .15 | | |
| | 2 | .308 | 2.343 | .85 | .85 | | |
| 2 | 1 | 2.543 | 1.000 | .02 | .06 | .02 | |
| | 2 | .394 | 2.541 | .04 | .94 | .05 | |
| | 3 | .064 | 6.327 | .95 | .01 | .93 | |
| 3 | 1 | 3.037 | 1.000 | .01 | .03 | .01 | .03 |
| | 2 | .628 | 2.199 | .03 | .05 | .04 | .43 |
| | 3 | .272 | 3.342 | .01 | .92 | .01 | .53 |
| | 4 | .063 | 6.920 | .94 | .00 | .93 | .00 |

a Dependent Variable: Total Cost

Table 4 Collinearity Diagnostics(a) in respect of regression

Subsequently, we ascertain whether the addition of other explanatory variables further optimises the model.

Table 5 shows that the explanatory power of a model that also incorporates the choice between surgery and conservative treatment is only marginally greater. The variables 'intervention' and 'hospitalisation days' have a low tolerance, implying that much of their variance is already explained by other predictive variables. Moreover, the first retained variable, namely days of TD, turns out to have by far the greatest explanatory power.

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .882(a) | .778 | .775 | 5.681.000 |
| 2 | .897(b) | .804 | .799 | 5.375.974 |
| 3 | .905(c) | .819 | .812 | 5.198.512 |
| 4 | .911(d) | .830 | .821 | 5.076.469 |
| 5 | .918(e) | .843 | .832 | 4.913.234 |

a Predictors: (Constant), Days of TD
b Predictors: (Constant), Days of TD, BDW TD
c Predictors: (Constant), Days of TD, BDW TD, PD %
d Predictors: (Constant), Days of TD, BDW TD, PD %, Intervention
e Predictors: (Constant), Days of TD, BDW TD, PD %, Intervention, Hospitalisation days
f Dependent Variable: Total cost

Table 5 Model Summary(f) in respect of regression, incl. choice of intervention

# 3 Results

Of the 112 patients treated for rotator cuff tear between 1998 and 2007, sixty were treated surgically (54%) and fifty-two conservatively (46%). Table 6 provides an overview of the gender makeup of the population by treatment option.

| | Male (81% of patients) | Female (19% of patients) |
|---|---|---|
| Conservative treatment | 67% | 33% |
| Surgical treatment | 87% | 13% |

Table 6 Rotator cuff tear sample

The imbalance between male and female patients in table 6 is explained by the fact that men are more likely than women to perform heavy and/or dangerous labour, implying a greater risk of injury through serious industrial accidents [18].

*Age*

Figure 1 shows the age at which the patients suffered posttraumatic rotator cuff tear in an industrial accident in the private sector. An industrial accident is defined as a sudden event whereby the employee suffers an injury during the performance of his/her duties under the terms of an employment contract. From this research population, it may be concluded that age has an important impact on the choice of treatment, since the mean age for the conservative treatment is 45 years as compared to 56 years for the surgical treatment. Thus, the null hypothesis of the t-test that "there is no significant difference in respect of age between the two types of treatment" may be rejected ($p = 0.036 < 0.05$).

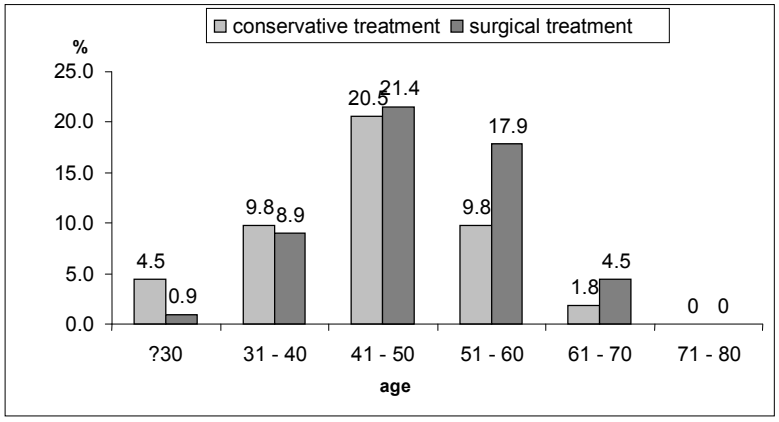


Figure 1 Distribution of treatment option by age of the patient (n= 112)

*Occupation*

The two groups (conservative and surgical) exhibit a similar distribution of patients by sector of industry. Intuitively, one might expect to observe a difference in choice of treatment strategy according to the occupational category to which the patient belongs: surgical treatment would seem the more likely option for workers in physically demanding jobs (e.g. the construction industry), while conservative treatment would appear more suitable for employees in the services industry (research, commercial and office duties). Workers in physically

demanding manual jobs are, after all, more likely to have to continue performing tasks that put stress on the shoulders.

However, the empirical data contradict this intuitive assumption and indicate that there is no significant difference in treatment option between employees in physically demanding and those in non-physically demanding work. In this instance, the result of the null hypothesis of the t-test is $p = 0.211 > 0.05$. Hence, the hypothesis that "there is no significant difference in respect of occupation between the two types of treatment" cannot be rejected.

*Size of the rupture*

The results for the empirical study for this parameter relate to just 93 patients, due to a lack of information in some of the insurance files. Partial ruptures are often treated conservatively: this was found to be the case in ***72.5%*** of such cases in the population under consideration. Full thickness ruptures, on the other hand, tend to be treated surgically: this option was chosen in ***71.4%*** of such cases in the patient sample. For patients with a massive rupture, there is no preferred option. So-called small full thickness ruptures were treated surgically in ***76.9%*** of such cases in the population studied.

When the size of the rupture, age and occupation are considered together, rupture size emerges as the most important predictive factor for treatment choice. Furthermore, age and rupture size turn out to be interconnected, as the incidence of massive ruptures is greater in older persons.

In the next phase of the study, the ruptures were categorised in two groups depending on size, namely the 'partial/ small full thickness' tears (n= 53) and the 'full thickness/ massive' tears (n= 40). In this case, the result of the null hypothesis of the t-test is $p = 0.004 < 0.05$, so that the hypothesis that "there is no significant difference in terms of rupture size between the two types of treatment" may be rejected. In other words, the treatment option chosen is codetermined by the severity of the tear. Full thickness/massive tears are most commonly treated surgically, while the partial/small full thickness tears are most often treated conservatively.

In figure 2, the number of days of temporary disability after respectively the conservative and the surgical treatment is represented by means of box plots. There is a significant difference in this respect between the two treatment options.

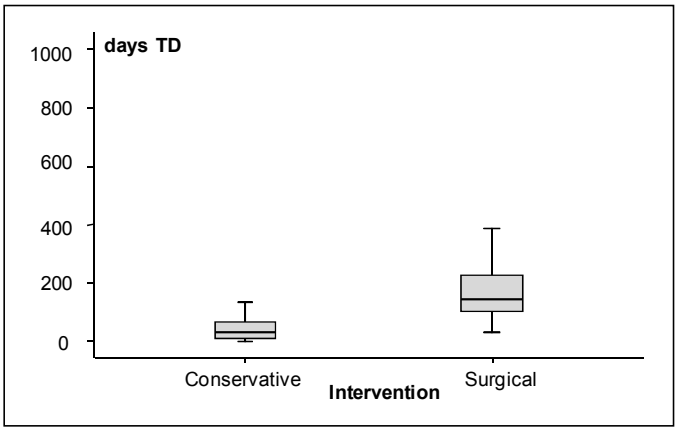


Figure 2 Number of days of TD by type of intervention

Clearly, the number of days of TD is significantly higher among the surgical group than among the conservative group. There are a number of explanations for this observation. First and foremost, surgery requires a longer rehabilitation period, in order to improve the chances of successful recovery. Second, the patients in the surgical group are, on average, older than those in the conservative group, and older persons may be assumed to recover more slowly.

Only if a higher temporary disability cost (TD cost) – which depends on the term of disability and the patient's basic wage – is offset by a lower cost of permanent disability (PD cost) does the total cost of the two treatments become comparable for the insurance company. In the next section, we examine whether there is a significant difference in PD percentage for the two groups.

*Percentage of permanent disability (PD)*

The mean PD percentage for the conservative versus the surgical treatment amounts to respectively 1.19% and 4.25%. This significant difference is confirmed by the t-test, yielding $p = 0.000 < 0.05$. It should be noted that PD percentage is a double-edged measure: on the one hand, it can be used to gauge treatment effectiveness (a higher percentage implies a higher degree of permanent disability), while on the other, it provides an indication of cost, as a higher PD percentage implies more substantial compensation to the patient.

The empirical data show a higher PD percentage for the surgical group. Also, full recovery is more exceptional among these patients than among those in the conservative group.

Clearly the findings in the previous paragraph need to be interpreted with some caution. A difference in PD percentage cannot be explained by a difference in treatment alone. Age differences and differences in tear size will inevitably also influence the degree of success of the treatment.

The number of days of TD is greater for the surgical group than for the conservative group, as surgery requires a longer rehabilitation period in order for the treatment to have a successful outcome. Furthermore, the PD percentage is significantly higher for the surgical group.

The parameters age and rupture size appear to be good predictors of treatment choice for the rotator cuff tears suffered in the industrial accidents considered in this study.

Figure 3 represents the number of cases by cost interval for the two treatments. The total cost (PD included) is notably higher for the surgical treatment than for the conservative treatment. The distribution of cost is skewed, with most of the patients undergoing a low-cost treatment and a small group incurring very high treatment costs.

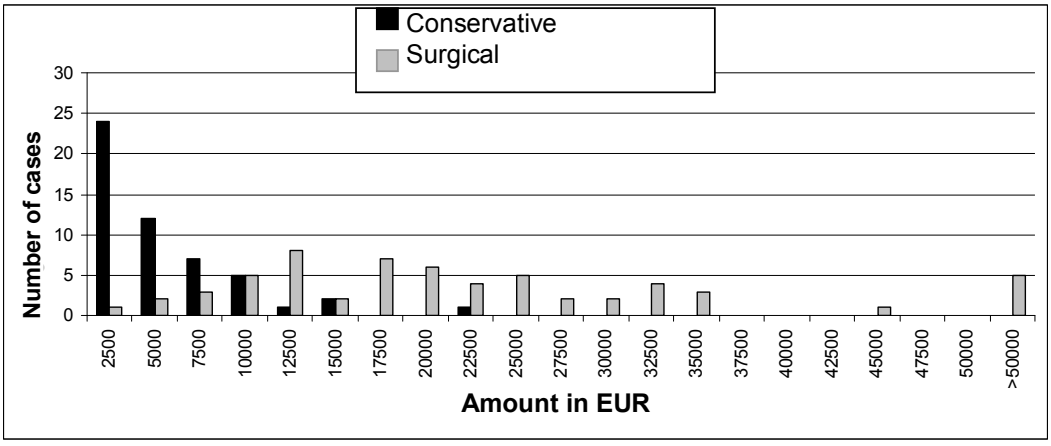


Figure 3 Total expenses for the insurance company

# 4 Discussion

The literature suggests that non-operative management of a rotator cuff tear can provide relief in approximately 50 percent of patients[15-18]. Two important predictors indicate poor outcome from this kind of treatment: long duration of symptoms (longer than 6-12 months) and large tears (in excess of 3 centimetres). The benefits of the treatment option are the avoidance of surgery and its inherent risks (infection, permanent stiffness and anaesthesia complications) and the absence of patient downtime. The negatives are a lack of strength improvement, the danger

of the rupture size increasing with time and the possibility of the patient needing to decrease activity levels.

Surgical repair is indicated for a rotator cuff tear that does not respond to non-operative treatment and is associated with weakness, loss of function and limited motion. Ianotti *et al.* indicate that, after rotator cuff repair, 80 to 95 percent of patients achieve a satisfactory result, defined as adequate pain relief, restoration or improvement of function, improvement in range of motion, and patient satisfaction with the procedure [19]. The main factors decreasing the likelihood of a satisfactory outcome are poor tissue quality, large or massive tears, poor compliance with post-operative rehabilitation and restrictions, patient age (older than 65 years), and workers' compensation claims. For the interested reader, a comprehensive overview of all published material relating to outcomes of rotator cuff repair surgery was presented in 2003 [20].

With regard to the related cost, we notice a typically skewed distribution: the majority of patients incur relatively low costs, while a small group face very high costs. On closer scrutiny, it emerges that that surgical treatment in particular is associated with substantial costs. In this context, it should be kept in mind, though, that the conservative and the surgical groups are inherently different in that the tears suffered are, on average, more serious among the surgically treated patients. The analysis of how the various cost items - i.e., primarily TD, PD and medical costs – contribute to total cost lead to the general conclusion that disability costs impact strongly. This finding is confirmed by comparison of a number of statistical indicators of total cost. The strong impact of disability costs on total cost was further confirmed in a stepped linear regression analysis. As far as the variance in medical costs is concerned, here the greatest explanatory power is attributed to whether or not the patient has undergone (a specific type of) surgery and / or whether or not infiltration has been applied.

Our study shows that variables such as gender, age, sector of employment, type of accident, rupture size, condition prior to accident, other injuries and place of residence cannot predict total cost prior to the choice of treatment.

The variance in medical costs is found to be explained for almost 50% by whether or not the patient has undergone surgery – and, if he/she has, which kind (open, arthroscopic) – and by whether or not infiltration has been applied. Hence, the variance in these costs explains the variance in medical costs only to a certain degree.

To conclude, comparing the surgical with the conservative group, the main conclusion is that they diverge in many ways.

First of all, the surgically treated ruptures are generally more serious, often involving full thickness and massive tears. In addition, the mean age of the patients in the surgical group is significantly higher than that of the patients in the conservative group. The occupational makeup of the two groups is quite similar. Hence, occupations involving heavy manual labour do not necessarily lead to more serious rotator cuff injuries.

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