

1 **Cutoff value of Japanese Orthopaedic Association Shoulder Score in Patients with Rotator Cuff**

2 **Repair: Based on the University of California at Los Angeles Shoulder Score**

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4 Takaki Imai, PT, MS^{1,2}, Masafumi Gotoh, MD, PhD^{3*}, Tsuyoshi Tokunaga, PT²,

5 Jyunichi Kawakami, PT, MS^{1,4}, Yasuhiro Mitsui, MD, PhD³, Keiji Fukuda, MD, PhD⁵,

6 Misa Ogino, MD, PhD⁵, Takahiro Okawa, MD, PhD³, and Naoto Shiba, MD, PhD⁶

7

8 ¹Kurume University School of Medicine Graduate School, Asahi-machi, Kurume,

9 Fukuoka, Japan

10 ²Department of Rehabilitation, Keishinkai Hospital, Haru-machi, Tosu, Saga, Japan

11 ³Department of Orthopedic Surgery, Kurume University Medical Center, Kokubu-machi,

12 Kurume, Fukuoka, Japan

13 ⁴Department of Rehabilitation, Saiseikai Yahata General Hospital, Haruno-machi,

14 Kitakyushu, Fukuoka, Japan

15 ⁵Department of Orthopedic Surgery, Keishinkai Hospital, Haru-machi, Tosu, Saga,

16 Japan

17 ⁶Department of Orthopedic Surgery, Kurume University, Asahi-machi, Kurume,

18 Fukuoka, Japan

19 * Correspondence: Masafumi Gotoh, MD, PhD, Department of Orthopedic Surgery,

20 Kurume University Medical Center, 155-1 Kokubu-machi, Kurume Fukuoka 839-0863,

21 Japan

22 Tel: +81-942-22-6111

23 Fax: +81-942-22-6657

24 Email address: gomasa@med.kurume-u.ac.jp (M. Gotoh).

25

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29 Ethical disclosure

30 The Institutional Review Board of Kurume University approved the study protocol

31 (#15122), and all subjects gave their informed consent for participation in the study.

32 **Abstract**

33 *Background:* The Japanese Orthopaedic Association shoulder score cutoff values were calculated in patients
34 with rotator cuff repair using the University of California at Los Angeles shoulder score.

35 *Methods:* Overall, 175 patients with rotator cuff repair were subjects in this study. The University of California
36 at Los Angeles and Japanese Orthopaedic Association shoulder scores were evaluated before surgery and at 3,
37 6, 9, and 12 months after surgery. The cutoff value of the Japanese Orthopaedic Association shoulder score was
38 determined using the 4- stage criteria of the University of California at Los Angeles shoulder score and a
39 University of California at Los Angeles shoulder score of 28 points, which is the boundary between an
40 excellent/ good group and a fair/ poor group.

41 *Results:* Both the JOA shoulder and UCLA shoulder scores showed significant improvement at 6, 9, and 12
42 months from the preoperative scores ($p < 0.0001$). There was a strong correlation between the total values of
43 the two scores ($r = 0.85$, $p < 0.0001$). The cutoff value of the Japanese Orthopaedic Association shoulder
44 score based on the highest accuracy from receiver operating characteristic curve analysis was 83
45 points.

46 *Conclusion:* A Japanese Orthopaedic Association shoulder score cutoff value of 83 was equivalent to a
47 University of California at Los Angeles shoulder score cutoff value of 28 for distinguishing between excellent/
48 good and fair/ poor outcomes after rotator cuff repair.

49

50

51 **Introduction**

52 Rotator cuff tears commonly occur in middle-aged and elderly persons [1]. Intrinsic (tendon degeneration
53 [2]) and / or extrinsic (subacromial impingement [3]) factors are associated with the development of the disease.
54 Conservative therapies [4], such as administration of non-steroidal anti-inflammatory drugs, intra-articular
55 injections [5], and physiotherapy [6], are usually selected; however, rotator cuff repair is performed when
56 preoperative treatment fails [7].

57 The Japanese Orthopaedic Association (JOA) shoulder score, which has been used to evaluate shoulder
58 function, consists of pain (30 points), functions (general functions, 10 points; daily activities, 10 points), range of
59 motion (active movement, 30 points), X-ray findings (5 points), and joint stability (15 points) for a total of 100
60 points [8]. In patients who undergo rotator cuff repair, the JOA shoulder score is often used to assess the
61 preoperative status and postoperative clinical outcome or to assess outcomes after different procedures in these
62 patients in Japan [8-13, 20, 21]. In those evaluated by the JOA shoulder score, ≥ 81 points after surgery is
63 reported to be satisfactory and ≤ 80 points before surgery is clinically unsatisfactory [8,9,20,21]. However, no
64 suitable evidence to support the cutoff value described above has been reported.

65 The University of California at Los Angeles (UCLA) shoulder score was designed to evaluate the
66 postoperative results for shoulder arthroplasty [14], and the revised edition is used to evaluate operative results
67 for rotator cuff tear [5, 16]. The UCLA shoulder score consists of pain (10 points), functions (10 points), range
68 of motion in the joint (5 points), manual muscle test (5 points), and patient satisfaction level (5 points) for a total
69 of 35 points [15]. The following outcome criteria are used: Excellent, ≥ 34 points; Good, 28 to 33 points; Fair,
70 21 to 27 points; and Poor, ≤ 20 points [15]. Since excellent / good is considered satisfactory and fair / poor is
71 considered unsatisfactory, the UCLA shoulder score cutoff value has been set to 28. At present, the UCLA
72 shoulder scoring system is used worldwide and shows good correlation with clinical outcome in patients who
73 have undergone rotator cuff repair [17, 18]. Therefore, the purpose of the present study was to determine the
74 JOA shoulder score cutoff value for distinguishing between excellent / good and fair / poor outcomes after

75 rotator cuff repair by using the UCLA shoulder score as a standard reference.

76

77 **Materials and Method**

78 The Institutional Review Board of Kurume University approved the study protocol
79 (approval number 15122) and all subjects gave their informed consent for participation in the
80 study.

81 *Subjects*

82 Between January 2002 and December 2013, 342 patients with rotator cuff tear underwent open or
83 arthroscopic surgery in our institution. The following inclusion criteria were used: (1) individuals who had
84 complete cuff tear received open or arthroscopic surgery and (2) individuals who followed strict rehabilitation
85 for at least one year after surgery. The following exclusion criteria were used: (1) individuals who had no
86 evaluation by either the UCLA shoulder score or JOA shoulder score, (2) individuals who had partial tear and
87 (3) individuals who had fractures involving the shoulder, progressive arthritis, osteoarthritis, or infection. On the
88 basis of these criteria, 175 patients (19 with small tears, 42 with moderate tears, 75 with large tears, and 39 with
89 massive tears [19]) were included as subjects in this study.

90 Of the 175 patients, arthroscopic surgery was performed in 114 patients and open surgery was performed
91 in 61 patients. There were 105 males and 70 females, with a mean age of 62.1 ± 8.7 years. The mean period
92 from onset to surgery was 9.3 ± 10.2 months. There were 18 patients with diabetes, 51 patients with shoulder
93 contracture who had manual manipulation and/or arthroscopic capsular release during surgery, and 114
94 patients with apparent traumatic history. Details are shown in Table 1.

95

96 *Data collection*

97 To evaluate the functional outcome, the JOA and UCLA shoulder scores were determined before surgery
98 and at 3, 6, 9, and 12 months after surgery. The data were obtained by a physical therapist in charge who was

99 blind to this study throughout the periods. The physical therapists had an average experience of 10.4 ± 3.4
100 years.

101

102 *Surgical procedure*

103 The operations were performed under general anesthesia in a beach chair position. Open surgery was
104 performed in 61 cases using the McLaughlin method in which the tendon stump of the torn rotator cuff was
105 re-attached into the bone trough on the greater or lesser tuberosities. Arthroscopic surgery was performed in 114
106 cases by using the single-row or suture bridge method. Open or arthroscopic subacromial decompression
107 (ASD) was performed in all patients followed by immobilization with an abduction pillow.

108

109 *Postoperative rehabilitation*

110 Elbow, wrist, and finger range of motion exercises were started immediately after surgery. At four days
111 after surgery, passive range-of-motion exercise was started. At seven weeks after surgery, active exercise and
112 isometric strength training were permitted. Isotonic muscle strength training was begun eight weeks after
113 surgery.

114 *Statistical analysis*

115 Statistical analysis was performed by using IBM® SPSS® Statistics 22.0 (IBM Inc., Armonk, NY, USA),
116 JMP® 11 and SAS® 9.4 (SAS Institute Inc., Cary, NC, USA).

117 The Friedman test and Steel–Dwass test was used to compare the scores before the operation and those at 3,
118 6, 9, and 12 months after surgery.

119 To evaluate the relationship between the JOA shoulder score and the UCLA shoulder score, we employed
120 the mixed-effect models since the JOA shoulder score and the UCLA shoulder score were obtained several
121 times from each patient. The Mixed Model contains two model parameters, intercept and slope, and the
122 relationship between the JOA shoulder score and UCLA shoulder score was evaluated by the estimated slope

123 as well as correlation coefficient defined as square-root of the total explained variance (R^2). In addition, we
124 similarly examined the relationship of the following four sub-items: (1) pain, (2) activities of daily living, (3)
125 range of motion (active motion), and (4) general functions of the JOA shoulder score and (1) pain, (2) function,
126 (3) active forward flexion, and (4) strength of forward flexion the UCLA shoulder score.

127 Next, we derived the cutoff value of the JOA shoulder score. To this end, all patients were classified into two
128 groups (excellent / good, fair / poor) based on the reported cutoff value of the UCLA shoulder score. Then,
129 receiver operating characteristic (ROC) curve analysis was performed to obtain the cutoff value for the JOA
130 shoulder score using random-effect logistic model which accounts for serial correlation between
131 repeated-measurement of the JOA and the UCLA shoulder scores from each patient. A p value of <0.05 was
132 taken as indicating a statistically significant difference.

133

134 **Results**

135 The total JOA shoulder scores before and at 3, 6, 9, and 12 months after surgery were 62.7 ± 10.8 , $77.3 \pm$
136 10.8 , 84.3 ± 9.6 , 87.5 ± 9.0 , and 88.5 ± 8.8 points, respectively, and the total UCLA shoulder scores were $14.3 \pm$
137 5.9 , 22.3 ± 5.4 , 28.4 ± 3.4 , 28.7 ± 3.9 , and 29.2 ± 4.5 points, respectively. Both the JOA shoulder and UCLA
138 shoulder scores showed significant improvement at 6, 9, and 12 months from the preoperative scores ($p <$
139 0.0001) (Figure 1).

140 There were significant correlations between the UCLA and JOA shoulder scores as shown by the following
141 results: total JOA/ UCLA shoulder scores ($r = 0.85$, $p < 0.0001$), JOA/ UCLA shoulder “Pain” scores ($r = 0.81$,
142 $p < 0.0001$), JOA shoulder “Activities of daily living” score and UCLA shoulder “Function” score ($r = 0.77$, p
143 < 0.0001), JOA shoulder “Range of motion” score and UCLA shoulder “Active forward Flexion” score ($r =$
144 0.89 , $p < 0.0001$), and JOA shoulder “General Functions” score and UCLA shoulder “Strength of forward
145 flexion” score ($r = 0.80$, $p < 0.0001$) (Table 3).

146 Because the cutoff value between “Satisfactory” and “Unsatisfactory” is set at 28 points in the UCLA

147 shoulder score, we next calculated the cutoff value in the JOA shoulder score that is equivalent to 28 points in
148 the UCLA shoulder score, using ROC curve after logistic regression analysis. The JOA shoulder score based
149 on the ROC curve analysis after logistic regression analysis that was equivalent to the UCLA shoulder score
150 cutoff value of 28 was 83 (area under the curve: AUC = 0.94, sensitivity = 91.8%, specificity = 84.1%) (Figure
151 2).

152

153 **Discussion**

154 In Japan, the JOA shoulder score has been used for postoperative evaluation of rotator cuff tear; however,
155 no standard cutoff value for differentiating between outcomes has been established. The present study
156 evaluated both the JOA and UCLA shoulder scores before and after surgery in the same patients and calculated
157 the JOA shoulder score cutoff value by using the UCLA shoulder score as a basic standard. Ellman and Kay
158 [15] classified the UCLA shoulder score (total of 35) into four grades: Excellent (≥ 34), Good (28–33), Fair
159 (21–27), and Poor (≤ 20). Excellent / good is considered satisfactory and fair / poor is considered unsatisfactory.
160 Therefore, in the present study, the UCLA shoulder score of 28 was set as the cutoff value to differentiate
161 between excellent / good and fair / poor outcomes after rotator cuff repair, and the equivalent JOA shoulder
162 score cutoff value was determined to be 83.

163 The UCLA shoulder score is considered to be a useful tool for evaluation of rotator cuff tears [3, 15, 16]. Ide
164 *et al.* [8, 12] used the UCLA and JOA shoulder scores for clinical evaluation of patients with mini-open or
165 arthroscopic cuff repair. In their study, preoperative / postoperative results were significantly improved, and
166 there was no statistical difference between the procedures [8]. When using UCLA shoulder scores to evaluate
167 outcomes in patients with rotator cuff repair, a mean JOA shoulder score of 89.3 points corresponded to a 91%
168 satisfaction level in the UCLA shoulder score [13]. Other studies have also used either the JOA, UCLA, or
169 both shoulder scores to evaluate clinical outcomes after rotator cuff repair [8-13, 15, 20, 21]. Thus, both scores
170 have been widely used for clinical evaluation of postoperative rotator cuff tear.

171 For the UCLA shoulder score, a total score of $\geq 80\%$ ($28 / 35 = 0.8$) is defined as excellent / good [15]. Ide et
172 al. [8] used the grading system of the JOA shoulder score; the outcome were deemed to be excellent, good, fair,
173 and poor if the total scores were > 90 , $81 - 90$, $71 - 80$, and < 71 points, respectively. In their report, excellent /
174 good was defined as satisfactory and fair / poor as unsatisfactory. However, the JOA shoulder score cutoff value
175 of 83 obtained in this study was associated with outcomes to those for the UCLA shoulder score of 28, after
176 ROC curve analysis of our data. Thus, these results suggest that not only the UCLA shoulder score but also the
177 JOA shoulder score is a useful grading system for patients with rotator cuff repair.

178 There were some limitations in this study. First, this was a retrospective study. Second, the follow-up period
179 in the present study was relatively short (one year after surgery); therefore, the clinical outcome was not simply
180 comparable with those in the other studies. Third, to calculate the JOA shoulder score cutoff value, only the
181 UCLA shoulder score was used as a basic standard. Referencing to other scores may have changed our results.
182 In the Constant score that is widely used, a cutoff value has also been designated, and studies using this score
183 are currently underway. Fourth, the apparent rationale about how the cutoff value between “Satisfactory” and
184 “Unsatisfactory” was set was not reported in the UCLA shoulder score. However, the JOA shoulder score
185 cutoff value of 83 was equivalent to the UCLA score cutoff value of 28 based on the ROC curve analysis.

186

187 **Conclusion**

188 A JOA shoulder score cutoff value of 83 was equivalent to a UCLA shoulder score cutoff of 28 for
189 differentiating between acceptable and unacceptable postoperative outcomes in patients after rotator cuff repair.

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238 **Tables**

239 Table 1. Patient demographics

	All patients	Arthroscopic surgery	Open surgery
Age (y)	62.1 ± 8.7	62.6 ± 9.2	61.2 ± 7.6
Sex Male / Female (n)	105 / 70	63 / 51	42 / 19
Diabetes (n)	18	11	7
Preoperative Contracture (n)	51	34	17
History of trauma (n)	114	68	46
Duration of symptoms (w)	7.7 ± 8.9	7.7 ± 8.4	7.8 ± 9.9

240

241 Table 2. Tear size and operative procedures

	All patients	Arthroscopic surgery	Open surgery
Tear Size ^a (n)			
Small	19	10	9
Moderate	42	32	10
Large	75	51	24
Massive	39	21	18
Surgical procedure (n)			
suture bridge / single row	69 / 45	69 / 45	-
McLaughlin	61	-	61
Treatment of biceps (n)			
tenotomy	44	40	4
tenodesis	12	5	7
no treatment	119	69	50

^a DeOrio & Cofield cuff tear size classification [19]

242

243 Table 3. Relationship between JOA shoulder score and UCLA shoulder score

JOA shoulder score	UCLA shoulder score	r	p-value
Total score	Total score	0.85	<0.0001
Pain	Pain	0.81	<0.0001
ADL	Function	0.77	<0.0001
ROM	Active forward flexion	0.89	<0.0001
General Functions	Strength of forward flexion	0.80	<0.0001

JOA shoulder score = Japanese Orthopaedic Association shoulder score, UCLA shoulder score = University of California at Los Angeles shoulder score, ADL = Activity of daily living, ROM = Range of motion, r = Correlation coefficient

244 **Figure captions:**

245 Figure 1. Preoperative and postoperative clinical course associated with the JOA shoulder score and UCLA
246 shoulder score

247 Preoperative JOA and UCLA shoulder scores showed significant improvement at 6, 9, and 12 months ($p <$
248 0.0001 , respectively)

249 B.O., before operation; P.O., post-operation; M, months; JOA shoulder score, Japanese Orthopedic Association
250 shoulder score; UCLA shoulder score, University of California at Los Angeles shoulder score.

251 Figure 2. Receiver operating characteristic curve for determining surgical outcomes by postoperative JOA
252 shoulder score

253 ROC curve analysis after logistic regression analysis demonstrated that 83 points of the JOA shoulder score
254 was equivalent to 28 points as a cutoff value in the UCLA shoulder scoring system ($AUC = 0.94$, sensitivity =
255 91.8% , specificity = 84.1%)

256 JOA shoulder score, Japanese Orthopedic Association shoulder score; AUC, area under the curve.

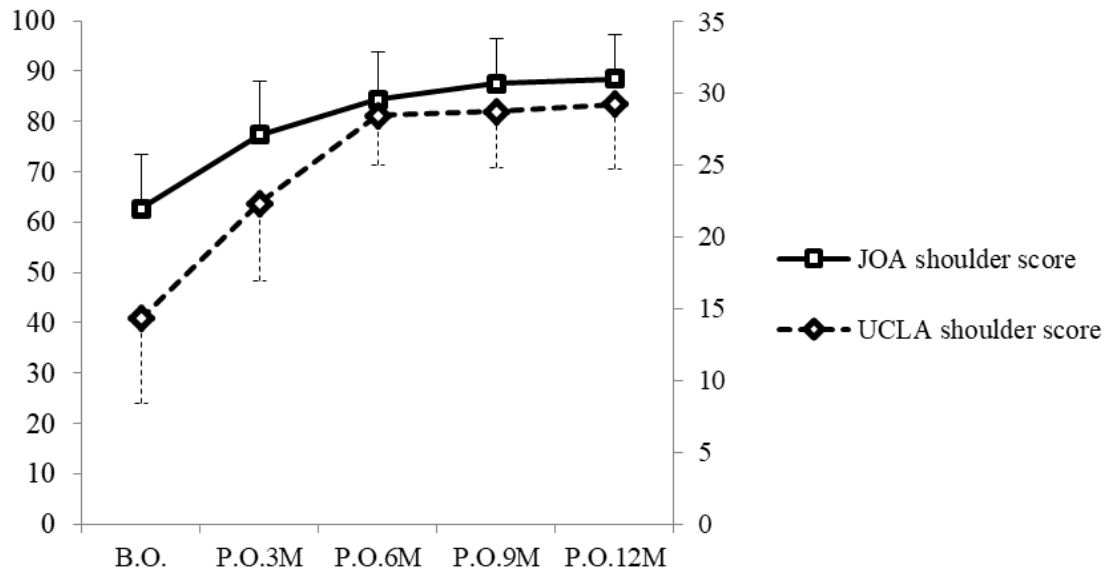


Figure 1.

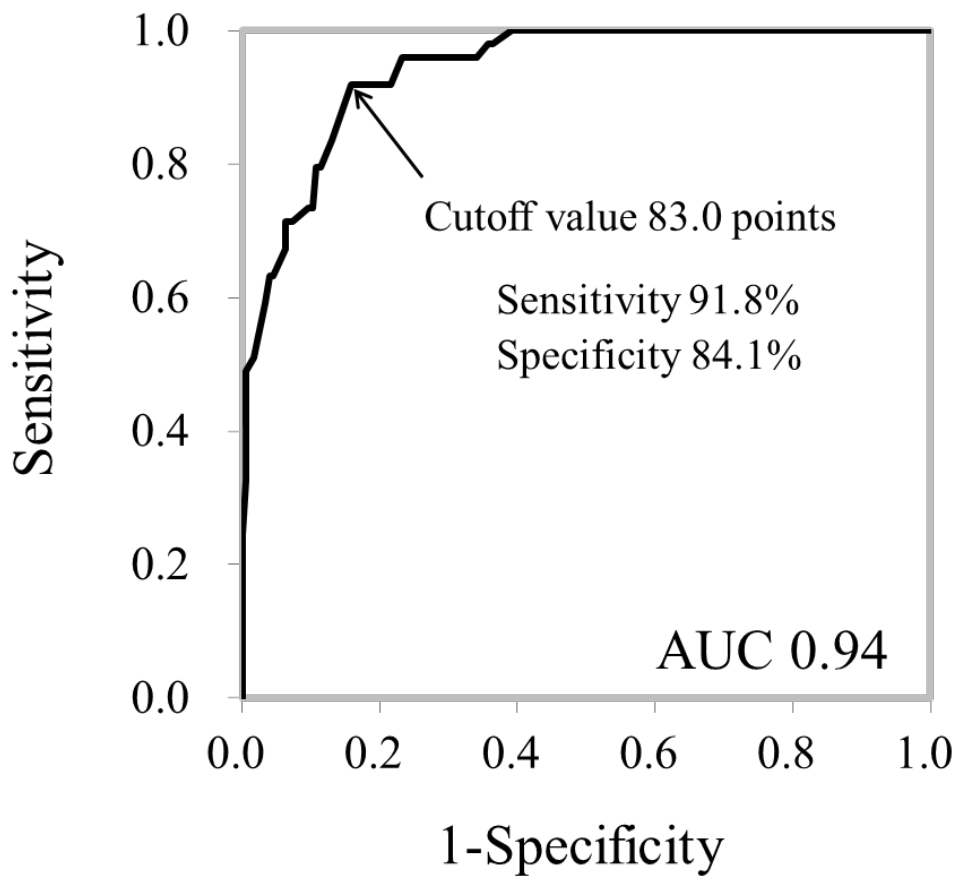


Figure 2.