Real-world clinical and economic impacts of delayed rotator cuff repair surgery in Japan: analysis of a large claims database

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Background: In patients with rotator cuff tears (RCTs), there is a lack of evidence regarding the impact of the timeliness of rotator cuff repair (RCR) surgery on treatment outcomes and overall healthcare burden. This study aimed to understand the impact of early vs. delayed RCR on real-world healthcare costs and resource use (HCRU) in Japan.

Methods: This study utilized JMDC health insurance claims data from January 2012 to February 2021. Patients aged $\geq$18 years were included if they had $\geq$1 inpatient or $\geq$2 nondiagnostic outpatient claims ($\geq$1 month apart) for RCT (diagnosis codes S460/S468), had RCR (procedure codes K080-X) within 12 months postindex, and had 12 months post-RCR continuous enrollment. Index month was defined upon the first RCT claim, and surgery month was defined upon the first RCR. Patients were categorized as having had early ($\leq$1 month postindex) or delayed (2–12 months postindex) RCR. RCT-related HCRU were reported for the 12-month postindex or postsurgery periods.

Results: Of 1243 RCR patients, 68.9% were male and the mean (standard deviation [SD]) age was 55.3 (8.9) years. Of 46.3% patients with an initial diagnosis of tendinosis, their RCT was diagnosed for only a mean (SD) of 5.7 (4.0) months later. The mean (SD) time from index to first RCR was 2.4 (2.3) months; 518 (41.7%) patients had early RCR. The mean total RCT-related healthcare costs were higher for patients with delayed vs. early RCR ($P < .05$ for both postindex and surgery). The mean (SD) postsurgery inpatient costs were higher for delayed vs. early RCR (¥1,260,066 vs. ¥1,119,381; $P < .05$), possibly partly driven by longer hospital stays among delayed RCR patients. Patients with delayed RCR had a higher mean number of physical therapy visits compared with early RCR, especially postsurgery (42.6 vs. 38.4; $P < .05$); physical therapy costs were significantly higher for delayed RCR patients, compared with early RCR, for both postindex or postsurgery periods ($P < .05$). During the postindex period, higher proportions of delayed vs. early RCR patients received opioids (22.1% vs. 16.2%; $P < .05$), nonopioid pain medications (77.7% vs. 69.5%; $P < .05$), cortisone injections (47.2% vs. 33.8%; $P < .05$), and oral cortisone (4.8% vs. 1.4%; $P < .05$). The mean outpatient pharmacy prescription costs were significantly higher for delayed vs. early RCR for both the postindex and postsurgery periods (both $P < .05$).

Conclusions: Long delays in the diagnosis or treatment of RCT in Japan may lead to higher burdens of healthcare. Patients with delayed RCR may require more prescription medications and/or PT before and after surgery. Improving the timeliness of RCT treatment could therefore reduce overall HCRU.

Rotator cuff tears (RCTs) are a form of shoulder injury with two causes as follows: trauma or degeneration.[1] RCTs as a result of degeneration are more common than acute tears from trauma, as degenerative tears may naturally occur with age as the tendons in the shoulder wear down over time.[1] Therefore, especially as those above the age of 40 have been shown to be at a higher risk of RCT than those below 40,[1] the burden of RCT is likely to increase in countries with ageing populations.

Symptoms of RCT include stiffness, weakness, and limited and unstable motion of the shoulder, which can lead to pain and a resulting reduction in patients' quality of life.[14,18] While combining multiple clinical tests has shown to improve the accuracy of RCT diagnosis, clinical assessments may remain ambiguous in

indicating a possible tear.[1,10,25] Imaging, such as ultrasonography and magnetic resonance imaging, are considered the gold standard for providing a confirmatory diagnosis.[25]

After RCT diagnosis, patients may initially be started on conservative management, such as physical therapy (PT) and medication, to improve their pain and strengthen the shoulder.[1,22] There has been strong evidence for conservative management in improving patient-reported outcomes (PROs), such as mobility and quality of life, at least in the short to medium term; however, with conservative therapy only, muscle atrophy and fatty infiltration may progress over 5 to 10 years, leading to worsening RCTs as the size of the tear increases.[1] Despite conservative management, a randomized trial reported that 37% of RCTs progress by more than 5 mm after five years.[1] Complex or worsened RCTs may subsequently be managed by surgical intervention.[22]

Rotator cuff repair (RCR) refers to a specific variety of surgical techniques to repair the muscles and tendons in the rotator cuff.[18] RCR surgeries are reported to improve functional PROs, compared with conservative management, such as PT.[1] However, severe or enlarged RCTs may require multiple RCR surgeries or may even become irreparable, leading to additional conservative and surgical interventions, such as decompression and débridement, where inflamed tissue in the shoulder is removed to improve function and pain relief, without repairing the rotator cuff itself.[19] As such, timely RCR surgery to repair the tear may prevent the injury from worsening or retearing and subsequently reduce the need for additional surgical management.[1]

Therefore, timeliness of RCR surgery may play a role in managing the progression of RCTs that cannot be managed effectively with conservative treatment. Retrospective studies in the UK and Greece have shown that early RCR surgery may lead to improved clinical outcomes compared with delayed surgery.[7,23] Additionally, a US claims database study reported that almost half of patients managed conservatively ultimately require RCR surgery; among these patients, earlier surgical intervention may reduce the economic burden associated with RCTs.[21] However, there are no studies that evaluate the impact of timeliness of RCR surgery in Asia and Japan. Given the anticipated increase in RCT incidence in Japan's ageing population and the potential for timely RCR surgery in reducing the burden of RCTs as seen from global data, there is a need to investigate the real-world treatment patterns for RCT using a large database in Japan.

Objective

The objective of this study was to describe the real-world healthcare resource use and associated economic burden among RCT patients who received early or delayed RCR in Japan.

Materials and methods

Data source

This was a retrospective analysis using data between January 2012 and February 2021 from the JMDC insurance claims database. The JMDC database is Japan's largest claims database, covering 11.6 million (9.2%) of the national population in Japan as of August 2021. It contains anonymized claims (hospitalization, outpatient treatment, and drug preparation) and medical evaluation data received from multiple health insurance associations since 2005.[17]

Study population and eligibility criteria

Patients aged ≥18 years were eligible to be included if they had ≥1 inpatient claim or ≥2 nondiagnostic outpatient claims, ≥1 month apart, for RCT (diagnosis codes S460 and S468; Supplementary Table S1) between January 2013 and February 2020 and had 12 months pre and postindex continuous enrollment (Fig. 1). All patients received RCR surgery within 12 months postindex (procedure codes K080-X, Supplementary Table S2). Patients were excluded if they had any claims for RCT or RCR in the 12-month preindex period.

Study design

Index month was defined as the month of the first (oldest) RCT claim observed in the database. The postindex period was defined as the 12-month period (including the index month) after the first RCT claim (Fig. 1). RCR patients were categorized into early and delayed RCR surgery subgroups; in alignment with a previous US analysis,[21] early RCR surgery patients were defined as those who had their first procedure within 1 month postindex, while delayed RCR surgery patients had their first procedure between 2 and 12 months postindex. Similarly, the surgery month was the month of the first RCR surgery, and the postsurgery period was a 12-month period from the surgery month. Demographic characteristics of included patients were described in the index month. Treatment patterns and healthcare costs and resource use (HCRU) were reported separately for early and delayed RCR patients. This included inpatient admissions, outpatient services such as PT, as well as opioid and nonopioid pain medication and cortisone use. Medications were identified using anatomical therapeutic chemical codes (Supplementary Table S3), while other treatments of interest were identified using medical procedure codes (Supplementary Table S2). The code lists were validated with a clinician to ensure their sensitivity and specificity in capturing the RCT-related HCRU. RCT-related HCRU were reported for the 12-month postindex and 12-month postsurgery period, including inpatient admissions and outpatient services. Claims were determined to be RCT-related if they corresponded to a diagnosis code for RCT (Supplementary Table S1) or a procedure code for RCR (Supplementary Table S2). Chi-square tests (for categorical variables) and two-sample t-tests (for continuous variables) were conducted using a cut-off of $P < .05$ to assess for statistical differences in treatment and HCRU between the early and delayed RCR groups.

Results

Patient disposition and baseline characteristics

Of 14,967 RCT patients identified, 1243 received RCR surgery and met the eligibility criteria for this analysis (Fig. 2). Of the RCR surgery patients, 857 (68.9%) were male and the mean (SD) age was 55.3 (8.9) years. Nearly half (46.3%) of RCR patients had an initial diagnosis of tendinosis; on average, RCT was diagnosed only 5.7 months later (Table I). The mean (SD) time from index (first RCT claim) to first RCR surgery was 2.4 (2.3) months. Of all RCR surgery patients, 518 (41.7%) patients had early RCR surgery, with the rest receiving RCR surgery 2–12 months after diagnosis (delayed RCR surgery). Baseline demographic and clinical characteristics were similar between early and delayed RCR groups (Table I).

Treatment patterns in patients with early vs. delayed RCR surgery

The mean total RCT-related healthcare costs were significantly higher for patients with delayed RCR surgery than early RCR surgery patients, across both the postindex and postsurgery periods (Table II; both $P < .05$). Numerically, more patients with delayed RCR surgery required repeat surgeries (14/725; 1.9%) than those with early RCR surgery (9/518; 1.7%), although this difference was
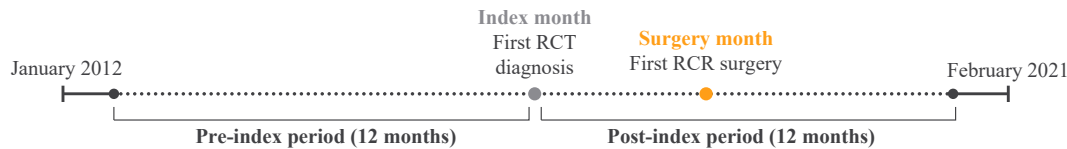
Figure 1 Overview of study design. *RCR*, rotator cuff repair; *RCT*, rotator cuff tear.
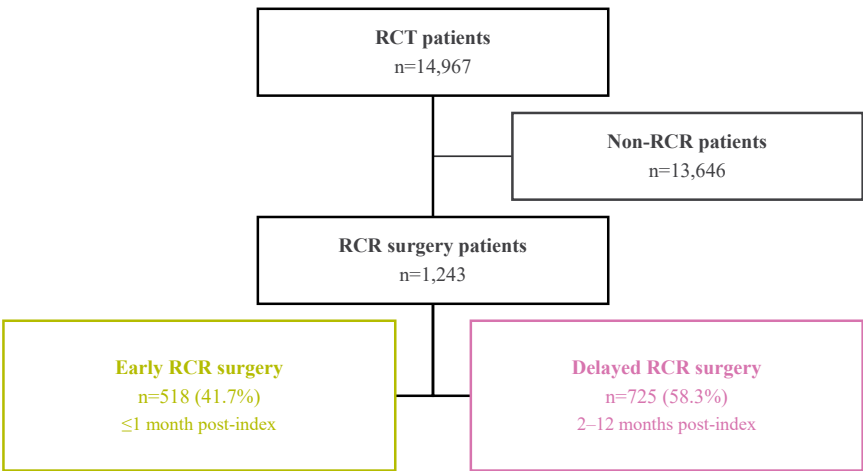

Figure 2 Patient disposition flow chart. *RCR*, rotator cuff repair; *RCT*, rotator cuff tear.

Table I
Patient demographics and clinical characteristics.

	All RCR patients N = 1243	Early RCR patients n = 518	Delayed RCR patients n = 725
Mean age, years (SD)	55.3 (8.9)	54.6 (10.0)	55.9 (7.9)
Sex			
Male, N (%)	857 (68.9%)	372 (71.8%)	485 (66.9%)
Female, N (%)	386 (31.1%)	146 (28.2%)	240 (33.1%)
Tendinosis diagnosis, N (%)	576 (46.3%)	247 (47.7%)	329 (45.4%)
Mean time to RCT diagnosis, months (SD)	5.7 (4.0)	5.6 (4.0)	5.8 (4.1)
Mean CCI Score (SD)	0.8 (1.3)	0.8 (1.2)	0.9 (1.3)

CCI, Charlson Comorbidity Index; *RCR*, rotator cuff repair; *RCT*, rotator cuff tear; *SD*, standard deviation.

Table II
RCT-related inpatient admissions and costs in early vs. delayed RCR surgery groups.

RCT-related healthcare utilisation and costs	Early RCR surgery		Delayed RCR surgery		P values[*]	
	Post-index N = 518	Post-surgery N = 518	Post-index N = 725	Post-surgery N = 725	Post-index	Post-surgery
Patients with an admission, % (N)	99.6% (516)	99.6% (516)	100.0% (725)	100.0% (725)	.094	.094
Average length of stay, mean (SD)	22.2 (19.2)	22.1 (19.2)	24.0 (20.7)	24.3 (21.2)	.115	.057
Length of stay, % (N)					.094	.051
≤7 days	126 (24.4)	126 (24.4)	157 (21.7)	154 (21.2)		
8–21 days	178 (34.5)	179 (34.7)	225 (31.0)	224 (30.9)		
≥22 days	212 (41.1)	211 (40.9)	343 (47.3)	347 (47.9)		
Mean total inpatient costs, ¥ (SD)	¥1,205,276 (¥543,904)	¥1,119,381 (¥536,764)	¥1,242,990 (¥599,003)	¥1,260,066 (¥631,324)	.249	**<.001**
Total healthcare costs, ¥ (SD)	¥1,444,851 (¥587,116)	¥1,415,847 (¥578,956)	¥1,542,699 (¥690,606)	¥1,510,751 (¥709,830)	**.007**	**.010**

RCR, rotator cuff repair; *RCT*, rotator cuff tear; *SD*, standard deviation.
P values in bold indicate where the differences between early and delayed RCR surgery groups were statistically significant.
[*]Chi-squared tests were conducted for categorical variables and two-sample t-tests were conducted for continuous variables.

not statistically significant ($P = .803$). The mean (SD) time from first to second RCR surgery was 5.5 (2.5) months.

Inpatient admissions

During the 12-month postsurgery period, almost all RCR patients had an inpatient admission (early surgical: 99.6%; delayed surgical: 100%). On average, delayed RCR surgery patients had slightly longer hospital stays during the postsurgery period, compared with those who had early RCR surgery (mean 24.3 vs. 22.1 days; $P = .057$; Fig. 3); this was driven by a numerically larger proportion of delayed RCR surgery patients with inpatient stays of over 3 weeks (47.9%), compared with 40.9% of early RCR patients (Table II; $P = .051$). Correspondingly, the mean inpatient costs
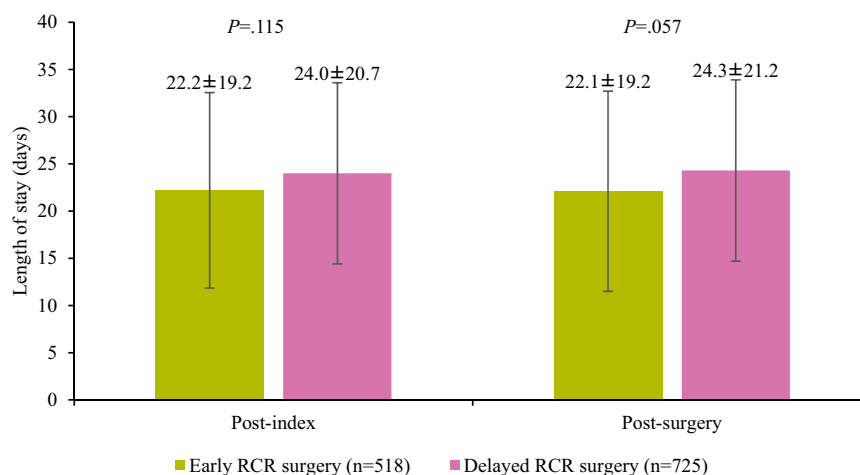
Figure 3 Mean inpatient hospital length of stay during the 12-month postindex and postsurgery periods in early vs. delayed RCR surgery groups. Error bars represent standard deviations. *P* values generated from two-sample t-tests compared between early and delayed surgery groups. *RCR*, rotator cuff repair.

during the 12-month postsurgery period were higher in patients with delayed RCR surgery (¥1,260,066 vs. ¥1,119,381; *P* < .05), compared with those who had early RCR surgery (Fig. 4). For patients with early RCR surgery, the mean inpatient costs were numerically lower postsurgery compared with the postindex period (¥1,199,381 vs. ¥1,205,276), whereas for delayed RCR surgery patients, costs were higher during the postsurgery period compared with the postindex period (¥1,260,066 vs. ¥1,242,990; Fig. 4).

Outpatient services

Almost all RCR surgery patients had at least one outpatient office visit during the 12-month postindex period (Table III). Patients with delayed RCR surgery had a higher mean number of PT visits compared with early RCR surgery patients (Fig. 5), particularly during the postsurgery period (42.6 vs. 38.4; *P* < .05). This also translated to significantly higher mean PT costs for delayed RCR patients (*P* < .05 for both postindex and postsurgery periods; Table III). Overall outpatient costs were higher with delayed RCR surgery compared with early RCR surgery during both the postindex and postsurgery periods (both *P* < .05; Fig. 6).

Pain management and medication use

During the 12-month postindex period, higher proportions of delayed RCR surgery patients received both opioids (22.1% vs. 16.2%; *P* < .05) and nonopioid pain medications (77.7% vs. 69.5%; *P* < .05), compared with early RCR surgery patients (Fig. 7A). Delayed RCR surgery patients also had a significantly higher mean (SD) number of outpatient pain medication prescriptions (5.2 [4.8]), compared with early RCR surgery patients (4.4 [4.5]) during the postindex period (*P* < .05; Table IV).

In terms of corticosteroid use, significantly higher proportions of delayed RCR surgery patients received cortisone injections (47.2% vs. 33.8%) and oral cortisone (4.8% vs. 1.4%) during the postindex period, compared with early RCR surgery patients (Fig. 7; both *P* < .05). The mean number of cortisone injections (2.9 vs. 1.9; *P* < .05) was also significantly higher among those with delayed RCR surgery than early RCR surgery (Table IV). A similar numerical trend was observed in the mean number of oral cortisone prescriptions for delayed RCR surgery (2.6 vs. 2.3 for early surgery), but this was not statistically significant (*P* = .777).

Fewer differences were seen between the early and delayed RCR groups during the postsurgery period. The percentage of patients receiving nonopioid medications were similar between early and delayed RCR surgery patients (60.6% vs. 55.9%; *P* = .094; Fig. 7B). The proportion of patients with cortisone injections (22.6% vs. 20.4%; *P* = .356) was also similar between early and delayed groups (Fig. 7B). Nevertheless, the mean number of cortisone injections during post-surgery period was significantly higher for patients with delayed RCR surgery, compared with early RCR surgery patients (mean [SD]: 2.8 [3.1] vs. 2.1 [1.6]; *P* < .05). The overall mean outpatient pharmacy prescription costs were significantly higher with delayed RCR surgery than early RCR surgery for both the 12-month postindex and postsurgery period (Table IV; *P* < .05 for both periods). The mean outpatient pharmacy prescription costs were higher during the postsurgery period compared with the postindex period in both early and delayed RCR groups.

Discussion

This analysis was a retrospective study of a large claims database in Japan to identify patients with RCT, in order to show the differences in HCRU between patients who received early RCR surgery and delayed RCR surgery. We utilized a nationwide claims database, which allowed for longitudinal follow-up of patients postdiagnosis and postsurgery.

Treatment patterns in patients with early vs. delayed RCR surgery

Even prior to treatment, Japanese patients may face a delay in obtaining an accurate RCT diagnosis. Almost half (46.3%) of RCR surgery patients first received a broader initial diagnosis of tendinosis; these patients received a more accurate RCT diagnosis only 5.7 months later. RCT diagnosis is known to be challenging in Japan, as a proportion of patients with shoulder pain may use over-the-counter pain medication or visit general orthopedists instead of presenting to a shoulder specialist for a formal diagnosis[9]; patients who receive a diagnosis from nonspecialists may be given inaccurate or nonspecific diagnoses,[2] leading to a delay in the optimal management of RCT even before RCR surgery.

In this analysis, patients received an RCR surgery on average of 2.4 months after their RCT diagnosis, with less than half receiving surgery within a month of diagnosis. Time to RCR surgery was shorter in a similar US analysis, where patients had an RCR surgery
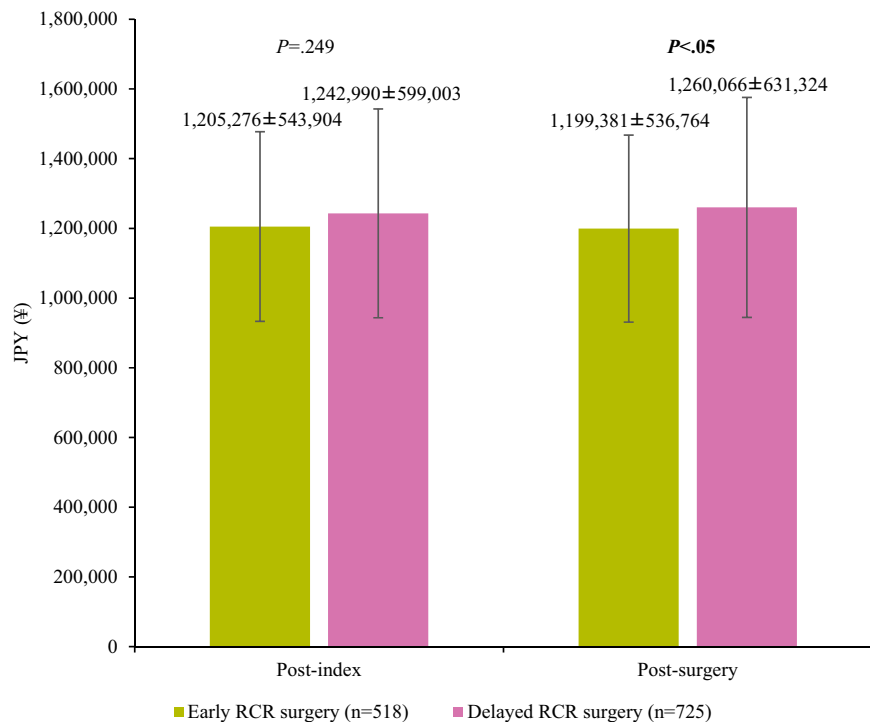
Figure 4 Mean RCT-related inpatient costs during the 12-month postindex and postsurgery periods in the early vs. delayed RCR surgery groups. Error bars represent standard deviations. *P* values generated from two-sample t-tests compared between early and delayed surgery groups. *JPY*, Japanese Yen; *RCR*, rotator cuff repair; *RCT*, rotator cuff tear.

Table III
RCT-related outpatient services and costs in early vs. delayed RCR surgery groups.

RCT-related healthcare utilisation and costs	Early RCR surgery		Delayed RCR surgery		P values[*]	
	Post-index N = 518	Post-surgery N = 518	Post-index N = 725	Post-surgery N = 725	Post-index	Post-surgery
Outpatient office visits						
Patients with an office visit, % (N)	97.9% (507)	97.9% (507)	100.0% (725)	99.6% (722)	**<.001**	**.005**
Mean number of office visits, n (SD)	44.8 (29.7)	43.7 (30.3)	49.0 (29.4)	47.1 (32.4)	**.014**	.060
Mean outpatient office visit costs, ¥ (SD)	¥230,976 (¥131,833)	¥208,416 (¥130,551)	¥278,126 (¥256,946)	¥233,837 (¥261,517)	**<.001**	**.025**
PT visits						
Patients with a PT visit, % (N)	94.4% (489)	94.4% (489)	97.1% (704)	96.6% (700)	**.017**	.067
Mean number of PT visits, n (SD)	38.1 (26.7)	38.4 (27.4)	40.7 (27.6)	42.6 (30.2)	.103	**.013**
Mean PT visit costs, ¥ (SD)	¥75,763 (¥56,220)	¥76,268 (¥57,443)	¥82,904 (¥61,092)	¥87,252 (¥67,031)	**.038**	**.003**
Mean total outpatient costs, ¥ (SD)	¥249,528 (¥154,057)	¥225,893 (¥152,213)	¥299,708 (¥268,007)	¥251,726 (¥273,143)	**<.001**	**.034**

PT, physical therapy; *RCR*, rotator cuff repair; *RCT*, rotator cuff tear; *SD*, standard deviation.
P values in bold indicate where the differences between early and delayed RCR surgery groups were statistically significant.
   [*]Chi-squared tests were conducted for categorical variables and two-sample t-tests were conducted for continuous variables.

approximately 1.7 months after diagnosis.[21] As degenerative RCTs do not heal spontaneously,[30] delays in obtaining appropriate diagnosis and treatment can lead to worse outcomes for RCT patients, due to increasing tear size, muscle atrophy, and fatty infiltration.[1,7] In particular, fatty infiltration, which is an irreversible process characterized by muscle fiber atrophy, fibrosis, and accumulation of fats within and around the rotator cuff muscles, has been found to be associated with poor clinical outcomes even after RCR surgery.[13,20]

Patients presenting with worse stages of fatty infiltration may be more likely to be faced with failed RCR surgeries (retear recurrences).[20] Studies of RCR surgery in other countries, including a small retrospective chart review in Greece,[7] a retrospective study in the United Kingdom,[3] and a large database study in the United States,[5] have similarly showed that delayed RCR surgery (variously defined as more than 3 weeks, 6 months, or 12 months after diagnosis) can result in worse clinical outcomes and a higher risk of retears. This is consistent with the results of our analysis, which showed a higher proportion of repeat RCR surgeries among patients who had a delayed initial RCR surgery in Japan, compared with patients who received RCR surgery within one month of diagnosis. Overall, total RCT-related healthcare costs were higher for delayed RCR surgery patients compared with early RCR surgery patients, which is in line with the findings from a retrospective database analysis by Parikh et al of RCT patients in the United States.[21]

Inpatient admissions

There were higher inpatient costs incurred with delayed RCR surgery than early RCR surgery, indicating that greater HCRU burden is associated with delayed RCR surgery, which was particularly significant during the postsurgery period. The higher inpatient costs may largely be attributed to longer mean lengths of inpatient stay for delayed RCR. The mean length of hospital stay after surgery was over 22 days among Japanese RCR surgery
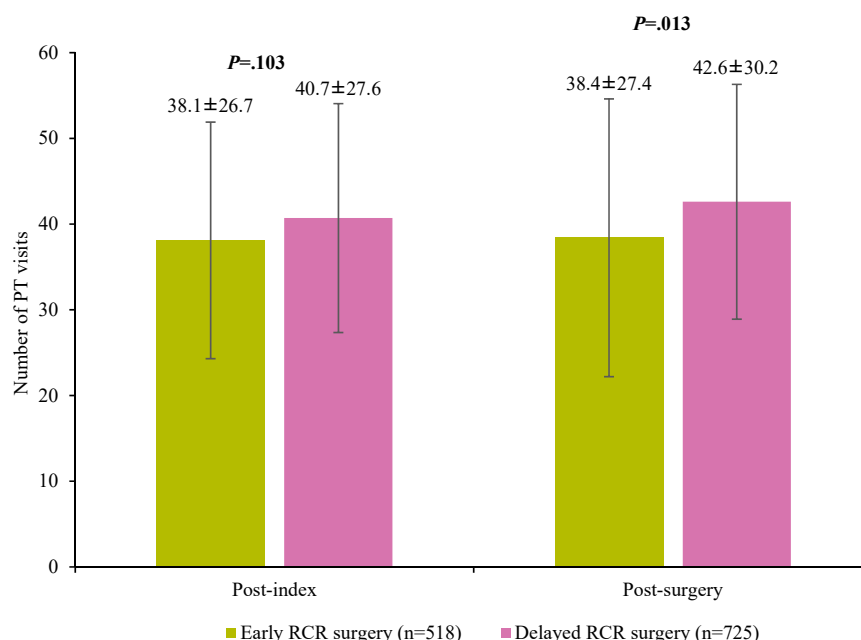
Figure 5 Mean number of PT visits during the 12-month postindex and postsurgery periods in the early vs. delayed RCR surgery groups. Error bars represent standard deviations. *P* values generated from two-sample t-tests compared between early and delayed surgery groups. *PT*, physical therapy; *RCR*, rotator cuff repair.
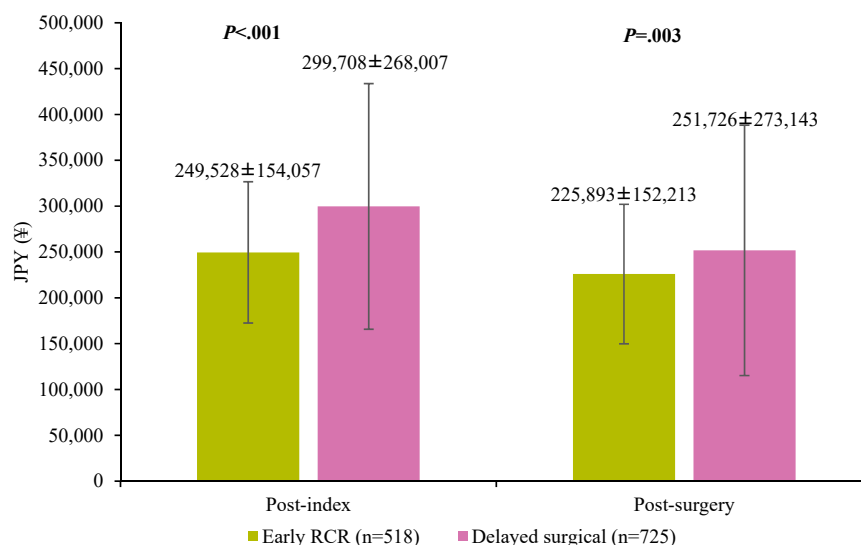

Figure 6 Mean RCT-related outpatient costs during the 12-month postindex and postsurgery periods in the early vs. delayed RCR surgery groups. Error bars represent standard deviations. *P* values generated from two-sample t-tests compared between early and delayed surgery groups. *JPY*, Japanese Yen; *RCR*, rotator cuff repair; *RCT*, rotator cuff tear.

patients in both the early and delayed groups, where over 40% of patients stayed in hospital for more than 3 weeks. This is longer than that reported in most other countries; for instance, in the United States, the post-RCR mean length of stay for those with inpatient admissions was reported to be approximately 3 days, with most RCRs conducted on an outpatient basis.[21]

Compared with other developed countries, such as Germany, France, and the UK, the average length of hospital stays in Japan are known to be over twice as long.[16,29] There is evidence that nonclinical factors, such as geographical location and structural characteristics, contribute to prolonged stays[16,29]; eg, patients may extend their postoperative stays in the hospital due to a lack of suitable discharge community rehabilitation facilities in rural areas, particularly as costs associated with hospital stays are largely covered by the national health insurance schemes.

Studies in other surgery types in Japan have indicated that increased postsurgical lengths of stay could also be due to clinical factors, such as surgical complications, postoperative rehabilitation, and the need for revision surgery.[26,34] In the context of universal health insurance coverage in Japan, the increased burden of postsurgery hospitalization among the delayed surgery group in this study may thus indicate an unmet need for improvements in RCT treatment. Timely diagnosis and surgery could shorten the postsurgery recovery process in line with national initiatives to reduce inpatient HCRU at acute hospitals.[8,11] In the current study, early RCR surgery patients reported a
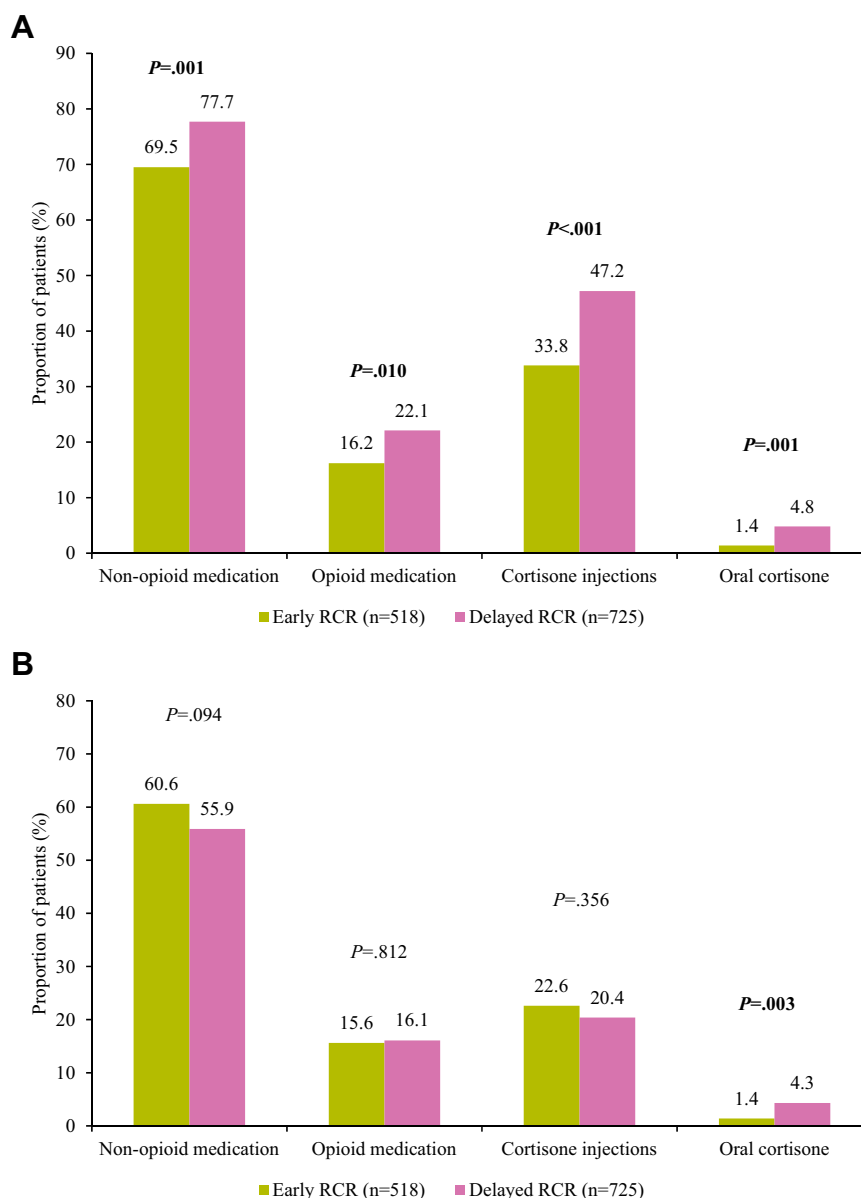
Figure 7 Pain medication use in early and delayed RCR surgery groups during the 12-month (A) postindex and (B) postsurgery periods. *P* values generated from two-sample t-tests compared between early and delayed surgery groups. *RCR*, rotator cuff repair.

small reduction in the mean postsurgery lengths of stay compared with delayed RCR surgery (22.1 days vs. 24.3 days); however, given the initial delay in obtaining an RCT diagnosis, even patients with early RCR surgery may have had substantial progression in their RCTs by the time they received surgery.

While the literature indicates that patients with both early and delayed RCR surgery are likely to show an improvement in clinical outcomes,[3,23] one single-center study in the United Kingdom showed that patients with earlier RCR surgery had almost double the improvement in average Oxford Shoulder Scores compared with delayed RCR surgery patients.[3] In a UK case-control study, delayed RCR surgery patients were reported to have a significantly longer recovery time than early RCR surgery patients; patients with delayed RCR surgery were also more likely to need dermal interposition grafts, following a failure to achieve direct repair.[23]

Outpatient services

On average, patients with delayed RCR surgery had significantly more outpatient office visits than those with early RCR surgery both postindex and postsurgery, indicating again that increased HCRU may be associated with delayed RCR surgery. Studies have shown that RCTs may continue to worsen over time in the long term with nonoperative treatment.[19] This may lead to higher resource use and costs to manage the pain associated with the tear, as well as limited mobility and decreased strength.[19] Delayed RCR surgery patients had greater overall outpatient costs during the postindex period compared with the postsurgery period. As the postindex period encompasses the presurgery period, this could be indicative of the substantial healthcare resource, and subsequently, costs accrued during the period while patients are waiting for surgery. During the postindex period, all patients with delayed RCR surgery had

Table IV
RCT-related pain management and medication use in early vs. delayed RCR surgery groups.

RCT-related healthcare utilisation and costs	Early RCR surgery		Delayed RCR surgery		P value[*]	
	Post-index N = 518	Post-surgery N = 518	Post-index N = 725	Post-surgery N = 725	Post-index	Post-surgery
Pain medication						
Patients with nonopioid pain medication use, % (N)	69.5% (360)	60.6% (314)	77.7% (563)	55.9% (405)	**.001**	.094
Salicylates, % (N)	4.6% (24)	4.4% (23)	3.0% (22)	2.8% (20)	.141	.110
NSAIDs, % (N)	58.5% (303)	48.1% (249)	64.8% (470)	42.6% (309)	**.023**	.057
Other nonopioid pain medication, % (N)	46.3% (240)	39.0% (202)	58.5% (424)	37.8% (274)	**<.001**	.667
Patients with opioid pain medication use, % (N)	16.2% (84)	15.6% (81)	22.1% (160)	16.1% (117)	**.010**	.812
Opiate agonists, % (N)	15.4% (80)	14.9% (77)	21.8% (158)	15.9% (115)	**.005**	.631
Opiate partial agonists, % (N)	1.2% (6)	1.0% (5)	0.6% (4)	0.4% (3)	.238	.231
Number of outpatient pain prescriptions, mean (SD)	4.4 (4.5)	4.3 (4.5)	5.2 (4.8)	4.4 (4.2)	**.003**	.691
Outpatient prescription costs, mean (SD)	¥81,649 (¥113,554)	¥75,487 (¥112,436)	¥109,780 (¥260,198)	¥99,958 (¥282,734)	**.010**	**.035**
Cortisone						
Patients with cortisone injections, % (N)	33.8% (175)	22.6% (117)	47.2% (342)	20.4% (148)	**<.001**	.356
Number of cortisone injections, mean (SD)	1.9 (1.5)	2.1 (1.6)	2.9 (2.8)	2.8 (3.1)	**<.001**	**.018**
Patients with cortisone oral use, % (N)	1.4% (7)	1.4% (7)	4.8% (35)	4.3% (31)	**.001**	.003
Number of cortisone oral use, mean (SD)	2.3 (2.6)	2.4 (2.9)	2.6 (2.2)	2.8 (2.5)	.777	.738

NSAID, non-steroidal anti-inflammatory drug; *RCR*, rotator cuff repair; *RCT*, rotator cuff tear; *SD*, standard deviation.
P values in bold indicate where the differences between early and delayed RCR surgery groups were statistically significant.
  [*]Chi-squared tests were conducted for categorical variables and two-sample t-tests were conducted for continuous variables.

outpatient visits, whereas a small number of patients with early RCR surgery did not require any outpatient visits, including PT visits. The mean number of outpatient visits was correspondingly smaller for early RCR surgery patients compared with patients who had delayed RCR surgery. PT is commonly used as a part of first-line treatment in newly diagnosed symptomatic RCT patients to help manage pain, strengthen muscles in the shoulder, and increase range of motion.[19,22] A conservative rehabilitation program, requiring prolonged PT, may be required for patients with larger or more complex tears due to delayed surgery.[31]

PT is also used for postsurgical rehabilitation after RCR surgery.[31] The mean number of PT visits by patients with delayed RCR surgery during the postsurgery period was significantly higher than early RCR surgery; more PT may be needed postsurgery to aid the patient's pain management as well as to improve mobility and strength of the shoulder when RCR surgery is delayed. The results of our analysis align with a trial conducted in Korea, which compared the clinical scores of RCT patients who received immediate RCR surgery against those who received delayed RCR surgery, after preoperative rehabilitation for shoulder stiffness.[12] The study found no clear advantage of delaying RCR surgery for preoperative PT, suggesting that immediate RCR surgery should be recommended in order to avoid HCRU associated with unnecessary rehabilitation.[12]

Pain management and medication use

Generally, in both the postindex and postsurgery periods, patients with delayed RCR surgery required more medications and corticosteroid use to manage their pain compared with early RCR surgery patients; this also led to higher associated outpatient prescription costs for patients with delayed RCR surgery. Postindex, significantly greater proportions of the delayed RCR surgery group compared to the early RCR surgery group received nonopioids and opioids, suggesting that these patients faced a higher burden of pain management. This indicates that delayed RCR surgery can result in the use of unnecessary pain medications that could have otherwise been avoided with earlier surgery. Patients with delayed RCR surgery had more pain medication prescriptions during the postindex period compared with the postsurgery period, indicating a substantial burden of conservative pain management incurred during the presurgery period in attempts to delay more effective but invasive treatment like surgery.[15]

Additionally, the higher use of opioid pain medication associated with delayed RCR surgery compared to early RCR surgery is of particular interest as multiple studies have reported that opioid use is an indicator for poor outcomes with regard to range of motion and strength in shoulder surgeries.[4,6,24,28,32] A retrospective study of a large healthcare database in the United States showed that RCTs have been associated with a high prevalence of opioid prescription as a mode of nonoperative treatment.[6] The potential for opioid misuse due to their addictive nature has given clinicians the added consideration of exercising caution when prescribing opioid medication intended to manage the pain from RCTs, in order to avoid opioid dependence.[24] The results of this study indicate that early RCR surgery could help reduce chronic pain medication use and thus reduce the potential for opioid misuse.

Cortisone injections and oral cortisone were also higher during the postindex period in patients with delayed RCR surgery than in those with an early RCR surgery, similarly suggesting a higher burden of pain management associated with delayed surgery. A higher use of steroid injections as conservative treatment prior to surgery may worsen the outcomes of RCR surgery.[33] For instance, the American Academy of Orthopaedic Surgeons guidance states that the integrity of the rotator cuff may be compromised by multiple steroid injections, consequently reducing chances of a successful repair.[1] This is congruent with the higher number of patients who required a second RCR surgery in patients with delayed RCR surgery in our analysis.

Limitations

As the data source is from health insurance societies, there are limited data from persons aged ≥65 and none aged ≥75.[17] Therefore, this analysis is representative of the burden of RCT among the working age population in Japan. While the findings on differences between early and delayed surgery may still be relevant to RCR patients elsewhere, the absolute numerical data on inpatient admissions and length of stay may be unlikely to be generalizable to other developed countries due to the long hospital stays that are characteristic of patient management in Japan.

Additionally, there are many varied techniques and modes of RCR surgery, such as open or arthroscopic to access the RCT, synthetic, auto- or allograft, to replace tendons and different forms of sutures,[18,27] which may have an impact on patient outcomes, costs, and HCRU. With the available data, it was not possible to determine

the type of RCR surgery that was carried out, which may have been a confounding factor in the differences between the early and delayed RCR surgery groups.

There was also a lack of information on social and financial factors as well as limited clinical data available on the included patients, including factors, such as whether the RCT was acute or chronic, the method of diagnosis, size of tears, length of symptoms, chronicity of the tear, or Goutallier classifications, all of which may have impacted the decision for and timing of surgery as well as the amount of postoperative rehabilitation and PT required. Future studies could conduct multivariable analyses to account for these potential confounding variables. While clinician validation was sought in identifying relevant diagnosis codes aiming to be sensitive and specific for identifying RCT patients (Supplementary Table S1), the choice of eligible diagnosis codes could still have introduced selection bias in the enrolled sample.

Furthermore, postindex, presurgery data could have provided additional insights on the comparison of treatment patterns before and after RCR surgery in Japan. In this analysis, patients were only followed-up for 12 months postindex and postsurgery. Future research could focus on longer follow-up periods in order to confirm the impact of delayed RCR surgery on HCRU in the longer term. In addition, treatment with over-the-counter drugs was not included in the analysis, as this was not covered by the JMDC database.

Data sharing statement

The data sets analyzed in this study can be purchased from JMDC. However, the authors cannot share the data with any third parties or make the data publicly available due to protections around the sharing of private health data.

Conclusions

There are long delays in the diagnosis and treatment of RCT in Japan. Timeliness is an important factor in the management of RCT, as lack of appropriate treatment could result in further degeneration of the rotator cuff over time. Patients with delayed RCR surgery may require more pain medications, cortisone, and/or PT before and after surgery in order to manage their RCT pain. Improving the timeliness of RCR surgery can therefore reduce overall HCRU.

Acknowledgments

Disclaimers:

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.xrrt.2024.09.004

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