

Identifying Factors Predicting Prolonged Rehabilitation After Simultaneous Bilateral Total Knee Arthroplasty: A Retrospective Observational Study

Shu Takagawa

Yokohama City University Medical Center: Yokohama Shiritsu Daigaku Fuzoku Shimin Sogo Iryo Center

<https://orcid.org/0000-0002-3993-026X>

Naomi Kobayashi (✉ naomik58@aol.com)

Yokohama City University Medical Center: Yokohama Shiritsu Daigaku Fuzoku Shimin Sogo Iryo Center

<https://orcid.org/0000-0002-2419-0860>

Yohei Yukizawa

Yokohama City University Medical Center: Yokohama Shiritsu Daigaku Fuzoku Shimin Sogo Iryo Center

Takayuki Oishi

Yokohama City University Medical Center: Yokohama Shiritsu Daigaku Fuzoku Shimin Sogo Iryo Center

Masaki Tsuji

Yokohama City University Medical Center: Yokohama Shiritsu Daigaku Fuzoku Shimin Sogo Iryo Center

Toshihiro Misumi

Yokohama city university School of Medicine

Yutaka Inaba

Yokohama City University School of Medicine Graduate School of Medicine: Yokohama Shiritsu Daigaku Igakubu Daigakuin Igaku Kenkyuka

Research article

Keywords: total knee arthroplasty, rehabilitation, length of hospital stay, hemoglobin, delayed discharge

Posted Date: October 26th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-95686/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Version of Record: A version of this preprint was published at BMC Musculoskeletal Disorders on April 20th, 2021. See the published version at <https://doi.org/10.1186/s12891-021-04211-x>.

Abstract

Background: Rehabilitation is an effective procedure for promoting functional recovery after simultaneous bilateral total knee arthroplasty (TKA); however, it has been cited as the single largest economic burden of medical care spending. Risk factors affecting prolonged rehabilitation utilization after simultaneous bilateral TKA have not been identified. We hypothesized that preoperative factors, including age, sex, body mass index, living alone, the knee society function score (KSS), the American society of anesthesiologists (ASA) grade, hemoglobin (Hb), albumin level, mean range of motion, and the Kellgren–Lawrence grade, would predict prolonged rehabilitation utilization.

Methods: A total of 191 patients undergoing simultaneous bilateral TKA in a single hospital were enrolled. The successful compliance group included patients who completed their rehabilitation program and were able to return to their residence within 3 weeks after surgery (n=132), whereas the delayed group included the remaining patients (n=59). Logistic regression analysis was performed using preoperative factors. A prediction scoring system was created using the regression coefficients from the logistic regression model.

Results: Logistic regression analysis revealed that age ($\beta=-0.0870$; $P<0.01$) and Hb ($\beta=0.34$; $P<0.05$) were significantly associated with prolonged rehabilitation programs, whereas body mass index (BMI), living alone, the KSS score, and the ASA class were not significantly associated with successful completion of rehabilitation programs; however, these factors contributed to the prediction scoring formula, which was defined as: $\text{score} = 10 - (0.09 \times \text{age}) - (0.09 \times \text{body mass index}) - (0.56 \times \text{living alone [alone: 1, others: 0]}) + (0.03 \times \text{KSS stairs}) + (0.34 \times \text{Hb}) - (1.1 \times \text{ASA class})$. The C-statistic for the scoring system was 0.748 (95% confidence interval, 0.672–0.824). The optimal cutoff point for balancing sensitivity and specificity was 3.5, with 66.6% sensitivity and 78.0% specificity.

Conclusions: Older age and lower preoperative Hb were significantly associated with prolonged rehabilitation programs. We defined a new scoring formula using preoperative patient factors to predict prolonged rehabilitation utilization in patients undergoing simultaneous bilateral TKA.

1. Background

Total knee arthroplasty (TKA) is a reliable treatment for damaged knee joints and provides excellent long-term results with respect to pain relief and functional restoration in patients with osteoarthritis [1]. As knee osteoarthritis has historically been considered an asymmetric disease [2], contralateral knee osteoarthritis is common in patients with end-stage unilateral osteoarthritis who undergo TKA [3]; therefore, simultaneous bilateral TKA has been commonly performed [4]. Rehabilitation is an effective procedure for promoting functional recovery; however, it has been cited as the single largest economic burden of medical care spending [5].

A previous systematic review has reported on the risk factors for prolonged hospital stay [6], and few studies have reported on the risk factors for increased duration of rehabilitation utilization [5, 7].

Therefore, predicting the duration of rehabilitation utilization among simultaneous bilateral TKA cases using a preoperative scoring system will be beneficial.

This study aimed to determine the risk factors that predict prolonged rehabilitation utilization after simultaneous bilateral TKA. In addition, we created a new scoring system to predict the necessary duration of physiotherapy after simultaneous bilateral TKA and evaluated the predictive ability of the model.

2. Methods

2.1. Description of population

This retrospective observational study was approved by the institutional review board of the authors' institutional review board of Yokohama City University (B190700017), and informed consent was obtained from all patients. Inclusion criteria for the current study included patients whose knees were treated with simultaneous bilateral TKA between January 2014 and December 2018 in a single hospital. In total, 212 patients met the inclusion criteria. We excluded 18 patients with rheumatoid arthritis, 7 patients who could not participate in rehabilitation program, and 3 with missing preoperative physical data. Finally, a total of 191 patients were enrolled in the study (Fig. 1). All patients were diagnosed with osteoarthritis.

2.2. Surgical interventions and postoperative treatments

Bilateral TKAs were performed sequentially by one team comprising five experienced orthopedic surgeons. General anesthesia with peripheral nerve block was used for all patients, except for those who did not agree with or could not undergo peripheral nerve block owing to complications. A lateral curved longitudinal skin incision and midvastus approach was employed. Intra- and extramedullary techniques were used for the placement of femoral and tibial cutting guides, respectively. A modified gap-balancing technique was employed. A tourniquet was inflated before incision and deflated after cement hardening. The Scorpio NRG® posterior-stabilized prostheses (Stryker Orthopedics, Mahwah, NJ, USA) were used in all cases.

All patients, except those with anemia (hemoglobin [Hb] < 11.0 g/dL), underwent two 400 mL autologous blood collections prior to surgery. Postoperative autologous blood transfusion of 800 mL was performed within 3 days after surgery, independent of Hb levels. Postoperative pain management comprised non-steroidal anti-inflammatory drugs for internal use with an additional acetaminophen infusion, when required. Rehabilitation was started on the day following surgery and continued until discharge. Full weight bearing was allowed from the day after the surgery. Patients underwent a stepwise program to achieve the ability to use a wheelchair, followed by walking using a walker and T-cane, depending on compliance. In our facility, the rehabilitation goal was set within 3 weeks post-surgery following the clinical pathway. Patients generally could not be discharged on time if stable independent walking with a T-cane and stepping up and down the stairs were not achieved within 3 weeks postoperatively. Patients

were informed that a hospital transfer would be required if rehabilitation programs needed more than 3 weeks. Patients were discharged to their homes when they were able to walk using a T-cane and step up and down the stairs on their own.

2.3. Data collection

Patient data, including age, sex, body mass index (BMI), living alone, the Knee Society function score (KSS) [8], the American Society of Anesthesiologists (ASA) grade, preoperative Hb levels (g/dL), serum albumin (Alb) level (g/dL, measured 8 weeks prior to surgery before autologous blood collection), mean range of motion (average of the two sides), and mean Kellgren–Lawrence classification (K–L grade, average of the two sides), were collected from the hospital's computer databases [9]. All parameters were obtained from the medical records at the time of preoperative outpatient examination and through patient interviews. The rehabilitation program utilization was calculated as the duration from the date of operation to the date of discharge from the hospital to the patient's home. Patients who were transferred to other hospitals due to delayed rehabilitation were analyzed separately as transferred cases. Patients who were able to return to their residence within 3 weeks after surgery were assigned to the compliance group (n = 132), whereas those who were unable to do so and transferred patients were assigned to the delayed group (n = 59).

2.4. Statistical analysis

Values are expressed as mean \pm standard deviation (SD). Compliance and delayed groups were defined as dependent variables. Age, sex, BMI, living alone, KSS, the ASA grade, Hb levels, Alb levels, mean range of motion, and the K–L grade were defined as predictor variables. The Mann–Whitney U test and chi-square test were used to compare preoperative parameters between the groups. Multivariate logistic regression analysis using a forward-backward stepwise selection method was performed to determine factors that influenced successful compliance or prolonged rehabilitation programs. According to the methods of Sullivan et al. [10] and Oba et al. [11], a prediction scoring formula was created using the multivariate logistic regression model results.

Briefly, factors with $P < 0.25$ were used to create the prediction scoring system. Scores were calculated by adding the results of multiplications between each independent factor and its coefficient β . To simplify the formula, up to three significant digits of the coefficient β were used. Ten points were added to the formula to make the score positive. C-statistics were used to assess the predictive ability of the model. Patients were stratified according to their score, and the observed probability of being in the compliance or delayed group was assessed. All statistical analyses were performed using the JMP 12.2 software (SAS Institute Inc., Cary, NC, USA). $P < 0.05$ was considered statically significant.

3. Results

The distribution of the required rehabilitation duration is shown in Fig. 2. The range of duration of the compliance and delayed groups was 12–21 and 22–29 days, respectively (mean \pm SD: 18.5 \pm 1.8 and

23.6 ± 1.6 days, respectively). The mean duration of the delayed group excluded values from 13 transferred cases.

Patients in the delayed group were significantly older, used more walking aids, had a higher ASA class, and had lower Hb and Alb levels than those in the compliance group. No significant differences between the groups were observed in sex ratio, BMI, incidence of living alone, walking ability, stair-climbing ability, mean range of motion, and mean K–L grade. The delayed group included 13 transferred cases. Patients' data are summarized in Table 1. Table 2 shows the results of the logistic regression analysis, which indicated that age ($\beta = -0.0870$; $P = 0.0059$) and Hb ($\beta = 0.340$; $P = 0.0370$) were significantly associated with rehabilitation duration.

Table 1
Summary of patient data

All patients (n = 191)	Compliance group (n = 132)	Delayed group (n = 59)	P-value
Age			
< 60	4	1	
60–70	26	6	
70–80	76	25	
80–90	26	27	
Average	74.2 ± 6.4	77.9 ± 6.9	< 0.001 ^a
Female, %	83.3%	88.1%	0.393 ^b
Body mass index, kg/m²			
< 20	3	0	
20–25	38	20	
25–30	66	22	
30–35	22	13	
> 35	3	4	
Average	27.1 ± 3.7	27.7 ± 4.4	0.706 ^a
Living alone, %	15.9%	27.1%	0.077 ^b
Knee Society score			
Walking	24.5 ± 7.6	22.7 ± 7.5	0.138 ^a
Stairs	27.1 ± 9.4	23.2 ± 13.1	0.061 ^a
Walking aids used	3.5 ± 3.4	5.0 ± 4.9	0.043 ^a
Total	48.1 ± 16.0	41.6 ± 20.5	0.057 ^a
ASA class			
I	11	2	
II	119	51	

Values are presented as mean ± SD (range). P-values were obtained using the Mann–Whitney U test or chi-square test. ^aMann–Whitney U test; ^bchi-square test; n, number; ASA, American society of anesthesiologists; K–L grade, Kellgren–Lawrence classification.

All patients (n = 191)	Compliance group (n = 132)	Delayed group (n = 59)	P-value
□	2	6	
Average	1.93 ± 0.31	2.07 ± 0.36	0.009 ^a
Hemoglobin, g/dL	13.1 ± 1.1	12.6 ± 1.2	0.014 ^a
Albumin, g/dL	4.4 ± 0.3	4.3 ± 0.5	0.018 ^a
Mean range of motion			
Extension	12.7 ± 11.5	12.3 ± 9.4	0.704 ^a
Flexion	113.4 ± 18.9	114.5 ± 18.4	0.964 ^a
Mean K–L grade	3.86 ± 0.32	3.89 ± 0.24	0.753 ^a
Length of stay (days, excluding transferred cases)	18.5 ± 1.8	23.6 ± 1.6	< 0.001 ^a
Transferred cases, number	0	13	
Values are presented as mean ± SD (range). P-values were obtained using the Mann–Whitney U test or chi-square test. ^a Mann–Whitney U test; ^b chi-square test; n, number; ASA, American society of anesthesiologists; K–L grade, Kellgren–Lawrence classification.			

Table 2
Results of regression analysis

Variable	β	P-value	Odds ratio	CI (95%)	
				Lower	Upper
Age	-0.0870	0.00590	1.09	1.03	1.16
BMI	-0.0892	0.0565	1.09	0.998	1.20
Living alone	-0.563	0.165	0.579	0.257	1.27
Knee Society score: stairs	0.0267	0.140	0.978	0.948231	1.01
Hemoglobin, g/dL	0.340	0.037	0.712	0.511493	0.971
ASA class	-1.13	0.0724	3.09	0.964960	12.0
CI, confidence interval; BMI, body mass index; ASA, American society of anesthesiologists.					

The prediction scoring formula was created as follows: score = 10 – (0.09 × age) – (0.09 × BMI) – (0.56 × living alone [alone: 1, others; 0]) + (0.03 × KSS stairs) + (0.34 × Hb) – (1.1 × ASA class). Table 3 shows the

formula and the observed probability of being in the compliance group for scores of 0–7 points.

Table 3
Scoring formula and the observed probability of required rehabilitation duration

Scoring formula		Outcomes				
Factors	Points	Total score	n	Compliance group	Delayed group	Observed probability of required rehabilitation duration conformance, %
	+ 10	0–1	1	0	1	0.0%
Age, (years)	× -0.09	1–2	9	2	7	22.2%
BMI	× -0.09	2–3	40	20	20	50.0%
Living alone	× -0.56	3–4	74	52	22	70.3%
KSS: stairs	× 0.03	4–5	47	41	6	87.2%
Hemoglobin, g/dL	× 0.34	5–6	13	11	2	84.6%
ASA class	× -1.1	6–7	7	6	1	85.7%
n, number; KSS, knee society score; BMI, body mass index.						

Figure 3 shows the receiver operating characteristic curve of the scoring system. The area under the curve was 0.748 (95% confidence interval [CI], 0.672–0.824). The optimal cutoff point for balancing sensitivity and specificity was 3.5, with 66.6% sensitivity and 78.0% specificity.

4. Discussion

The main point of clinical relevance in this study is the ability of preoperative factors to predict the likelihood of prolonged rehabilitation after simultaneous bilateral TKA. Based on our scoring formula, we predicted that less than half of the patients with a preoperative score < 3 points would not complete the rehabilitation programs and would not be able to return to their residence.

The role of rehabilitation programs is considered essential as patients rapidly recover independent movement and transfer capacities during this period; thus contributing to an early home discharge [7]. The mean length of stay (LOS) after TKA procedures has gradually decreased from 15 days to 5 days over the last few decades in Europe and the United States [6]; however, long-term hospitalization remains the norm in Japan [12]. In Japan, LOS after TKA included rehabilitation programs. The cutoff value was defined as 3 weeks in this study. The first reason for this is that the Japanese insurance system

(diagnosis procedure combination [DPC]) defined 22 days post-hospital admission as the target to proceed with TKA. Thus, the Japanese insurance system enforces the LOS goal within 3 weeks post-TKA as the acceptable clinical pathway. Second, in the early postoperative phase, the quadriceps strength is significantly lower than the preoperative levels [13], and it takes up to 3 weeks to restore lower extremity function to pre-surgery levels [14].

Older age was associated with decreased complication functional scores (as represented by the KSS score) and increased postoperative complication rates [15]. Blood management has the most significant impact on LOS after TKA, and correction of preoperative anemia with iron and/or erythropoiesis-stimulating agents helps in decreasing transfusion risk [16]. In accordance with past findings, our study identified older age and low preoperative Hb levels as factors with the strongest association with delayed achievement of rehabilitation programs after simultaneous bilateral TKA. In contrast, BMI, living alone, the KSS score, and the ASA class were not significantly associated with the achievement of rehabilitation programs but contributed to the prediction scoring formula.

Return to their residence after surgery is associated with multiple factors, including the patient's social background, which may influence the achievement of rehabilitation programs. Our study demonstrated a simple method to calculate scores at the time of scheduling surgery for outpatients. The prediction scoring system may facilitate social services when early discharge is likely and adjustment when transfer to a rehabilitation hospital is likely. For cases with lower scores under the 3.5-point cutoff value, pre-hospitalization interventions such as physical therapy for weight loss, lower limb strengthening, and/or introduction of home care services may be effective in improving the ability to return to their normal residence with the ability to move independently.

Several limitations in our study should be addressed. First, the sample size in this study was relatively small. Further studies with a larger sample size are required to validate the reliability of our scoring system. Second, we excluded patients with rheumatoid arthritis and those with postoperative complications. Patients with rheumatoid arthritis tend to have a lengthier duration of hospitalization and discharge to rehabilitation facilities than patients with osteoarthritis, independent of adverse events [17]. Third, the study population was predominantly Japanese, and the results may not be generalizable to other demographic groups. Additional investigations are needed to validate the scoring system in other countries and different situations.

5. Conclusion

We developed a new scoring system using preoperative patient factors that were able to predict delayed discharge in patients undergoing simultaneous bilateral TKA. Additional studies are warranted to confirm the value of this scoring system and improve its accuracy.

Abbreviations

TKA: total knee arthroplasty

KSS: knee society function score

ASA: American society of anesthesiologist

BMI: body mass index

Hb: hemoglobin

Alb: albumin

LOS: length of stay

DPC: diagnosis procedure combination

K-L: Kellgren-Lawrence classification

Declarations

Ethics approval and consent to participate:

Ethical approval for the study was obtained from the institutional review board of Yokohama City University (IRB No. B190700017). Informed and written consent was obtained from all patients.

Consent for publication:

Not applicable

Availability of data and materials:

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests

Funding:

There were no sources of funding for this study

Authors' contributions:

ST, NK, and YI designed the study; ST and MT analyzed the data; ST and NK wrote the manuscript; and YY, MT, and TO supervised the study. All authors read and approved the final manuscript.

Acknowledgements:

We thank all the patients involved in the study.

References

1. Kobayashi S, Niki Y, Harato K, Nagura T, Nakamura M, Matsumoto M. Rheumatoid arthritis patients achieve better satisfaction but lower functional activities as compared to osteoarthritis patients after total knee arthroplasty. *J Arthroplasty*. 2019;34:478-82.e1.
2. Metcalfe AJ, Andersson MLE, Goodfellow R, Thorstensson CA. Is knee osteoarthritis a symmetrical disease? Analysis of a 12 year prospective cohort study. *BMC Musculoskelet Disord*. 2012;13:153.
3. Gunther KP, Sturmer S, Sauerland S, Zeissig I, Sun Y, Kessler S, et al. Prevalence of generalised osteoarthritis in patients with advanced hip and knee osteoarthritis: the ulm osteoarthritis study. *Ann Rheum Dis*. 1998;57:717-23.
4. Lindberg-Larsen M, Pitter FT, Husted H, Kehlet H, Jorgensen CC, Lundbeck foundation centre for fast-track hip and knee replacement collaborative group. Simultaneous vs staged bilateral total knee arthroplasty: a propensity-matched case-control study from nine fast-track centres. *Arch Orthop Trauma Surg*. 2019;139:709-16.
5. Bettger JP, Green CL, Holmes DN, Chokshi A, Mather RC, Hoch BT, et al. Effects of virtual exercise rehabilitation in-home therapy compared with traditional care after total knee arthroplasty: VERITAS, a randomized controlled trial. *J Bone Joint Surg Am*. 2020;102:101-9.
6. Shah A, Memon M, Kay J, Wood TJ, Tushinski DM, Khanna V, et al. Preoperative patient factors affecting length of stay following total knee arthroplasty: a systematic review and meta-analysis. *J Arthroplasty*. 2019;34:2124-65.
7. Dauty M, Smitt X, Menu P, Dubois C. Which factors affect the duration of inpatient rehabilitation after total knee arthroplasty in the absence of complications? *Ann Phys Rehabil Med*. 2009;52:234-45.
8. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res*. 1989;248:13-4.
9. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthritis. *Ann Rheum Dis*. 1957;16:494-502.
10. Sullivan LM, Massaro JM, D'Agostino RB. Presentation of multivariate data for clinical use: the Framingham study risk score functions. *Stat Med*. 2004;23:1631-60.
11. Oba T, Makita H, Inaba Y, Yamana H, Saito T. New scoring system at admission to predict walking ability at discharge for patients with hip fracture. *Orthop Traumatol Surg Res*. 2018;104:1189-92.
12. Ishii Y, Noguchi H, Takeda M, Sato J, Suzuki T. Length of hospital stay with patient-dependent determination in bilateral. *Eur J Orthop Surg Traumatol*. 2014;24:961-5.
13. Bade MJ, Stevens-Lapsley JE. Restoration of physical function in patients following total knee arthroplasty: an update on rehabilitation practices. *Curr Opin Rheumatol*. 2012;24:208-14.

14. Kennedy DM, Stratford PW, Hanna SE, Wessel J, Gollish JD. Modeling early recovery of physical function following hip and knee arthroplasty. *BMC Musculoskelet Disord.* 2006;7:100.
15. Fang M, Noiseux N, Linson E, Cram P. The effect of advancing age on total joint replacement outcomes. *Geriatr Orthop Surg Rehabil.* 2015;6:173-9.
16. Monsef JB, Della Valle AG, Mayman DJ, Marx RG, Ranawat AS, Boettner F. The impact of blood management on length of stay after primary total knee. *Open Orthop J.* 2014;8:108-13.
17. Stundner O, Danninger T, Chiu YL, Sun X, Goodman SM, Russell LA, et al. Rheumatoid arthritis vs osteoarthritis in patients receiving total knee arthroplasty: perioperative outcomes. *J Arthroplasty.* 2014;29:308-13.

Figures

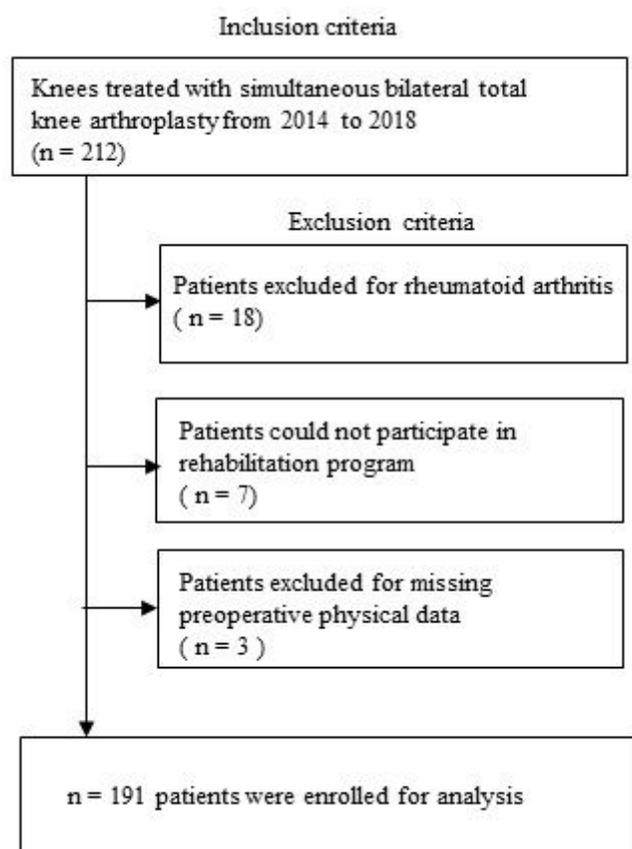


Figure 1

Inclusion and exclusion criteria for the study participants.

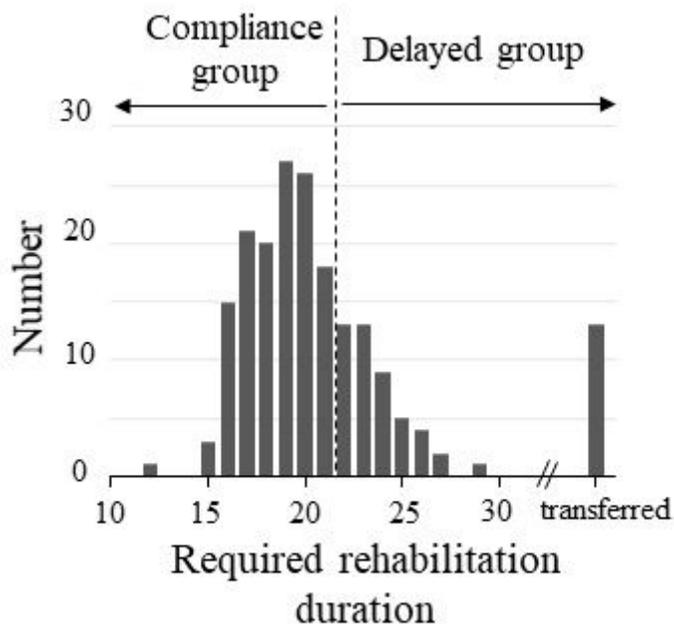


Figure 2

Distribution of the required rehabilitation durations. Patients who required a rehabilitation duration of less than 21 days after surgery were assigned to the compliance group. Patients with a required rehabilitation duration of over 21 days and transferred cases were assigned to the delayed group.

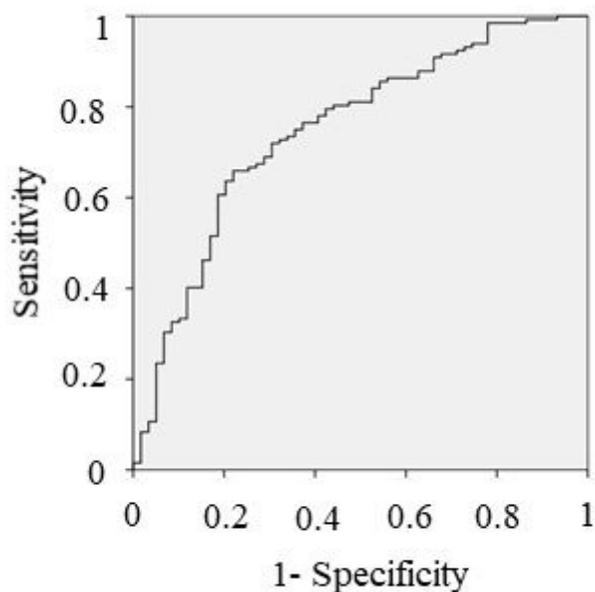


Figure 3

Prediction of compliance with the target. The figure depicts the prediction of compliance with the target of less than 3 weeks duration of required rehabilitation.