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Original Article

A Novel Method of Real-Time Assessment for Coronary Artery Anastomosis Skill

Kohei Abe,[1] Hiroyuki Nishi,[2] Kazuma Okamoto,[3] Hitoshi Yokoyama,[4] Hirokuni Arai,[5] Hitoshi Yaku,[6] Shuichiro Takanashi,[7] Hirofumi Takemura,[8] Tohru Asai,[9] and Young-Kwang Park[4]

Purpose: Coronary anastomosis is the most key factor to accomplish coronary artery bypass grafting, which is one of the largest areas in cardiovascular surgery. Although we have organized on-site simulator training courses of coronary anastomosis using BEAT YOUCAN, it became difficult to continue it because of COVID-19. Therefore, we established a real-time evaluation sheet instead of an Objective Structured Assessment of Technical Skills (OSATS) evaluation sheet. The purposes of this study was to develop the real-time assessment system and to prove the correlation between the score obtained by the OSATS and the score obtained by the real-time evaluation system.
Subjects and Methods: A total of 22 videos from the qualifying round of real-time coronary anastomosis competition evaluated by both the modified OSATS and the real-time evaluation system were utilized in this study. The global rating score of OSATS was compared with the global rating score of real-time evaluation system.
Results: When examined the relationship between the OSATS total score and the real-time total score, there was a significant correlation (R = 0.752, p <0.001). The OSATS general definition score and the real-time total score also showed a strong correlation (R = 0.733, p <0.001).
Conclusions: We developed a real-time assessment sheet to evaluate coronary anastomosis. This assessment sheet had a good correlation with the OSATS evaluation sheet.

Keywords: coronary, real time, simulation training, COVID-19, scoring system

[1]*Department of Cardiovascular Surgery, St. Luke's International Hospital, Tokyo, Japan*
[2]*Department of Cardiovascular Surgery, National Hospital Organization, Osaka National Hospital, Osaka, Osaka, Japan*
[3]*Department of Cardiovascular Surgery, Kindai University, Osakasayama, Osaka, Japan*
[4]*Department of Cardiovascular Surgery, Fukushima Medical University, Fukushima, Fukushima, Japan*
[5]*Department of Cardiovascular Surgery, Hokushin General Hospital, Nakano, Nagano, Japan*
[6]*Department of Cardiovascular Surgery, University Hospital Kyoto Prefectural University Hospital, Kyoto, Kyoto, Japan*
[7]*Department of Cardiac Surgery, Kawasaki Heart Center, Kawasaki, Kanagawa, Japan*
[8]*Department of Cardiovascular Surgery, Kanazawa University Hospital, Kanazawa, Ishikawa, Japan*
[9]*Department of Cardiovascular Surgery, Shonan Kamakura General Hospital, Kamakura, Kanagawa, Japan*

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Introduction

There is no controversy that coronary artery anastomosis is one of the key factors to accomplish coronary artery bypass surgery. We have dedicated to teaching young surgeons to perform coronary anastomosis on site and assessing the anastomosis by using the modified

Corresponding author: Kohei Abe. Department of Cardiovascular Surgery, St. Luke's International Hospital, 9-1 Akashicho, Chuo-ku, Tokyo 104-0044, Japan
Email: koabe@luke.ac.jp

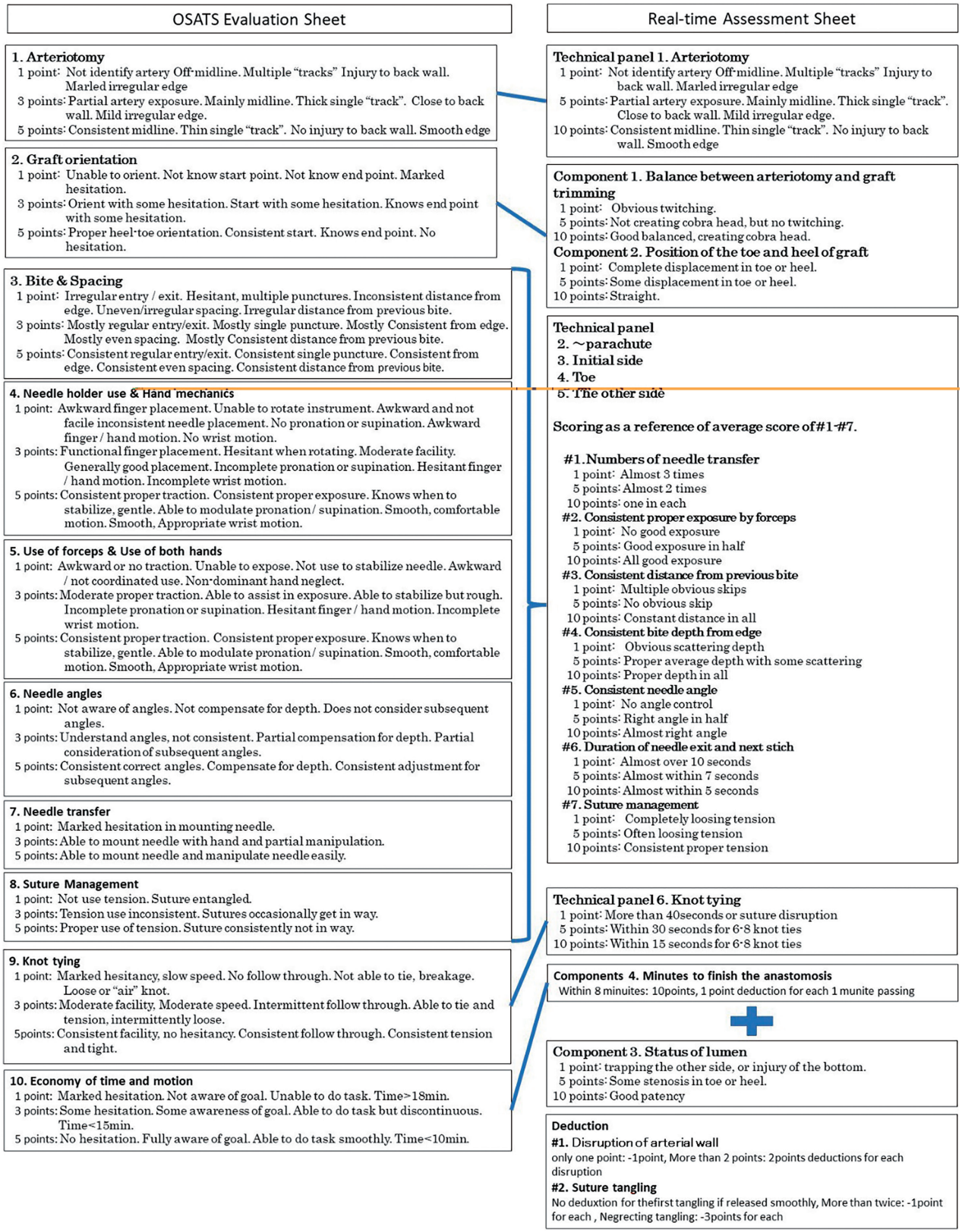

Fig. 1 Conversion from the OSATS evaluation sheet to the real-time evaluation sheet. Solutions composed with the OSATS evaluation sheet were converted into technical panel and component panel. Items of status of lumen and deduction were added to be able to evaluate the final condition. OSATS: Objective Structured Assessment of Technical Skills

Objective Structured Assessment of Technical Skills (OSATS) evaluation sheet,[1] which was originally invented by Reznick and colleagues[2] and adopted to evaluate coronary anastomosis by Fann and colleagues.[3] Nishi and colleagues[4] reported that evaluation of coronary artery anastomosis using the OSATS is useful. However, situations have been changed due to COVID-19 pandemic, which forced us to organize the online training system. At that moment, the Japanese Association for Coronary Artery Surgery asked us to perform the competition of coronary artery anastomosis online. Because we could not evaluate until finishing an anastomosis if we use the OSATS evaluation sheet, we developed the real-time assessment system to evaluate an anastomosis by getting inspiration from the International Skating Union (ISU) Judging System.[5] In this article, we evaluate the correlation between the modified OSATS and the real-time evaluation system.

Objectives

The first objective is to develop a real-time assessment system to evaluate coronary anastomosis. The second objective is to prove the correlation between the score obtained by the OSATS and the score obtained by the real-time evaluation system.

Development of real-time assessment system

The modified OSATS evaluation sheet has 10 individual scales, and each scale is graded from 1 to 5. Solutions composed with this OSATS evaluation sheet were converted into technical panel and component panel (**Fig. 1**). The technical panel consisted of arteriotomy, parachute, initial side, toe, the other side, and knot tie to be able to score immediately after each part is completed. Each part was graded from 1 to 10. On the other hand, the component panel consisted of balance between arteriotomy and graft trimming, position of the toe and heel of graft, status of lumen, and munities to finish the anastomosis. These components were also graded from 1 to 10 points in each part after an anastomosis was finished. Additionally, some deduction of points were given if there were disruption of arterial wall and/or suture tangling (**Fig. 2**). These scores were entered into the Google spreadsheet for aggregate calculation, and the average score became the final value of each part (**Fig. 3**). If judgment was performed by more than 5 evaluators, the highest and the lowest scores were deleted before averaging. The total score became 10 to 100 points because the real-time assessment sheet was composed of 10 parts.

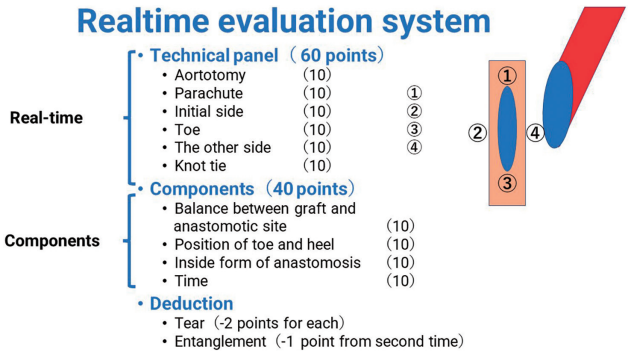

Fig. 2 Structure of real-time evaluation sheet. Each score of technical panel was entered just after finishing each part. Scores of components and deduction were entered after finishing an anastomosis

Training and averaging of judgments

The evaluation committee (KA, HN, and KO) and YP created the standard videos of 6 and 8 points in each part. During the competition, we recruited 16 experienced and cardiovascular (CV) surgery certified surgeons as judges. After checking these standard videos, they scored on audition videos. Each score was compared with the average score of evaluation committee members, and the feedback was applied if there was remarkable dissociation. This feedback was performed continuously during the competition.

Competition of coronary anastomosis

The competition was held on every Saturday for four consecutive weeks divided by experience years, Grade 1: medical students/1 to 2 years after graduate, Grade 2: 3 to 6 years after graduate, Grade 3: 7 to 10 years after graduate, and Grade 4: no limit for experience years. In each grade, applicants tossed their videos of making anastomosis. A total of 3 evaluators and 16 judges scored these videos by using the modified OSATS evaluation sheet. The next step was to check 4 to 8 videos on borderline of elected and defeated with the real-time evaluation system and to nominate the finalists by 3 evaluators and 4 judges. Finally, 3 to 5 finalists attended the online competition and performed coronary anastomosis, which were checked with the real-time evaluation system by 1 evaluator and 4 judges using the Google spreadsheet (**Fig. 4**). The online competitions were held via Zoom (**Fig. 5**).

	A	B	C	D	E	F	G
2	Total Score	60		points	Competiter No.	2	
3							
4	Technical panel	43		points			
5							
6		score		referring average points	Evaluation Items	Score	Evaluation Criteria
7	1. Arteriotomy	8			Arteriotomy	8	straight in the middle(5points)+Adequate length(5points)
8							
9	2. ~Parachute	7		6.85714			
10					Numbers of needle transfer	4	(one in each: 10points, almost twice: 5points, almost 3 times: 1point)
11					Consistent proper exposure by forceps	5	(All good exposure: 10points, Good exposure in half: 5points, No good exposure: 1point)
12					Consistent distance from previous bite	6	(Constant distance in all: 10points, No obvious skip: 5points, Multiple obvious skips: 1point)
13					Consistent bite depth from edge	7	(Proper depth in all: 10points, Proper average depth with some scattering: 5points, Obvious scattring depth: 1point)
14					Consistent needle angle	9	(Almost right angle: 10points, Right angle in half: 5points, No angle control: 1point)
15					Duration of needle exit and next stich	8	(Almost within 5 seconds: 10points, almost within 7 seconds: 7points, 10 seconds in half: 5points, almost over 10 seconds: 1point
16					Suture manegement	9	(Constant proper tensin: 10points、Often loosing tension: 5points、Completely loosing tension: 1point)
17	3. Initial side	8		7.71429			
18					Numbers of needle transfer	10	(one in each: 10points, almost twice: 5points, almost 3 times: 1point)
19					Consistent proper exposure by forceps	8	(All good exposure: 10points, Good exposure in half: 5points, No good exposure: 1point)
20					Consistent distance from previous bite	9	(Constant distance in all: 10points, No obvious skip: 5points, Multiple obvious skips: 1point)
21					Consistent bite depth from edge	9	(Proper depth in all: 10points, Proper average depth with some scattering: 5points, Obvious scattring depth: 1point)
22					Consistent needle angle	7	(Almost right angle: 10points, Right angle in half: 5points, No angle control: 1point)
23					Duration of needle exit and next stich	6	(Almost within 5 seconds: 10points, almost within 7 seconds: 7points, 10 seconds in half: 5points, almost over 10 seconds: 1point
24					Suture manegement	5	(Constant proper tensin: 10points、Often loosing tension: 5points、Completely loosing tension: 1point)
25	4. Toe	9		8.57143			
26					Numbers of needle transfer	8	(one in each: 10points, almost twice: 5points, almost 3 times: 1point)
27					Consistent proper exposure by forceps	9	(All good exposure: 10points, Good exposure in half: 5points, No good exposure: 1point)
28					Consistent distance from previous bite	9	(Constant distance in all: 10points, No obvious skip: 5points, Multiple obvious skips: 1point)
29					Consistent bite depth from edge	8	(Proper depth in all: 10points, Proper average depth with some scattering: 5points, Obvious scattring depth: 1point)
30					Consistent needle angle	10	(Almost right angle: 10points, Right angle in half: 5points, No angle control: 1point)
31					Duration of needle exit and next stich	6	(Almost within 5 seconds: 10points, almost within 7 seconds: 7points, 10 seconds in half: 5points, almost over 10 seconds: 1point
32					Suture manegement	10	(Constant proper tensin: 10points、Often loosing tension: 5points、Completely loosing tension: 1point)
33	5. The other side	6		5.71429			
34					Numbers of needle transfer	7	(one in each: 10points, almost twice: 5points, almost 3 times: 1point)
35					Consistent proper exposure by forceps	5	(All good exposure: 10points, Good exposure in half: 5points, No good exposure: 1point)
36					Consistent distance from previous bite	3	(Constant distance in all: 10points, No obvious skip: 5points, Multiple obvious skips: 1point)
37					Consistent bite depth from edge	2	(Proper depth in all: 10points, Proper average depth with some scattering: 5points, Obvious scattring depth: 1point)
38					Consistent needle angle	8	(Almost right angle: 10points, Right angle in half: 5points, No angle control: 1point)
39					Duration of needle exit and next stich	9	(Almost within 5 seconds: 10points, almost within 7 seconds: 7points, 10 seconds in half: 5points, almost over 10 seconds: 1point
40					Suture manegement	6	(Constant proper tensin: 10points、Often loosing tension: 5points、Completely loosing tension: 1point)
42	6. Kot tie	5			Knot tie	5	(Within 15 seconds for 6-8 knot ties: 10points, Within 30 seconds for 6-8 knot ties: 5points, More than 40seconds or suture disruption: 1point
43							
44							
45	Component pane	29		points			
46					Balance between arteriotomy and graft triming	9	(Good balanced, creating cobra head: 10points, Not creating cobra head, but no twitching: 5points, Obvious twitching: 1point)
47					Position of the toe and heel of graft	8	(Straight: 10points, Some displacement in toe or heel: 5points, Complete displacement in toe or heel: 1point)
48					Status of lumen	7	(Good patency: 10points, Some stenosis in toe or heel: 5points, trapping the other side, or injury of the bottom: 1point)
49					Munites to finish the anastomosis	5	(Within 8 minuites: 10points, 1 point deduction for each 1 munite passing)
50							
51	Deduction	12		points			
52					Disruption of arterial wall	5	only one point: -1point, More than 2 points: 2points deductions for each disruption
53					2022/12/30	7	No deduxtion for thefirst tangling if released smoothly, More than twice: -1point for each , Negrecting tangling: -3points for each

Fig. 3 Google spreadsheet for real-time evaluation. In each part of the technical panel from ~Parachute to the other side, it consists of 7 evaluation items. The final points of each part are entered by referencing the average scores of 7 evaluation items. The final score is the sum of technical points and composition points minus deductions

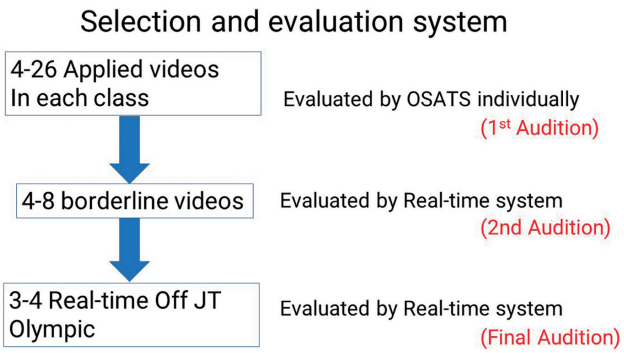

Fig. 4 Selection and evaluation system of real-time competition (Off JT Olympic). The submitted videos were evaluated by OSATS, narrowed down to 4 to 8, and several borderline videos were further compared in the real-time system to determine the finalists. JT: job training; OSATS: Objective Structured Assessment of Technical Skills

Regulation of the competition

The model Anathon A-1 kit specially created by the EBM Corporation was used (**Fig. 6A**). Coronary arterial model (YOUCAN-SD), graft model (ITA graft EXF), and suture (7-0 polypropylene) were also provided by the EBM Corporation (**Figs. 6B–6D**). Videos were recorded by placing a smartphone on the model.

Subjects and Methods

A total of 22 videos on the borderline of elected and defeated scores evaluated by both the modified OSATS and the real-time evaluation system were utilized in this study. The global rating score of the OSATS was compared with the global rating score of the real-time evaluation system.

Fig. 5 A scene from the real-time competition in Zoom. The scores for each component and the final score were displayed. Feedback for the competitor was given by the evaluators and judges

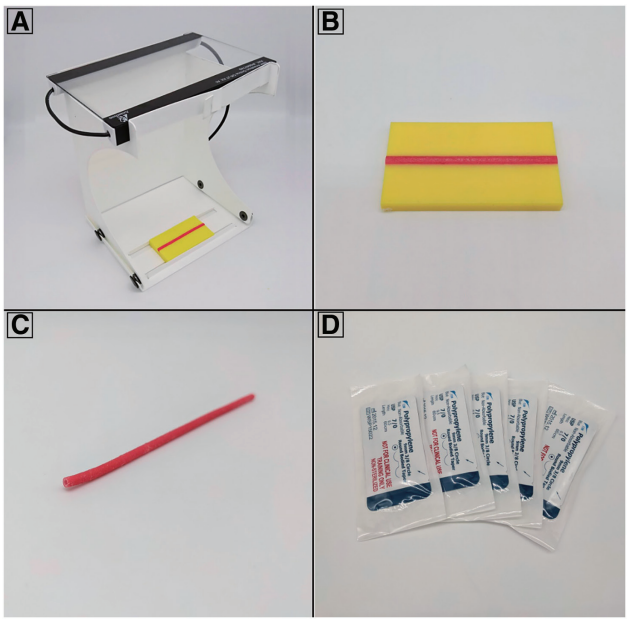

Fig. 6 Officially adopted equipment for the real-time competition. Anathon A-1 kit (**A**), coronary arterial model (YOUCAN-SD) (**B**), graft model (ITA graft EXF) (**C**), and 7-0 polypropylene sutures (**D**) from EBM Corporation

Statistical analysis

Pearson's product–moment correlation was used to analyze the comparison of global rating score between the OSATS and the real-time evaluation system. R version 3.4.1 was utilized in this analysis.

Results

A total of 59 participants participated in the 4 consecutive week competition. At the first nomination, 22 videos were borderline of elected and defeated, and these videos were examined. Some individual component scores could not be extracted because of overwriting of videos. The average score of the OSATS total score and OSATS general definition score was 38.3 ± 4.2 and 3.6 ± 0.5, respectively. On the other hand, real-time technical panel score, component score, deduction score, and real-time total score were 42.7 ± 3.5, 31.8 ± 2.8, 0.0 ± 0.1, and 74.5 ± 6.3, respectively. When examined the relationship between the OSATS total score and real-time total score, there was a significant correlation ($R = 0.752$, $p < 0.001$) (**Fig. 7A**). The OSATS general definition score and the real-time total score also showed a strong correlation ($R = 0.733$, $p < 0.001$) (**Fig. 7B**).

Discussion

It is crucial for surgeons to receive surgical training. Although there are off-the-job training and on-the-job training, on-the-job training is limited because it needs patients, and it might be harmful if a surgeon is not enough skillful to perform the procedure. While the benefits of off-the-job training are many and varied, such as

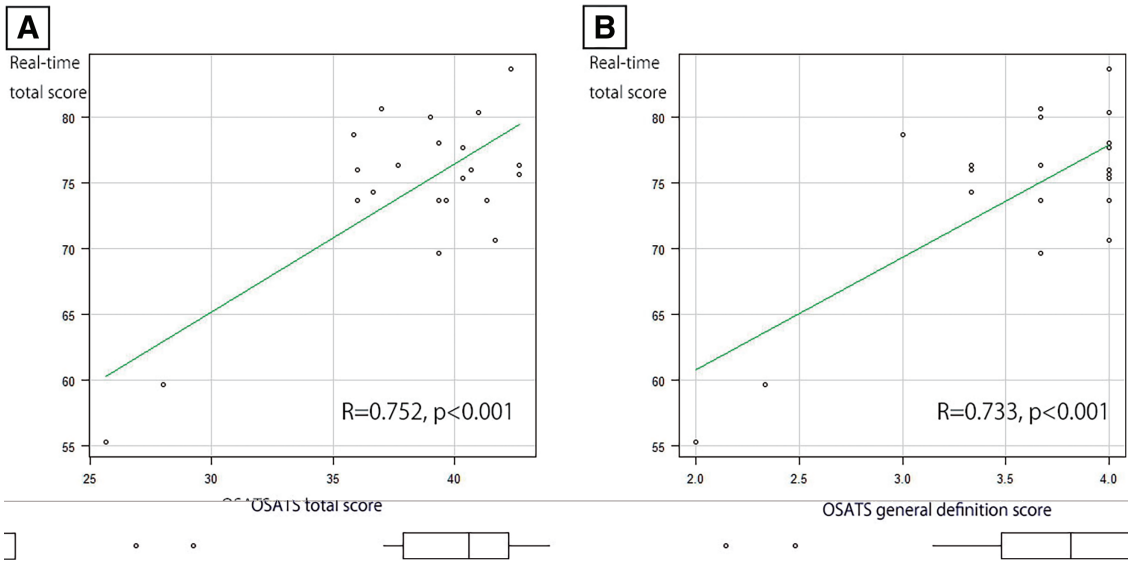

Fig. 7 Correlation between real-time evaluation score and OSATS score. Real-time total score and OSATS total score (**A**), and real-time total score and OSATS general definition score (**B**). A good correlation between real-time evaluation score and OSATS score was obtained. OSATS: Objective Structured Assessment of Technical Skills

being able to do it anytime, anywhere, and as many times as you want, you need a good simulator to receive more advanced training.

Under such circumstances, various simulators have been developed and used in the field of CV surgery, and their usefulness has been reported.[1,4,6,7] Among them, we have conducted numerous on-site trainings using the BEAT YOUCAN simulator and OSATS evaluation sheet.[4] As a result, we succeeded in instructing many surgeons, but it became difficult to continue due to the influence of COVID-19.

At that moment, the Japanese Association for Coronary Artery Surgery asked us to perform the competition of coronary artery anastomosis online. Because we could not evaluate until finishing an anastomosis if we use the OSATS evaluation sheet, we came up with the idea of real-time assessment system to evaluate an anastomosis by getting inspiration from the ISU Judging System.[5] Therefore, we created a new real-time evaluation table by dividing the evaluation items of OSATS, which have been used for many years, into a technical panel that evaluates in real time like ISU and components that evaluate the finish. The results from this study showed a good correlation with the OSATS evaluation sheet, suggesting the usefulness of this evaluation sheet. However, this study is still a trial, and we believe that it will become a more practical evaluation sheet by continuing to use it and further improving it based on the feedback from trainees and evaluators.

Conclusions

We developed a real-time assessment sheet to evaluate coronary anastomosis. This assessment sheet had a good correlation with the OSATS evaluation sheet.

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Disclosure Statement

The authors have no conflict to disclose.

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