



Mortality and functional outcomes of fragility fractures of the pelvis by fracture type with conservative treatment: a retrospective, multicenter TRON study

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Abstract

Purpose Fragility fractures of the pelvis (FFP) are becoming a commonly encountered disease in aging societies. We aimed to (1) clarify the overall survival rate of FFP, (2) compare survival rates by Rommens and Hofmann classification FFP type, (3) investigate the complications during hospitalization, and (4) investigate walking ability before and after injury depending on the type of fracture in patients with FFP treated conservatively.

Methods This retrospective, multicenter study included 867 patients with FFP treated conservatively between 2014 and 2018 and excluded patients with insufficient follow-up for two years, lost data, and operative cases. This is a retrospective multicenter study. We established the database, which is named as TRON. We evaluated survival rate by fracture type using the log-rank test. We compared walking ability as defined by a new mobility score and the modified Majeed Pelvic Score among fracture types.

Results We reviewed 552 cases (98 males and 454 females) with conservative treatment. The overall survival rates of patients with FFP treated conservatively were 0.90 at 1 year and 0.83 at 2 years. Although the survival rate was the lowest in FFP Type III, there was no significant difference in survival rates between fracture types ($P=0.143$). The rates of complications during hospitalization were high for both Type III and Type IV fractures. Walking ability post-injury was worse in the patients with Type III fracture.

Conclusions The survival rate of patients treated by conservative treatment was relatively good. Type III in the Rommens and Hofmann classification was related to lower life expectancy and loss of walking ability.

Keywords Fragility fractures of pelvis · Conservative treatment · Rommens and Hofmann classification · Multicenter study

Introduction

Fragility fractures of the pelvis (FFP), which are one type of fragility fractures (also known as osteoporotic fractures or insufficiency fractures), are defined as a pathological fractures resulting from minimal trauma [1–4]. FFP are becoming a commonly encountered disease in aging societies [3, 5, 6].

There are several classification systems for pelvic fracture [7–9]. However, the past classification systems were not enough to represent the FFP for the elderly [10–12]. In 2013, Rommens and Hofmann published a new classification system focusing on FFP [12], which is the first comprehensive classification system for FFP.

Rommens and Hofmann recommended surgery in FFP Type III and FFP Type IV. They recommended conservative

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treatment in FFP Type II, but surgical treatment in unsuccessful conservative treatment. [10]. Another previous study has shown that early surgical treatment for FFP is associated with improved long-term survival rate [13]. In contrast, complications and overall mortality remain high among geriatric patients with a FFP when treated operatively [14]. To our best knowledge, few studies have reported the clinical results of the conservative treatment of FFP by Rommens and Hofmann classification. It would help orthopedic surgeons to know the prognosis of conservative treatment for FFP and would assist them in making treatment decisions. We, therefore, conducted a retrospective, multicenter study to clarify the clinical outcomes of patients receiving conservative treatment for FFP.

First, we analyzed the overall survival rate of patients with FFP who received conservative treatment. Second, we compared survival rates by type of Rommens and Hofmann classification. Third, we investigated the complications during hospitalization, and fourth, we investigated patient walking ability before and after injury depending on fracture type.

Materials and methods

The study procedures were carried out in accordance with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of our university Graduate School of Medicine. This is a retrospective multicenter study. We established the database, which is named as TRON. We have registered orthopedic trauma cases in the TRON database annually since 2014. Our database includes patient background information such as age, gender, body mass index (BMI), Charlson Comorbidity Index (CCI), pain as assessed by Numeric Rating Scale, and new morbidity score (NMS) as walking ability. For details about the

patient's gait, the need for aids, the presence of a limp, and the continuous walking distance are also collected as data. This information was entered by the clerical assistants of each facility based on the information from the medical records written by the physicians.

The 11 hospitals participating in the database are all hospitals associated with the Department of Orthopedic Surgery of our university in Japan. All patients provided informed consent to participate in the study. The ethics committee of each participating hospital approved this multicenter retrospective study.

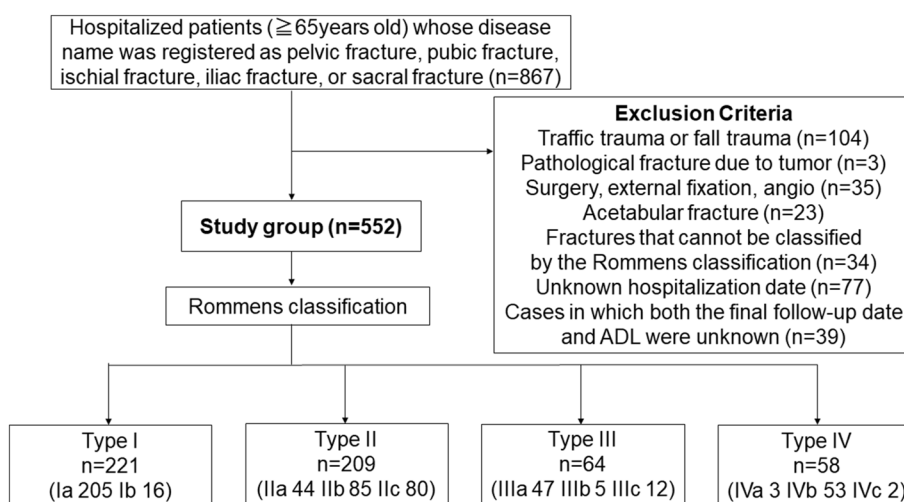
Subjects

From the database, we extracted the 867 patients aged 65 and over who had been hospitalized from 2014 to 2018 for pelvic fractures, pubic fractures, ischial fractures, iliac fractures, and sacral fractures (Fig. 1). First, we excluded the patients who suffered high-energy trauma, acetabular fractures, and pathological fractures, and patients unclassifiable by the Rommens and Hofmann classification of FFP (including those who had not undergone pelvic computed tomography [CT] examination at admission). Second, we excluded the operative cases. The number of cases by classification type was 2 cases of Type I, 2 cases of Type II, 21 cases of Type III, and 10 cases of Type IV. All surgical cases are performed within one week of injury.

Treatment protocol

We used basically the same protocol among our hospitals. However, the rehabilitation protocol is adjusted according to the hospital's resources (number of rehabilitation staff). All patients with FFP are treated conservatively with bed rest and analgesia, followed by adequate pain relief and rapid mobilization. In particular, the next day after admission,

Fig. 1 Patient flow chart. ADL: activities of daily living



the patient started rehabilitation in bed. After about 1 week of rest with checking the progress of the displacement of fracture on radiographs. If the displacement progressed, we should consider surgical treatment; however, all the patients in this cohort continued conservative treatment. These patients started to mobilize depending on their pre-injured walking ability, the degree of pain, and the severity of the fracture. Type III and Type IV patients started full-weight bearing only after pain relief and checking bone union. These decisions about treatment should be made by a multidisciplinary team including orthopedic surgeons, nurses, and physiotherapists. Our goal is to be able to optimize the patient's condition as soon as possible.

Data collection

We obtained patient demographic data including, age, sex, and body mass index (BMI) from electronic medical records in each hospital. We recorded the medical comorbidities of the patients according to the Charlson Comorbidity Index (CCI) [15] when they were admitted. The CCI is an index for scoring and evaluating medical comorbidities and is calculated by adding 1 to 6 points for each item. We evaluated patients according to the total score, which ranges from 0 to a maximum of 33 depending on the presence of certain diseases with assigned values. We obtained the date of injury from medical chart. We phoned all patients' homes or nursing-home to ask if they were alive and well. If they did not answer the phone, we sent them a letter. Even then, if the patient was still unidentified, we checked the electronic medical record for the last time they visit each hospital. We defined complications during hospitalization as any disease that was treated by another hospitalist.

Radiographical evaluation

We took the radiographs and CT scan at the first-time visit in all cases. Plain pelvic radiographs are taken immediately when a patient visits the outpatient clinic or emergency room. If the physician recognized a fracture on the plain radiograph, the physician could order a CT scan on the same day to evaluate the fracture in more detail. We reviewed the randomized selected 100 radiographs by two orthopedic trauma surgeons (OT, TY). We calculated Kappa coefficient (categorical data) for inter-observer reliability for fracture type, which was 0.84.

Clinical evaluation

We used the following two methods to assess walking ability before injury and at the last follow-up visit after injury:

New morbidity score (Supplemental Table 1)

The new morbidity score (NMS) is a simple evaluation scale that can assess activity by evaluating three items assigned 1–3 points (Able to get about the house, Able to get out of the house, and Able to go shopping). The total score is 9 points [16].

Modified Majeed Pelvic Score focusing on mobility (Supplemental Table 2)

We assessed the Modified Majeed Pelvic Score focusing on mobility (mmMPS) according to a previous report by Yoshida et al. [17]. This score is a modified version of the Majeed Pelvic Score [18], which consists of Walking with aids: 12 points, Gait unaided: 12 points, and Walking distance: 12 points. The total score is 36 points. We removed questions about pre-injury pain, work, sitting, and sexual intercourse because acquisition of these types of patient data has been difficult in determining patient scoring.

Statistical analysis

Fisher's exact test was used for categorical variables, the Kruskal–Wallis test and one-way analysis of variance were used for continuous variables by Tukey's post-hoc test. We estimated survival rates with Kaplan–Meier curve and differences in survival were compared with the log-rank test. The statistical analysis was performed using EZR software version 1.40 (Jichi Medical School, Tochigi, Japan) [19].

Results

We reviewed 552 cases (98 males and 454 females). Table 1 shows the patient demographics. The length hospital stay in the patients with Type III fracture was significantly longer than that of the patients with other fracture types ($P=0.004$). (Table 1).

The overall survival rate of patients with FFP with conservative treatment was 0.90 (95% confidence interval [CI]: 0.87–0.93) at 1 year and 0.83 (95% CI: 0.78–0.87) at 2 years (Fig. 2).

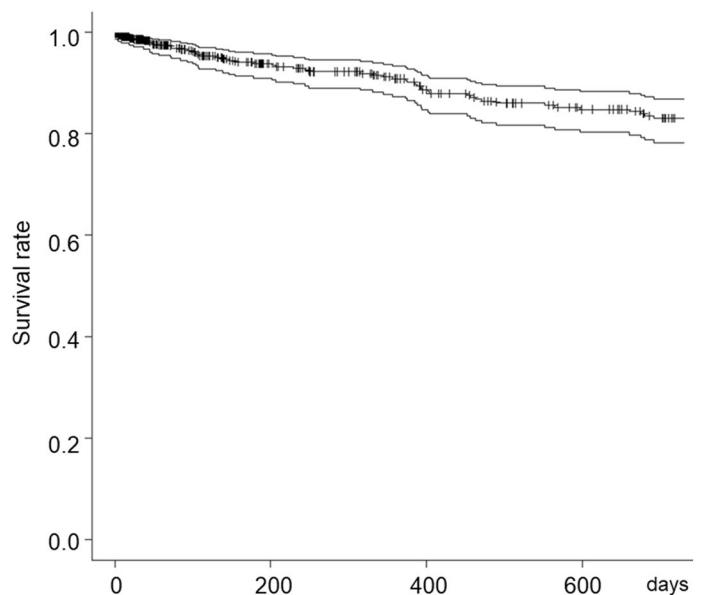
Figure 3 shows the survival rate by fracture type. The 1-year survival rates by Rommens and Hofmann classification were type I: 0.91 (95% CI: 0.84–0.95), type II: 0.91 (95% CI: 0.86–0.95), type III: 0.83 (95% CI: 0.70–0.91), and Type IV: 0.97 (95% CI: 0.83–0.99). The 2-year survival rates were type I: 0.85 (95% CI: 0.77–0.90), type II: 0.80 (95% CI: 0.71–0.86), type III: 0.77 (95% CI: 0.63–0.87), and type IV: 0.94 (95% CI: 0.77–0.99). The survival rate was the lowest in FFP Type III, but there was no significant difference in survival rates between fracture types ($P=0.143$).

Table 1 Patient demographics

	Rommens classification				<i>P</i> -value
	Type I	Type II	Type III	Type IV	
Number, <i>n</i> (%)	221 (40.0)	209 (37.9)	64 (11.6)	58 (10.5)	
Age, y, mean (SD)	83.37 (7.37)	82.73 (7.49)	83.88 (6.23)	81.14 (7.87)	0.143
Sex, male/female, <i>n</i> (%)	39/182 (17.6/82.4)	37/172 (17.7/82.3)	14/50 (21.9/78.1)	8/50 (13.8/86.2)	0.713
BMI, kg/m ² , mean (SD)	19.90 (4.08)	19.94 (4.00)	19.21 (3.81)	19.61 (3.62)	0.626
Length of hospital stay, d, mean (SD)	21.10 (18.88)	23.13 (19.10)	31.06 (20.69)	26.53 (25.92)	0.004
Follow-up, d, mean (SD)	515.61 (625.36)	577.31 (625.16)	683.27 (655.57)	582.32 (618.33)	0.292
CCI, median (range)	1.00 (0.00, 9.00)	1.00 (0.00, 7.00)	1.50 (0.00, 7.00)	1.00 (0.00, 8.00)	0.055
Pre NMS, mean (SD)	6.69 (2.32)	6.87 (2.36)	6.21 (2.54)	6.10 (2.52)	0.096
Pre mmMPS, mean (SD)	27.1 (9.10)	27.0 (9.35)	24.6 (9.53)	25.2 (10.3)	0.175

BMI body mass index, *CCI* Charlson Comorbidity Index, *NMS* New Mobility Score, *mmMPS* modified Majeed Pelvic score focusing on mobility

Fig. 2 Kaplan–Meier survival curves of patients with fragility fractures of the pelvis with conservative treatment. Upper and lower line indicated the 95% confidence intervals



The rates of complications during hospitalization were significantly different between the fracture types: Type I, 12.0%; Type II, 12.0%; Type III, 19.4%; and Type IV, 27.8% ($P = 0.02$) (Table 2).

There were no significant differences by fracture type in the pre-injury NMS and walking ability score (Table 1). The values of the post-injury NMS are shown in Fig. 4. The values of the post-injury NMS by fracture type were Type I, 5.40; Type II, 5.28; Type III, 4.30; and Type IV, 5.03. The value of the NMS in the patients with Type III fracture was significantly lower than that of the patients with a Type I fracture ($P = 0.037$). The values of the post-injury mmMPS are shown in Fig. 5. The values of the post-injury mmMPS by fracture

were Type I, 20.8; Type II, 19.4; Type III, 15.7; and Type IV, 18.6. The value of mmMPS of Type III was significantly lower than that of Type I ($P = 0.006$) (Fig. 5).

Discussion

We showed that (1) the overall 1- and 2-year survival rates of patients with FFP treated conservatively were 90% and 83%, respectively, and that the survival rates by Rommens and Hofmann classification of FFP fracture types were low for Type III but high for Type IV fractures; (2) the rates of complications during hospitalization were high for fractures

Fig. 3 Kaplan–Meier survival curves of patients with fragility fractures of the pelvis with conservative treatment by fracture type

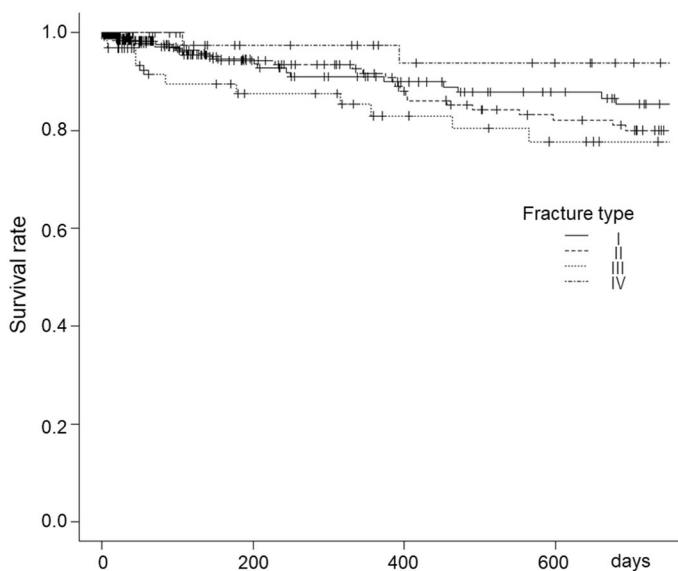


Table 2 Complications during hospitalization

	Fracture type				<i>P</i> -value
	Type I (<i>n</i> = 183)	Type II (<i>n</i> = 133)	Type III (<i>n</i> = 62)	Type IV (<i>n</i> = 54)	
Overall complications ^a , <i>n</i> (%)	25 (12.0)	17 (12.0)	12 (19.4)	15 (27.8)	0.024
Cranial nerve vascular system	2			1	
Respiratory system	8	4	1	1	
Digestive system	4	1	1	2	
Renal urinary system	4	8	3	4	
Cardiovascular system	3		2	3	
Endocrine metabolic system	1	1	3	2	
Refractory pressure ulcer	1	2	1		
Others	2	1	2	4	

^aIncluding duplicates

Fig. 4 New mobility score at pre-injury and post injury by fracture type. **P* < 0.05 for post hoc analysis

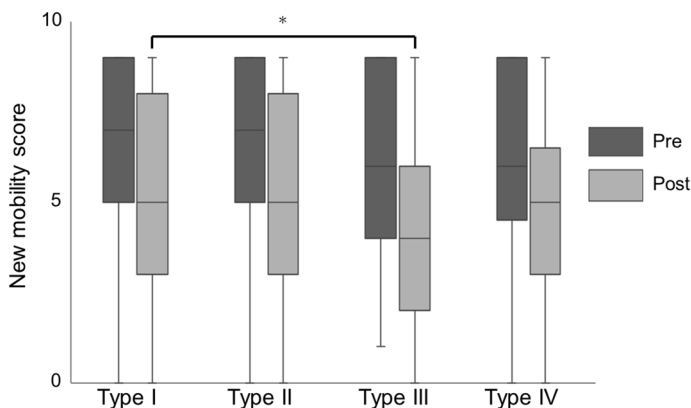
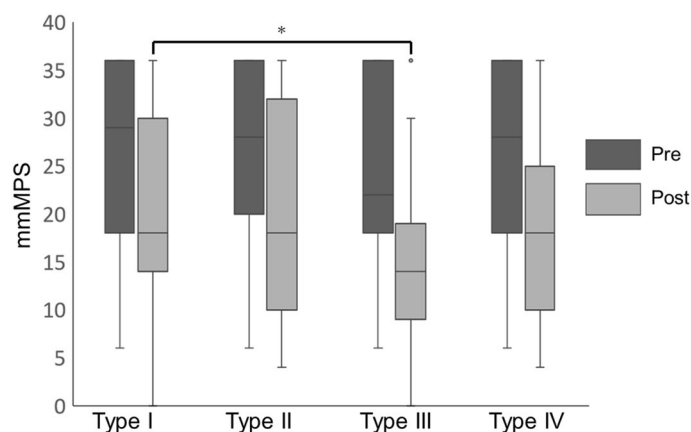


Fig. 5 Modified Majeed Pelvic Score (mmMPS) focusing on mobility at pre-injury and post-injury by fracture type. * $P < 0.05$ for post hoc analysis



of Types III and IV; and (3) the post-injury walking ability of the patients with Type III fracture was worse than that of the patients with Type I fracture.

Some previous studies have shown that the 1-year survival rate of FFP is 86–93%, which is not much different from that of the survival rate of the general population [17, 20, 21]. Thus, we investigated the survival rates by fracture type and found no significant difference in mortality rates between the different types of fracture. Interestingly, the survival rate at 1 year of patients with Type III fracture was lowest (87%), whereas that of patients with type IV was high (97%). Regarding Type IV fractures, consistent with our results, a better prognosis for fragility fractures of the sacrum has been reported since the 1990s. One report showed that 5 years after of conservative treatment of 20 cases of insufficiency sacral fracture, there were no deaths and 17 patients recovered to their original activities of daily life [22]. In general, the stability of the posterior parts of the pelvis are important. However, the spectrum of instability in high-energy trauma, as represented by Tiles classification and Young-Burgess system, is much higher than in low-energy trauma. [23, 24] The fractures classes do not reflect the same spectrum. Difference in instability in FFP are much lower. The Rommens and Hofmann classification is based on the degree of instability. Rommens and Hofmann also considered that the FFP Type IV lesions had the highest instability according to the previous classifications [10]. A previous study also mentioned that H-type sacral fractures, whose shape is similar to Rommens and Hofmann classification type IVb, are potentially unstable and are referred to as spinopelvic dissociation injuries [25]. Spinopelvic dissociation, which is described as bilateral longitudinal sacral fractures with a transverse fracture component, is a rare injury resulting from high-energy trauma. Frequently, these fractures are angulated and undergo translational displacement resulting in dissociation of the spine and upper central segment of the sacrum from the pelvic ring and caudal sacral segments [26]. The spinopelvic dissociation is often accompanied

by a posterior ligamentous complex (PLC). The integrity of the PLC is thought to be directly proportional to spinopelvic stability [27]. However, FFP are caused by minimal trauma [28]. The continuity of the lumbar spine, sacrum, and ilium is maintained by PLC in the patients with FFP. Unless the fracture site is completely disrupted, spinopelvic stability would be maintained. We consider that a type IVb FFP, which is an H-shaped fracture of the sacrum, may be a stable fracture. A previous report showed that the prognosis of pubic fractures with displacement was poor [29]. These results suggest that the displacement of the fracture itself may be related to the prognosis.

Our study showed that the rates of complications during hospitalization were high for Type III and Type IV fractures (19.4% and 27.4%, respectively). Table 2 shows the details of the complications. A 20.2% complication rate was reportedly found during hospital admission, mainly caused by infectious diseases, including urinary tract infection and pneumonia [30]. In another report, adverse events during the hospital stay were registered in 58% of the patients (61% with urinary tract infection, 29% with pneumonia, 5% with depression, and 3% with thromboembolic events) [31].

The patients with type III and IV fractures had a longer hospital stay. An association may exist between longer hospital stays and complications. The treatment team should always consider a treatment program that will allow patients to start early mobilization to prevent complications associated with infections. The surgeon should consider operative treatment in patients with persistent pain that requires bed rest for longer than a week, regardless of the type of fracture.

Our results showed walking ability after injury was significantly different among the fracture types. In particular, the walking ability in patients with Type III fractures was significantly worse than that in patients with Type I fractures. Brouwers et al. compared patients who received a perfect score on the MPS according to fracture type of AO/OTA. Although 28–31% of the patients with stable fractures were able to achieve a perfect score, those with

unstable fractures were not able to achieve a perfect score at all [32]. The stability of the pelvic fracture site would affect patient mobility. These results indicate that Rommens and Hofmann classification Type III would be an unstable fracture, which may have led to the loss of walking ability.

This study has several limitations. First, this is the retrospective study, which excluded the operative cases. More severe cases would receive a surgical procedure. Surgical treatment for FFP could provide lower mortality rate [33–35]. This led to selection bias. Second, FFP has an interesting finding called “fracture progression” [36] or “FFP transition” [37], which is the progression from a less unstable fracture type to a more unstable fracture type. Fracture progression was confirmed in 14.2% of the patients diagnosed with all types of FFP and was positive on the second CT scan in 39.2% of patients with prolonged pain and limitation of movement [36]. Our study typed FFP by CT only at admission, and we did not evaluate fracture progression. Third, we used the mmMPS to evaluate patient walking mobility. The mmMPS has not been externally validated except by one study. Fourth, the numbers of patients with Type IVa and IVc fractures were small. This may have affected the clinical outcome of Type IV fractures. However, the Rommens and Hofmann report in 2013 [10] also showed that of the 47 Type IV fractures, 2 (4.2%) were Type IVa, 37 (78.7%) were Type IVb, and 8 (17%) were Type IVc, with Type IVb accounting for most of the Type IV fractures. Fifth, Japan's inpatient care system differs from that of other countries. According to data compiled by the Organization for Economic Development and Cooperation (OECD), the number of hospitals per capita in Japan is 1.5 times that of the United States. [38] Therefore, it is easier to admit patients with relatively minor injuries.

In conclusion, the prognosis for survival of patients with conservative treatment of FFP was relatively good. Rommens and Hofmann classification Type III would be the most unstable fracture and would be related to the lowest life expectancy and loss of walking ability in FFP. However, there was no difference in the outcome of conservative treatment for Type IV compared to the other stable fracture types.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00068-021-01839-1>.

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Availability of data and material The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Conflict of interest None.

Ethical approval The approval number in our institute is 2020-0549.

Consent to participate and publication All patients provided written informed for their data to be used.

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