Clinical experience of the use of reamer irrigator aspirator in Japanese patients: A report of the first 42 cases

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Clinical experience of the use of reamer irrigator aspirator in Japanese patients: A report of the first 42 cases

Takahiro Niikura, MD, Keisuke Oe, MD, Tomoaki Fukui, MD, Shinya Hayashi, MD, Tomoyuki Matsumoto, MD, Takehiko Matsushita, MD, Ryosuke Kuroda, MD

T. Niikura (✉) • K. Oe • T. Fukui • S. Hayashi • T. Matsumoto • T. Matsushita •R. Kuroda

Department of Orthopedic Surgery, Kobe University Graduate School of Medicine, 7-5-1 Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan

Tel: +81-78-382-5985; Fax: +81-78-351-6944

E-mail: tniikura@med.kobe-u.ac.jp

CONFLICTS OF INTEREST

None declared.

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ABSTRACT

Background

A reamer irrigator aspirator (RIA) can be used to harvest substantial amounts of autologous bone and debride the intramedullary canal. Clinical experience using reamer irrigator aspirators in Japan is very limited. The applicability of the reamer irrigator aspirator head with a minimum diameter of 12 mm for Japanese people is often questioned as the Japanese are smaller than Americans and Europeans. There are no reports of complications in Japanese patients. This study aimed to retrospectively review clinical cases and describe reamer irrigator aspirator use in Japanese patients.

Methods

All patients for whom a reamer irrigator aspirator was used during surgery at our hospital between January 2014 and September 2018 were included. The patients' clinical and radiographic data were retrospectively reviewed.

Results

Data of 40 patients (42 cases) were collected. The reamer irrigator aspirator was used for bone graft harvesting in 32 cases, intramedullary debridement and irrigation in 9 cases, and reaming for exchange nailing in 1 case. The diameter of the reamer irrigator aspirator reamer head was 12 mm in 22 cases (53.7%), 12.5 mm in 4 cases (9.8%), 13 mm in 9 cases (22.0%), 13.5 mm in 1 case (2.4%), 14.0 mm in 1 case (2.4%), 14.5 mm in 1 case (2.4%), and 15 mm in 4 cases (9.8%). Mean intraoperative bleeding volume was 1158.6 mL (range, 100–3800 mL). We experienced no difficulty inserting the reamer irrigator aspirator into the intramedullary canals and no cases of insertion-related intraoperative fracture. Five cortical perforations (11.9%) were observed on postoperative computed tomography scans, although no patient was symptomatic. One case (2.4%) of

postoperative femur fracture occurred.

Conclusions

Reamer irrigator aspirators can be used in Japanese patients. Smaller reamer head sizes were mainly used in our experience. We should manage complications as in previous reports from Western countries.

INTRODUCTION

A reamer irrigator aspirator (RIA; DepuySynthes, West Chester, PA, USA) is a device that provides simultaneous irrigation and aspiration during reaming of the intramedullary canal of long bones. RIA was initially developed to decrease intramedullary pressure, heat generation induced thermal necrosis, and the systemic effects of reaming, including fat embolism [1-7]. In addition, shortening of the surgical time was expected as, theoretically, it is a one-step procedure involving the passage of the reamer rod [7]. However, RIA devices are now mostly used to harvest substantial autologous bone grafts [8-12] although they are also used to debride the intramedullary canal in the treatment of osteomyelitis [13,14].

The RIA was first used in 2005 and 2013 in Europe and Japan, respectively. Therefore, clinical experience with RIA in Japanese patients is very limited compared to Western patients [15]. It has been reported that Asian populations have smaller intramedullary canals than Caucasian [16-18]. Therefore it has been questioned whether an RIA reamer head with a minimum diameter of 12 mm can be used in Japanese people, who are smaller than Americans and Europeans. However, there are no reports of complications in Japanese patients. This study aimed to retrospectively review our first 42 clinical cases and provide information about RIA use in Japanese patients.

MATERIALS AND METHODS

Patients

All patients in whom RIA was used during surgery at our hospital between January 2014 and September 2018 were included in this retrospective review.

Data collection

Medical charts, radiographs, and computed tomography were retrospectively reviewed. This retrospective review was approved by our hospital's institutional review board. Patient data collected included age, sex, height, body weight, body mass index (BMI), diagnosis, bone to which RIA was applied (femur or tibia), indication for RIA use, diameter of the RIA reamer head, harvested quantity of bone grafted using RIA, intraoperative bleeding volume, and complications. In cases in which an RIA was used to harvest bone, the side (ipsilateral or contralateral) of the femur into which the RIA was inserted was also noted.

Choosing RIA head diameter

We chose the RIA head diameter using preoperative radiographic and intraoperative clinical assessments. We measured the diameter of the isthmus on preoperative radiographs as a reference for approximate isthmus size. Because the shape of the intramedullary canal of the femur is ellipsoid rather than circular [19], we took the measurements from two orthogonal radiographs, the measurements being calibrated (Figure 1). Magnification was adjusted when measurements were taken. If either isthmus diameter measured by anteroposterior and lateral radiographs was smaller than 10.5 mm, we judged the patient as being unsuitable for RIA use because we accepted 1.5 mm over-reaming and the smallest diameter of the RIA reamer head is 12 mm. Intraoperatively, the SynReam (DepuySynthes) reamer head was manually inserted and the diameter of the head increased until resistance was felt at the isthmus. The RIA reamer head diameter was selected by adding 1.5 mm to the final diameter of the SynReam reamer head.

Radiographic measurement

We measured the diameter of the isthmus again and the outer diameter of the narrowest part of the femur using the anteroposterior and lateral preoperative radiographs for this study for all patients. Magnification was adjusted using the measures for calibration.

RESULTS

Patients' data

Data of 40 patients (36 men, 6 women; 42 cases) were collected (Table 1). The diagnosis was infected non-union for 19 patients, osteomyelitis for 12 patients, non-infected non-union for 9 patients, and open fracture for 2 patients. Mean patient age was 52.9 (range, 21–86) years. Mean height was 167.3 cm (range, 144.8–187.0 cm). Mean weight was 69.7 kg (range, 52.3–102.2 kg). Mean BMI was 24.8 (range, 18.5–35.4). RIA was used in the femur in 40 cases (38 patients) and in the tibia in 2 cases (2 patients). Cases 8, 13, and 25 involved the same patient, while the same femur was reamed by RIA repeatedly in cases 8 and 25.

Indication for RIA use

The indication for RIA use was bone graft harvesting in 32 cases, intramedullary debridement and irrigation in 9, and reaming for exchange nailing in 1 (Figure 2). The indication for RIA use in the 2 patients in whom it was used in the tibia was intramedullary debridement and irrigation (Table 1). For bone graft harvesting, the ipsilateral femur was reamed in 29 cases (90.6%), while the contralateral femur to the treated limb was reamed in 3.

Diameter of the used RIA reamer head

The diameter of the used RIA reamer head was 12 mm in 22 cases (53.7%), 12.5 mm in 4 cases (9.8%), 13 mm in 9 cases (22.0%), 13.5 mm in 1 case (2.4%), 14.0 mm in 1 case (2.4%), 14.5 mm in 1 case (2.4%), and 15 mm in 4 cases (9.8%) (Figure 3). The mean intramedullary canal diameter of the isthmus measured on the anteroposterior radiographs was 11.8 mm (range, 8.6–17.8 mm). The percentage of the diameter of the used RIA reamer head compared to the intramedullary canal diameter of the isthmus measured on the anteroposterior radiographs was 109.8% (range, 84.2–139.7%). The mean intramedullary canal diameter of the isthmus measured using the lateral radiographs was 13.7 mm (range, 10.5–17.3 mm). The percentage of the diameter of the used RIA reamer head compared to the intramedullary canal diameter of the isthmus measured using the lateral radiographs was 93.5% (range, 74.2–143.0%) (Table 2). The mean outer diameter of the narrowest part of the bone measured using the anteroposterior radiographs was 26.7 mm (range, 21.9–33.5 mm). The percentage of the diameter of the used RIA reamer head compared to the outer diameter of the narrowest part of the bone measured using the anteroposterior radiographs was 47.8% (range, 39.2–60.0%). The mean outer diameter of the narrowest part of the bone measured using the lateral radiographs was 28.3 mm (range, 22.0–33.3 mm). The percentage of the diameter of the used RIA reamer head compared to the outer diameter of the narrowest part of the bone measured using the lateral radiographs was 45.2% (range, 36.0–57.4%) (Table 3).

Bone graft quantity harvested using RIA

The quantity of bone harvested using RIA was measured for the last 10 cases. The mean quantity was 29.1 g (range, 8–60 g). For case 33, cancellous bone was harvested from the left posterior ilium in addition to the bone harvested by the RIA. The harvested quantity of bone was greater for the RIA (8 g) than the posterior ilium (5 g) in this case (Table 4).

Intraoperative bleeding volume

The mean intraoperative bleeding volume was 1158.6 mL (range, 100–3800 mL). There was a tendency toward decreased intraoperative bleeding volume as the number of cases increased ($y = -18.093x + 1547.6$; $R^2 = 0.0775$) (Figure 4). The mean intraoperative bleeding volume of the first 21 cases was 1331.2 mL, while that of the last 21 cases was 986.0 mL.

Complications

Excessive intraoperative bleeding is considered to be one of the complications of RIA procedures. We experienced no difficulty inserting the RIA into the intramedullary canals and there were no cases of insertion-caused intraoperative fracture. Five cortical perforations (11.9%) were observed by routine postoperative computed tomography scan, although all patients were asymptomatic (Figure 5). There was one case (2.4%) of postoperative femur fracture (Figure 6).

CASE PRESENTATION

Case 13. (Same patient as cases 8 and 25). This was the only patient who required multiple RIA procedures. The patient was a 59-year-old man treated for chronic osteomyelitis of the distal tibia, distal fibula, and talus. We attempted reconstruction of the bone defect caused by radical debridement, using the induced membrane technique and filled with the RIA graft. Harvesting of the bone graft was performed using an RIA from the ipsilateral femur. However, the infection recurred and an additional bone resection was performed. In this second attempt at reconstruction, harvesting of the bone graft from the contralateral femur was performed. Five weeks after this surgery, the patient jumped repeatedly on this leg and a femoral fracture occurred (Figure 6a). The fracture was fixed with insertion of an intramedullary nail (Figure 6b). Retrospectively, we found a small cortical perforation at the distal metaphysis (Figure 5). Less compliance and bone fragility caused by hemodialysis may have contributed to this fracture.

DISCUSSION

The smallest RIA reamer head diameter is 12 mm. Many Japanese surgeons think that a 12-mm diameter is too large for small Japanese patients. This is the first study to report RIA use in a large number of Japanese patients.

We referred to past reports to choose which RIA reamer head diameter to use. Masquelet et al [9] mentioned that the RIA reamer head should not be oversized by more than 2 mm considering the canal diameter at the isthmus of the femur, and Han et al [15] followed this rule. Giannoudis et al [19] reported selecting a reamer head of 1 or 1.5 mm larger than the diameter of the isthmus, and Yee et al [12] followed this rule. Alternatively, a reamer head that is no more than 45% of the outer diameter of the narrowest part of the bone should be selected [19,20]. We measured these parameters using preoperative radiographs and estimated the diameter of the isthmus. Intraoperatively, we inserted a SynReam (DepuySynthes) into the intramedullary canal until resistance was felt at the isthmus, to determine the isthmus size. Our rule when choosing an RIA reamer head was to select one that was 1.5 mm larger than the isthmus. We confirmed that we selected the proper size using radiographic analyses. Because the shape of the intramedullary canal of the femur is ellipsoid rather than circular [19], we measured two orthogonal radiographs. If either diameter of the isthmus measured on the anteroposterior and lateral radiographs was 10.5 mm or larger, we determined that the RIA could be used in the patient. However, it should be noted that substantial amounts of cortical bone will be reamed even if the smallest-diameter RIA is used in a patient with a small isthmus diameter. An RIA reamer head diameter of 13 mm or less was selected in over 85% of cases, while an RIA reamer head diameter greater than 13 mm was used for large patients or when intramedullary nails were inserted.

The literature says that the RIA procedure is not free of complications. There are past reports of fracture and cortical perforation [21-24]. We experienced one case of a postoperative femoral fracture. To avoid this complication, we applied an RIA to the ipsilateral femur to harvest bone grafts because this allowed us to limit postoperative weight bearing. If we apply an RIA to the contralateral femur, we should be very wary of postoperative femoral fracture; because both limbs are affected, it is difficult to limit femoral weight bearing. We also experienced 5 cases of femoral cortical perforation, although no patient was symptomatic; of these, 4 were located at the anteromedial side of the distal metaphyseal part of the femur. The RIA reamer head is sharp and the RIA has less flexibility than the ordinary intramedullary reamer; which is probably why the cortical perforation occurred at this location. There was one case of cortical perforation at the anterior shaft (case 37). This case involved chronic osteomyelitis of the femur accompanied by sclerosis of the intramedullary canal. Care is needed to prevent these possible complications. To avoid fracture and cortical perforation, we should consider using fluoroscopy during the RIA procedure and avoid eccentric reaming [9,19,25].

There are reports of excessive blood loss and subsequent cardiac events during RIA procedures [24,26]. The blood transfusion rate and mean hematocrit drop were reportedly greater in bone graft harvest procedures performed with an RIA than in iliac crest bone grafting [27]. RIA use always involves suction of the intramedullary canal; therefore, extended insertion of the RIA carries the risk of excessive blood loss. We agree with the recommendation that surgeons should consider shortening the RIA insertion time within the intramedullary canal and communicate well with anesthesiologists pre- and intraoperatively [9,26]. There was a tendency toward decreasing the intraoperative bleeding volume as the number of cases increased. Thus, there may be a learning curve for the RIA procedure [28].

It has been reported that there are populations with excess bowing of the femur in Japan [29]. We have not experienced such excess bowing, which might be expected to render insertion of the RIA impossible. However, assessing preoperative radiographs of the femur is mandatory. If we see an excessively bowed femur, we should either consider it a contraindication to insertion of the RIA or be aware there is a high-risk of causing cortical perforation.

There are some limitations to this study. First, it was based on a single-institute experience and included a relatively small number of patients. Second, it was retrospective. Third, the amount of bone harvested using RIA was measured in only 10 cases. Fourth, the measured intraoperative bleeding volume is the total bleeding volume caused by the surgery, not the bleeding volume caused by the RIA procedure only. And finally, the studied patients were a heterogeneous population.

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FIGURE LEGENDS

FIGURE 1. Two orthogonal radiographs of the femur with planned insertion of a reamer irrigator aspirator taken preoperatively to measure isthmus diameter and outer diameter of the narrowest part of the bone. The radiographs were taken with measures for calibration of magnification.

FIGURE 2. Purpose of the reamer irrigator aspirator use in the 42 cases.

FIGURE 3. Diameters of the reamer irrigator aspirator heads used in the 42 cases.

FIGURE 4. Intraoperative bleeding volumes in the 42 cases.

FIGURE 5. Five cases of asymptomatic cortical perforation observed on postoperative computed tomography.

FIGURE 6. A case of postoperative femur fracture. (a) Fracture that occurred 5 weeks after the reamer irrigator aspirator use. (b) Fracture fixation by an intramedullary nail.

Figure

Figure 1

Figure

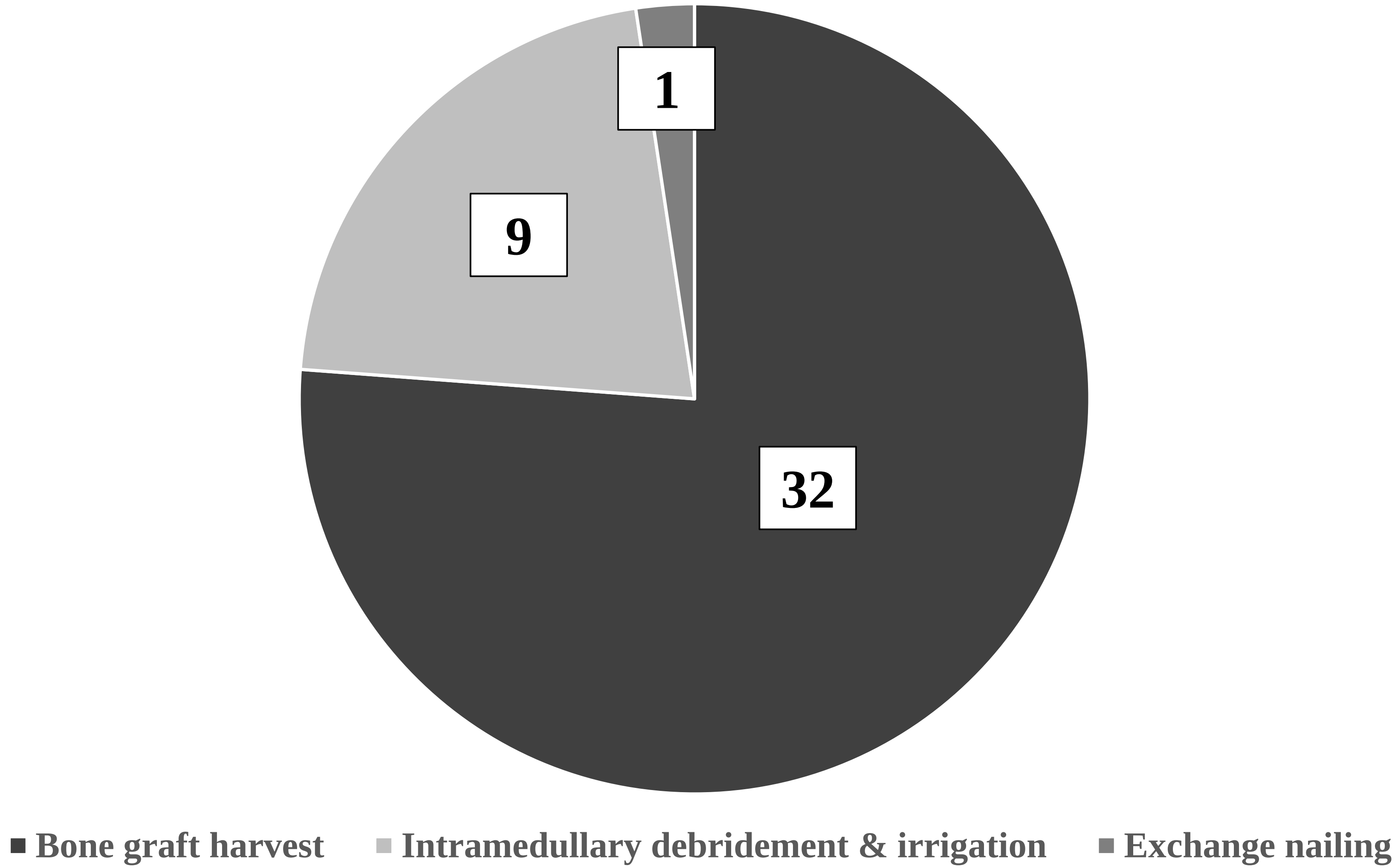

Figure 2

Figure

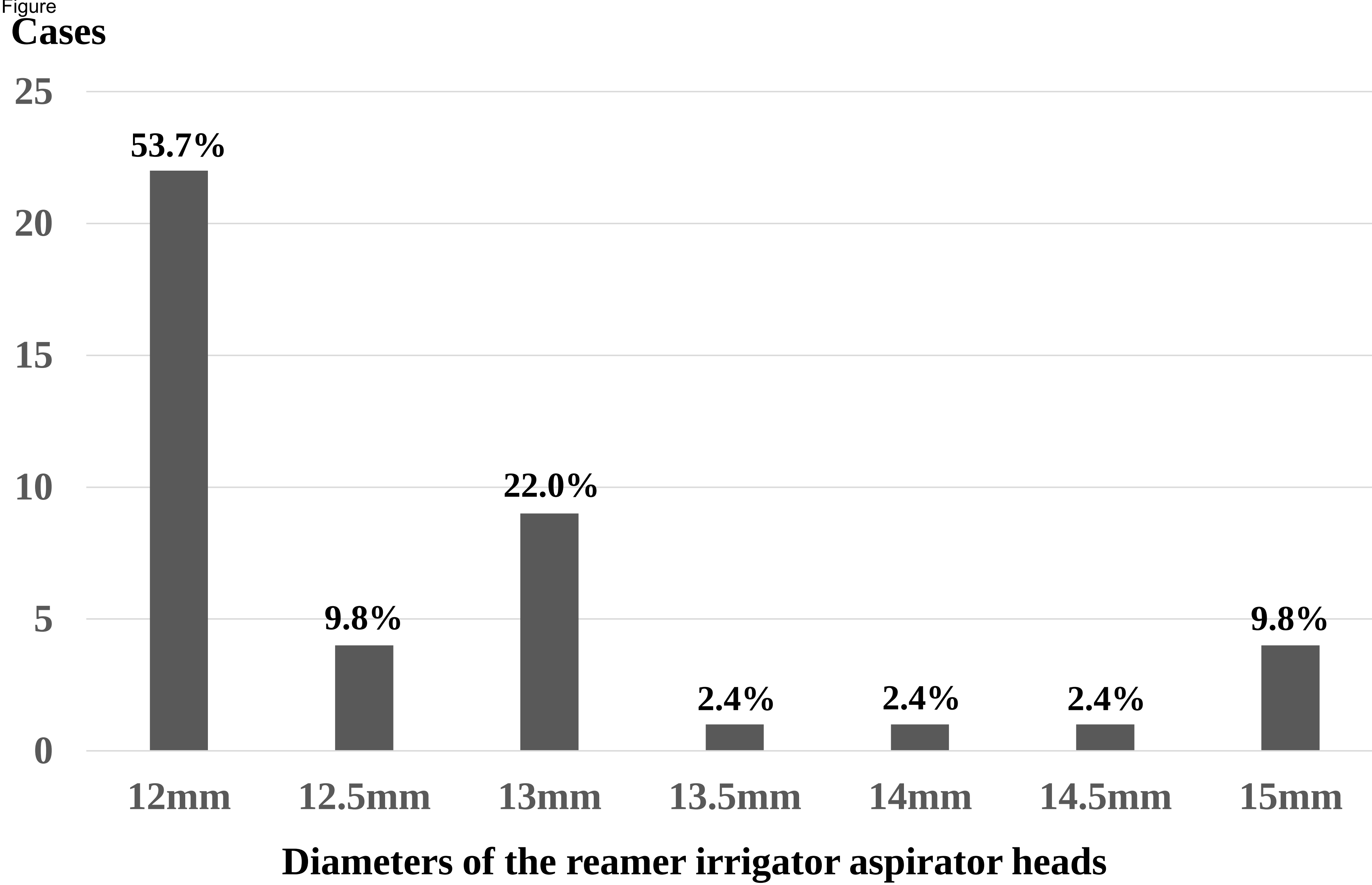

Figure 3

Figure

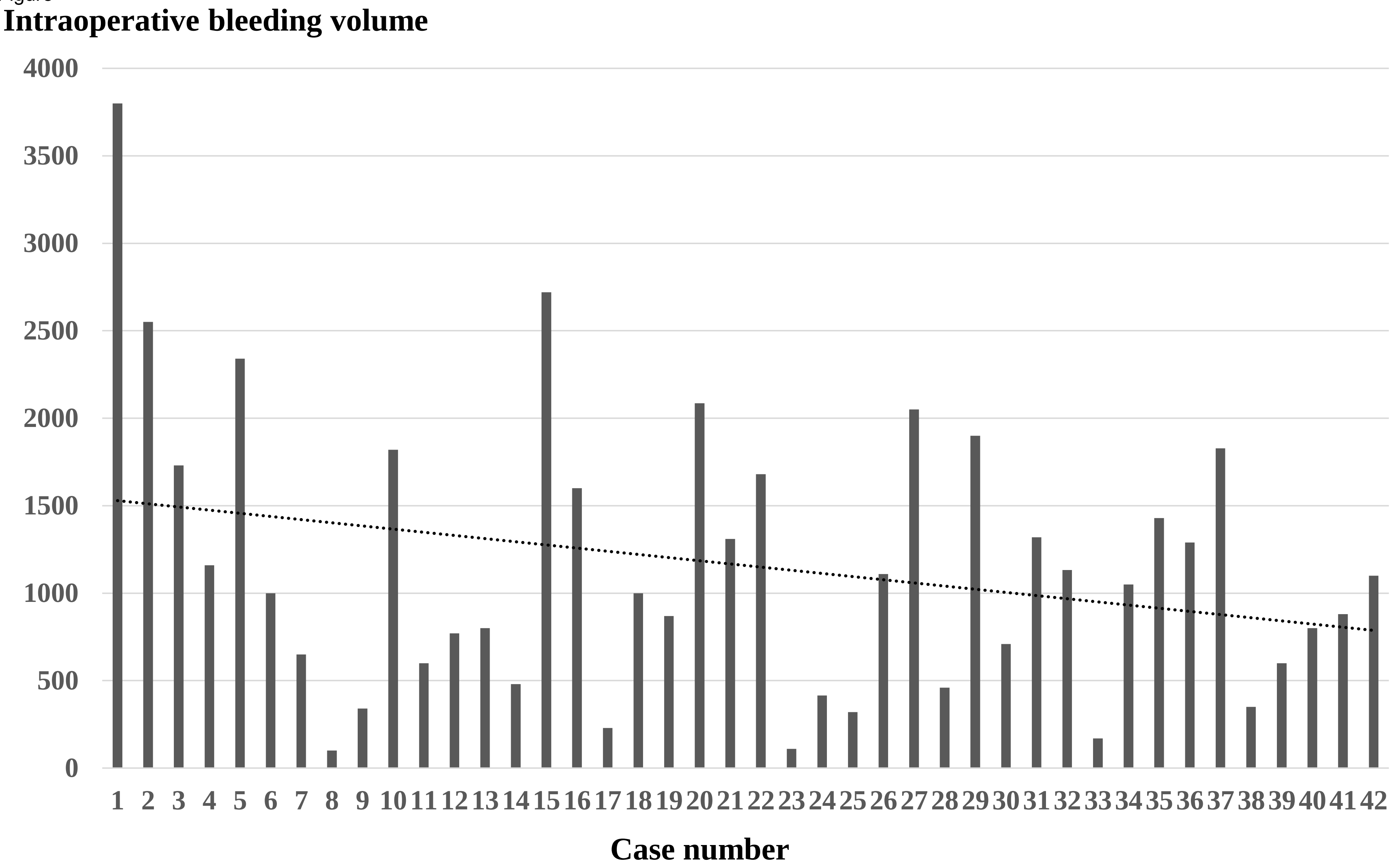

Figure 4

Figure

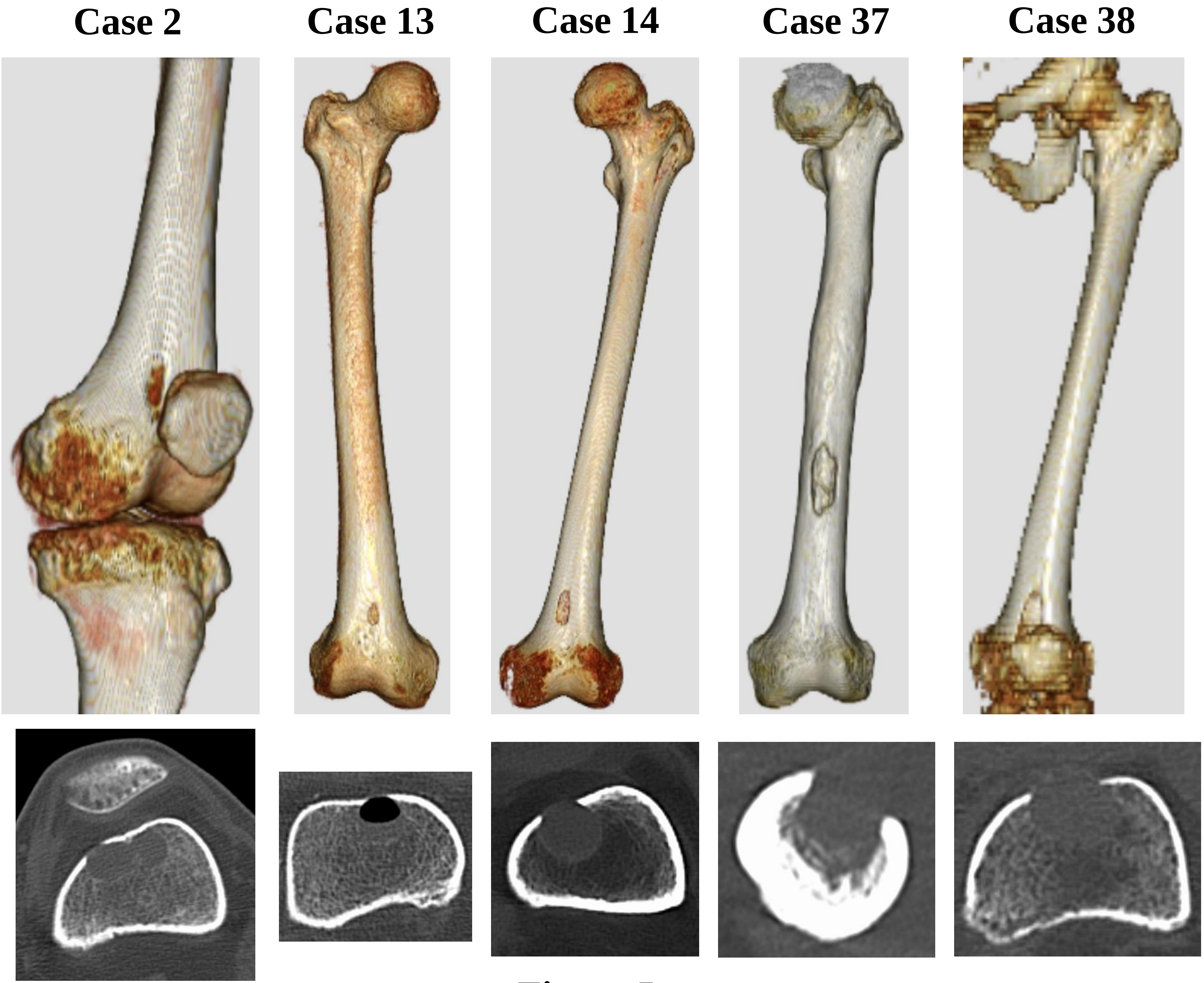

Figure 5

Figure

Figure 6

(a) (b)

Table

Table 1. Patient characteristics

Case	Diagnosis	Sex	Age	Height (cm)	Weight (kg)	BMI	RIA applied bone	Purpose of RIA application	Harvest side, grafted side
1	Osteomyelitis, femur	M	75	158.9	52.3	20.9	Femur	Intramedullary debridement and irrigation	
2	Infected nonunion, tibia	M	53	168.0	66.6	23.6	Femur	Bone graft harvest	Ipsilateral
3	Infected nonunion, femur	M	55	176.0	89.5	28.9	Femur	Intramedullary debridement and irrigation	
4	Nonunion, femur	M	23	170.1	78.8	27.2	Femur	Nail insertion	
5	Osteomyelitis, femur	F	85	145.0	52.6	25.0	Femur	Intramedullary debridement and irrigation	
6	Osteomyelitis, tibia	M	48	164.0	61.2	22.8	Femur	Bone graft harvest	Ipsilateral
7	Infected nonunion, tibia	M	57	174.4	60.0	19.7	Tibia	Intramedullary debridement and irrigation	
8	Infected nonunion, tibia, fibula	M	58	165.0	67.0	24.6	Femur	Bone graft harvest	Ipsilateral
9	Infected nonunion, tibia	M	44	160.3	68.3	26.6	Femur	Bone graft harvest	Ipsilateral
10	Nonunion, femur	M	24	170.0	64.5	22.3	Femur	Bone graft harvest	Contralateral
11	Infected nonunion, tibia	M	29	184.3	70.0	20.6	Tibia	Intramedullary debridement and irrigation	
12	Osteomyelitis, fibula	M	67	166.5	65.7	23.7	Femur	Bone graft harvest	Ipsilateral
13	Osteomyelitis, tibia, fibula, talus	M	59	165.0	70.3	25.8	Femur	Bone graft harvest	Contralateral
14	Infected nonunion, calcaneus	M	69	171.8	65.0	22.0	Femur	Bone graft harvest	Ipsilateral
15	Infected nonunion, tibia	M	60	165.7	63.9	23.3	Femur	Bone graft harvest	Ipsilateral

16	Infected nonunion, femur	F	86	144.8	53.2	25.3	Femur	Intramedullary debridement and irrigation	
17	Nonunion, tibia	F	66	149.6	55.3	24.7	Femur	Bone graft harvest	Ipsilateral
18	Infected nonunion, talus	M	48	177.0	92.6	29.6	Femur	Bone graft harvest	Ipsilateral
19	Osteomyelitis, femur	M	37	172.6	86.6	29.1	Femur	Intramedullary debridement and irrigation	
20	Infected nonunion, femur	M	45	161.5	61.5	23.6	Femur	Intramedullary debridement and irrigation	
21	Open fracture, tibia	M	43	187.0	80.2	22.9	Femur	Bone graft harvest	Ipsilateral
22	Osteomyelitis, tibia, fibula, talus	M	69	170.0	65.7	22.7	Femur	Bone graft harvest	Ipsilateral
23	Nonunion, tibia	M	43	172.3	85.9	28.9	Femur	Bone graft harvest	Ipsilateral
24	Infected nonunion, Tibia & Fibula	M	73	169.0	60.2	21.1	Femur	Bone graft harvest	Ipsilateral
25	Osteomyelitis, tibia, fibula, talus	M	60	165.0	73.5	27.0	Femur	Bone graft harvest	Ipsilateral
26	Nonunion, femur	M	45	170.5	79.0	27.2	Femur	Bone graft harvest	Ipsilateral
27	Nonunion, femur	M	33	168.8	98.9	34.7	Femur	Bone graft harvest	Ipsilateral
28	Nonunion, tibia	F	48	158.7	66.2	26.3	Femur	Bone graft harvest	Ipsilateral
29	Nonunion, femur	M	21	170.0	102.2	35.4	Femur	Bone graft harvest	Ipsilateral
30	Infected nonunion, tibia	M	70	159.0	52.8	20.9	Femur	Bone graft harvest	Ipsilateral
31	Nonunion, femur	M	38	177.9	69.4	21.9	Femur	Bone graft harvest	Ipsilateral
32	Osteomyelitis, femur, tibia, fibula	M	70	166.7	53.0	19.1	Femur	Bone graft harvest	Ipsilateral
33	Osteomyelitis, calcaneus	F	66	154.0	61.4	25.9	Femur	Bone graft harvest	Ipsilateral
34	Osteomyelitis, tibia	M	32	176.1	76.3	24.6	Femur	Bone graft harvest	Ipsilateral
35	Infected nonunion, tibia	M	48	171.0	62.0	21.2	Femur	Bone graft harvest	Ipsilateral

36	Open fracture, femur	M	23	172.0	54.6	18.5	Femur	Bone graft harvest	Contralateral
37	Osteomyelitis, femur	M	68	167.6	76.8	27.3	Femur	Intramedullary debridement and irrigation	
38	Infected nonunion, tibia, fibula	F	61	158.5	59.7	23.9	Femur	Bone graft harvest	Ipsilateral
39	Infected nonunion, tibia	M	65	162.6	58.3	22.1	Femur	Bone graft harvest	Ipsilateral
40	Infected nonunion, tibia, fibula	M	56	178.0	77.7	24.5	Femur	Bone graft harvest	Ipsilateral
41	Nonunion, fibia	M	55	168.0	86.5	30.6	Femur	Bone graft harvest	Ipsilateral
42	Osteomyelitis, femur, tibia, fibula	M	47	174.4	82.0	27.0	Femur	Bone graft harvest	Ipsilateral

RIA, reamer irrigator aspirator; M, male; F, female; BMI, body mass index

Table 2. Diameters of the isthmus intramedullary canal and the applied reamer irrigator aspirator head

A	B	C		
Diameter of the applied RIA reamer head (mm)	**Intramedullary canal diameter of the isthmus (mm) AP**	**Intramedullary canal diameter of the isthmus (mm) ML**	**A/B (%)**	**A/C (%)**
12.7 ± 1.0	**11.8 ± 2.0**	**13.7 ± 1.7**	**109.8 ± 13.6**	**93.5 ± 12.6**

RIA, reamer irrigator aspirator; AP, anteroposterior; ML, mediolateral
Data are shown as average ± standard error.

Table

Table 3. Diameter of RIA reamer head and outer diameter of narrowest part of bone

A	B	C		
Diameter of the applied RIA reamer head (mm)	**Outer diameter of the narrowest part of the bone (mm) AP**	**Outer diameter of the narrowest part of the bone (mm) ML**	**A/B (%)**	**A/C (%)**
12.7 ± 1.0	**26.7 ± 2.5**	**28.3 ± 2.6**	**47.8 ± 4.3**	**45.2 ± 5.2**

RIA, reamer irrigator aspirator; AP, anteroposterior; ML, mediolateral
Data are shown as average ± standard error.

Table

Table 4. Bone harvested using RIA

Case	Amount (g)
33	8
34	31
35	21
36	18
37	35
38	36
39	23
40	60
41	38
42	21

RIA, reamer irrigator aspirator