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ORIGINAL ARTICLE

Treatment of intractable septic ankle arthritis with a continuous closed irrigation system

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ABSTRACT

Objectives: The study aimed to evaluate the efficacy of a continuous closed irrigation system (CCIS) after open debridement for patients with intractable septic ankle arthritis.

Patients and methods: The retrospective study analyzed the intractable septic arthritis of 12 (6 males, 6 females; mean age: 64.1±14.7 years; range, 33 to 80 years) patients managed by CCIS between July 2015 and July 2020. All patients had previously undergone operations to treat septic ankle arthritis without resolution of the infection. After open debridement, the CCIS was usually equipped with two outflow tubes and one inflow tube. Saline inflow was about 1 L per day.

Results: The mean follow-up period was 30.8±14.9 (range, 15 to 70) months. The CCIS was maintained for a mean of 5.1±2.1 (range, 3 to 7) days. The mean number of operations the patients had previously undergone was 2.83±1.5 (range, 1 to 6). For 11 (91.6%) out of 12 patients, infection did not recur after one-time CCIS, and laboratory test results remained normal. Six patients had previously undergone total ankle replacement arthroplasty. These patients underwent antibiotics-mixed cement arthroplasty after CCIS. For five of six with infected total ankle replacement arthroplasty, infection did not recur after CCIS. However, one patient without the removal of both implants experienced recurrence at the same site after four postoperative months. In the reoperation, after the removal of both implants and the application of antibiotics-mixed cement arthroplasty, the infection was cleared.

Conclusion: Use of CCIS after open debridement for intractable septic ankle arthritis is a good treatment option since it is relatively simple and safe, with good results.

Keywords: Continuous closed irrigation system, infection, intractable septic ankle arthritis.

Septic arthritis can cause severe joint destruction and dysfunction.[1-3] Septic arthritis of the native joint is a significant issue, but prosthetic joint septic arthritis causes even greater problems. Infected arthroplasty sites are difficult to treat in any joint, but infected ankle arthroplasties are more complicated due to poor soft tissue coverage, a lack of remaining bone after implant removal, and a lack of revision implant designs to choose from.[4-8]

Early and active treatment is important to prevent irreversible damage to the joint. In addition to antibiotic treatment, various surgical treatments can be performed, such as incision and drainage (I&D), as well as arthroscopic or open debridement.[9,10]

However, the optimal treatment strategy for septic ankle arthritis, which does not heal well even after such surgical procedures, has not yet been established, and repeated I&D, arthroscopic debridement, or open debridement are typical approaches. The most commonly used method for mechanical removal of infected tissue is saline irrigation. However, there

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are limitations in terms of the duration of irrigation and the amount of saline that can be used for one time surgery. Continuous irrigation would facilitate effective washouts of infected hematomas or joint fluid, leading to more favorable outcomes associated with septic arthritis treatment.[11-13] However, since the ankle has a relatively poor soft tissue envelope and is a small joint, no published studies to our knowledge have investigated the use of a continuous closed irrigation system (CCIS). Therefore, this study evaluated the efficacy of a CCIS after open debridement for patients with intractable septic ankle arthritis.[11,14,15]

PATIENTS AND METHODS

The retrospective study analyzed the intractable septic arthritis cases managed at the Department of Orthopaedic Surgery between July 2015 and July 2020. The study included 12 patients (6 males, 6 females; mean age: 64.1±14.7 years; range, 33 to 80 years). Intractable septic arthritis was defined when clinical symptoms and follow-up laboratory values (white blood cell [WBC], C-reactive protein [CRP], and erythrocyte sedimentation rate [ESR]) did not heal after ≥2 weeks of intravenous antibiotic treatment after previous surgery (debridement or I&D) for infection. Diagnoses were determined by comprehensively considering synovial fluid analysis findings, clinical symptoms, and laboratory data. Septic arthritis was diagnosed when *(i)* infection was confirmed by culture obtained from synovial fluid aspiration; *(ii)* a WBC ≥50,000/µL was found in the joint fluid; *(iii)* clinical symptoms were present, including ankle pain, limited motion in the ankle joint, swelling, joint effusion, redness, fever, and chills; *(iv)* and when there was a raised blood WBC, CRP, and ESR.

Surgical technique

1) Debridement and CCIS

Depending on the patient's condition, surgery was performed under general anesthesia or spinal anesthesia. An incision was made along the previous surgical site, and debridement was performed on the infected tissue. Biopsy examination and culture of the tissue and joint fluid obtained during surgery were requested. After debridement, massive irrigation was performed with normal saline and povidone-iodine solution.

Suction drains were installed for continuous irrigation. They were usually equipped with two outflow tubes and one inflow tube. The outflows

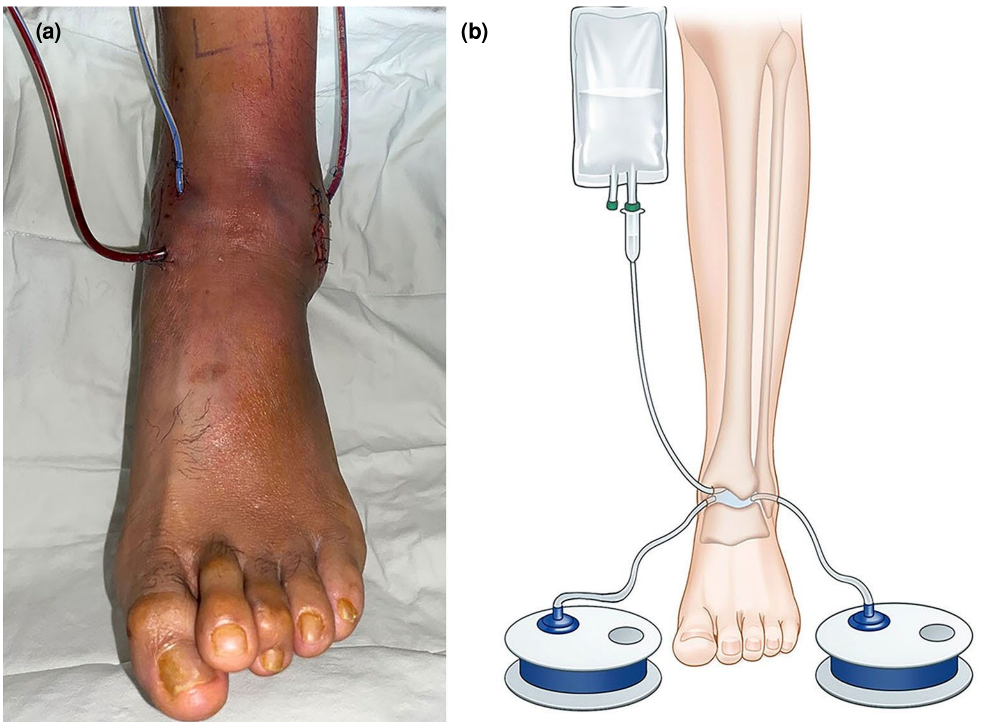

FIGURE 1. Establishment of a CCIS for the ankle joint: **(a)** Photograph of the CCIS applied ankle. **(b)** Schematic diagram.
CCIS: Continuous closed irrigation system.

were located on the inferomedial and inferolateral sides of the ankle joint, and the inflow was located on the superior side of the ankle joint (Figure 1). Two Jackson-Pratt (JP) drains (4.8-mm size) and one infusion set were used; the infusion set was connected to the inflow, and the JP line was connected to the outflow. After the drains were installed, the joint capsule was meticulously sutured to prevent leakage, and the drains were tagged together with the skin to prevent leakage.

A normal saline (gravity inflow) line was connected to the inflow tube and drained into outflow tube (JP bag) naturally without negative pressure. Saline inflow was about 1 L per day. Dressing changes were performed daily, and obstruction and leakage, along with input and output tube, were observed regularly. The drain was removed in the ward after clinical symptom was stabled.

2) Following surgery after CCIS removal

Seven of 12 patients (six infected total ankle replacement arthroplasties [TARAs], one septic arthritis of native joint) underwent antibiotics-mixed cement arthroplasty[16] after drain removal in the operating room, and one patient underwent ankle fusion, one patient underwent ankle and subtalar joint fusion after CCIS. Tissue culture and biopsy were reobtained during the second surgery. For the other three patients, no additional surgery was performed after drain removal in the ward (Figure 2, Case 2).

Six patients with infected TARAs underwent antibiotics-mixed cement arthroplasty[16] for bone defect filling after implant removal. There were three patients who had both tibial and talar implants removed, one patient with only tibial implants removed (Figure 3, Case 10), and

FIGURE 2. Case 2. **(a)** Infection after modified Broström operations in a 61-year-old female. Initial wound with discharge. **(b)** Postoperative (CCIS) radiograph, which shows draining tubes. **(c)** Radiograph at the 28 month follow-up after CCIS application. **(d)** Improved final wound.
CCIS: Continuous closed irrigation system.

one patient with only a talar implant removed (Figure 4, Case 11). The other one patient underwent CCIS with cement arthroplasty without implant removal (Figure 5, Case 12).[16]

3) Antibiotics administration

Intravenous antibiotics were administered for a mean of 27±13.4 (range, 18 to 41) days after surgery, and additional oral antibiotics were administered for a mean of 13.42±23.0 (range, 0 to 30) days after discharge. When a new microorganism was identified, antibiotics were changed according to culture and sensitivity findings.

RESULTS

The mean follow-up period was 30.75±14.9 (range, 15 to 70) months. Before CCIS implementation, all patients had undergone a mean of 2.83±1.5 operations (range, 1 to 6) to treat septic ankle arthritis in another hospital without resolution of the infection. Eight of 12 patients had underlying diseases: six patients with diabetes mellitus, one patient with rheumatoid arthritis, and three patients were on immunosuppressants (including steroids). The mean amount of saline or povidone-iodine solution used for irrigation was 3±1.7 L (range, 2 to 5 L). The mean time to remove the drain was 5.1±2.1 (range, 3 to 7) days.

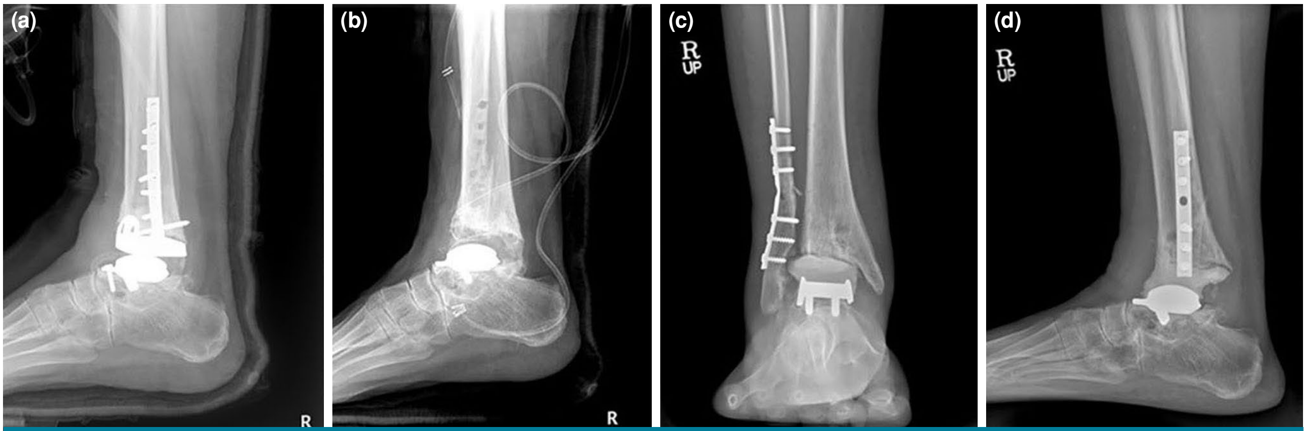

FIGURE 3. Case 10. **(a)** Infected total ankle replacement arthroplasty in a 33-year-old female. **(b)** Postoperative (CCIS) radiograph, which shows draining tubes and remained talar implant. **(c, d)** Standing anteroposterior and lateral radiograph at the 70 month follow-up.

CCIS: Continuous closed irrigation system.

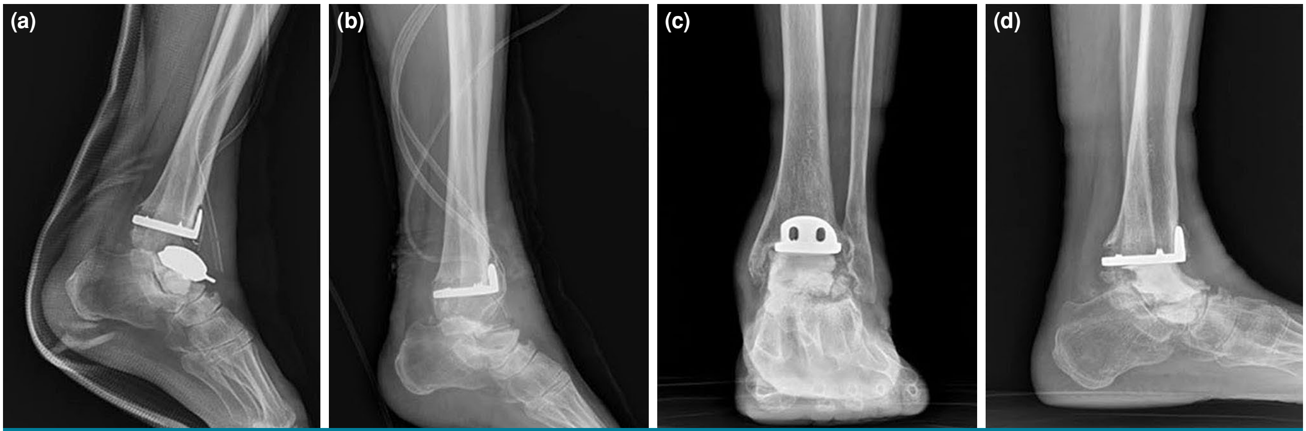

FIGURE 4. Case 11. **(a)** Infected total ankle replacement arthroplasty in a 62-year-old female. **(b)** Postoperative (CCIS) radiograph, which shows draining tubes and remained tibial implant. **(c, d)** Standing anteroposterior and lateral radiograph at the 17 month follow-up.

CCIS: Continuous closed irrigation system.

FIGURE 5. Case 12. **(a)** Infected total ankle replacement arthroplasty in a 75-year-old female. **(b)** The CCIS applied without implant removal. **(c)** Postoperative radiograph shows antibiotics-mixed cement block instead of PE reinsertion between both components. **(d)** Cement block subluxation and reinfection occurred four months after the first CCIS procedure. **(e, f)** Standing lateral and anteroposterior radiograph at the 21-month follow-up after the removal of both implants and application of cement arthroplasty.
CCIS: Continuous closed irrigation system.

1) Cause of infection

Of the 12 patients, six had previously undergone TARA. Two patients developed infection after undergoing modified Broström operations for chronic ankle instability (Figure 2, Case 2). One of these patients developed infection 10 months after open reduction and internal fixation for an open distal tibia fracture, and the other patient developed infection a month after supramalleolar osteotomy for osteoarthritis. Two patients developed infection without any surgical history. Among patients who developed septic ankle arthritis without a surgical history, diabetes mellitus-associated chronic osteomyelitis of the distal tibia was considered the cause, and one patient was thought to be due to decreased immunity in association with adrenal insufficiency due to long-term steroid use (Table I).

Of the six patients with infected arthroplasty sites, five had received Hintegra (Newdeal, Lyon, France) prostheses, and one patient had received a

TABLE I
Summary of patient demographics

Patients	Age/Sex	Underlying conditions	Cause of infection	Previous operation	Microorganism	Antibiotics	Duration of irrigation (days)	IV antibiotics (days)	Final operation	Follow-up duration (months)	Recurrence
1	44/M	(-)	SMO	Open debridement	MSSA	Cefazolin	6	18	(-)	15	(-)
2	61/F	(-)	MBO	Open debridement	MRSA	Vancomycin	6	22	(-)	28	(-)
3	76/M	DM, HTN, asthma, adrenal insufficiency	Septic ankle arthritis	Open debridement	*Staphylococcus lugdunensis*	Nafcillin	3	30	Cement arthroplasty	41	(-)
4	73/F	DM	ORIF	Open debridement	*Corynebacterium striatum*	Vancomycin	7	21	Ankle fusion	35	(-)
5	31/M	(-)	MBO	Open debridement	*Staphylococcus spp. coagulase-negative & Klebsiella spp.*	Levofloxacin	7	23	(-)	33	(-)
6	71/M	DM, HTN	Chronic osteomyelitis	Cement insertion	Culture (-)	Cefazolin + TB medication	7	32	Ankle & subtalar fusion	35	(-)
7	66/M	(-)	TARA (Hintegra)	Cement arthroplasty	*Enterococcus faecium*	Vancomycin + cefazolin	6	33	Cement arthroplasty	32	(-)
8	80/F	DM, HTN	TARA (Hintegra) (Acupuncture hx.)	Cement arthroplasty	Culture (–)	Vancomycin + rifampin	5	41	Cement arthroplasty	17	(-)
9	66/M	DM, HTN, gout	TARA (Hintegra) (Acupuncture hx.)	Open debridement	*Staphylococcus epidermidis*	Cefazolin	3	18	Cement arthroplasty	25	(-)
10	33/F	RA	TARA (Hintegra) (Dental procedure hx.)	Open debridement	MRSA & *Streptococcus dysgalactiae*	Teicoplanin	3	30	Cement arthroplasty (tibial component removal only)	70	(-)
11	62/F	HTN, LC, CKD	TARA (Hintegra)	Cement arthroplasty	*Streptococcus sanguinis*	Ceftriaxone	4	26	Cement arthroplasty (talar component removal only)	17	(-)
12	75/F	DM, HTN	TARA (ZENITH)	Cement arthroplasty	*Corynebacterium striatum* & *Staphylococcus epidermidis*	Vancomycin + cefazolin	4	30	Cement arthroplasty	21	4 months after

SMO: Supramalleolar osteotomy; MSSA: Methicillin-sensitive *Staphylococcus aureus*; MBO: Modified Broström operation; MRSA: Methicillin-resistant *Staphylococcus aureus*; DM: Diabetes mellitus; HTN: Hypertension; ORIF: Open reduction and internal fixation; TARA: Total ankle replacement arthroplasty; RA: Rheumatoid arthritis; LC: Liver cirrhosis; CKD: Chronic kidney disease.

Zenith (Corin, Cirencester, UK) prosthesis. Among the patients who underwent TARA surgery, two had a recent acupuncture history, and one developed symptoms of infection after having had a dental procedure the day before.

2) Previous surgery for infection control

Before CCIS, a mean of 2.83±1.5 operations (range, 1 to 6) were performed for infection control. All patients visited our hospital because the infection did not improve even after open debridement was performed at another hospital. Antibiotics-mixed cement block insertion was performed for four of six patients with infected TARA, but the infection was not controlled.

3) Laboratory data after CCIS

Continuous closed irrigation system was performed for a mean of 5.1±2.1 (range, 3-7) days. The mean CRP level improved from 6.19 (range, 0.16 to 17.64) mg/dL before surgery to 0.34 (range, 0.1 to 1.22) mg/dL four weeks after CCIS. The mean ESR improved from 48.25 (range, 4 to 81) mm/h before surgery to 36.33 (range, 6 to 62) mm/h four weeks after CCIS. The mean preoperative WBC was 9,400/μL (range, 5,100 to 18,700/μL) compared to 6,017/μL (range, 4,200 to 8,400/μL) after CCIS. Clinical symptoms of infection resolved in all patients at the final follow-up.

In the joint fluid and tissue culture and biopsy results, no bacteria were identified in two of the 12 cases. Among the 10 positive cultures, Staphylococcus spp. were identified in seven (70%) patients, and polymicrobial infection was confirmed in three (30%) patients.

4) Clinical results of CCIS

For 11 (91.6%) out of 12 patients, infection did not recur after one-time CCIS, and laboratory test results remained normal. For five of six with infected TARA, infection did not recur after CCIS with tibial implant removal in one, a talar implant removal in one, and both implants removal in three. However, one patient without TARA implant removal experienced recurrence at the same site after four postoperative months. In the reoperation, antibiotics-mixed cement arthroplasty was applied after the removal of both implants, and the infection was cleared (Figure 5, Case 12).[16]

DISCUSSION

Chronic joint infections are difficult to treat with only antibiotic treatment, and most require surgical treatment, such as I&D or arthroscopic or open debridement with implant removal. If symptoms persist even after debridement, treatment is more difficult, and repeated surgery is inevitable. However, repeated surgery is a great burden for both patients and doctors.

When debridement is performed for infected arthritis, associated postoperative hematomas are a conducive medium for bacterial growth. Continuous closed irrigation system is implemented in the ward to continuously wash out the causative bacteria and purulent effusions in the joint after surgery. This has the advantage of eliminating the chance of infection reactivation and protecting the articular cartilage by diluting the active enzyme substance.[17]

Parisien and Shaffer[18] proposed a suction drainage for treating septic knee joints, and Kuo et al.[19] found that the frequency of reoperation was lower and hospitalization days were reduced when a CCIS was implemented compared to arthroscopy alone. However, Royo et al.[15] determined a success rate associated with CCIS implementation that was not higher than that associated with arthroscopic treatment alone, and CCIS implementation was associated with longer hospitalizations and costs. Another report advocates against CCIS because of the high risk of secondary infection due to the installation of a continuous suction drain.[20-22] Unlike the knee joint, the ankle joint has a relatively poor soft tissue envelope and is a small joint. Therefore, chronic infection of the ankle joint is more difficult to treat, and there are no reports on the effectiveness of CCIS for ankle infection treatment.

When a stable implant is removed during revision surgery after TARA, the bone defect is so large that the following operation is difficult. For such cases in our series, unstable components and polyethylene (PE) were removed before CCIS implementation. However, for stable implants, all infected soft tissue around the implant was removed, and CCIS was performed with the implant left in place. For one patient, only the tibial component was removed (Figure 3, Case 10), and for one patient, cement arthroplasty was performed after removal of only the talar component, and infection did not recur (Figure 4, Case 11). Although implant reinsertion was planned after infection control, ambulation was tolerable even in the cement arthroplasty state with only one implant remaining, and the patients did not want any further surgery; thus, follow-up was conducted for 70 and 17 months, respectively.

Infection recurred in one of the 12 included patients (Figure 5, Case 12). This patient had previously undergone TARA. The subsequent operation was considered difficult due to bone loss after stable implant removal. Hence, CCIS was performed without implant removal, and antibiotics-mixed cement arthroplasty was performed instead of PE reinsertion. After infection control, PE reinsertion was planned, but the infection recurred four months later. During the reoperation, both the tibial and talar implants were removed, and antibiotics-mixed cement arthroplasty was performed. There was no recurrence at the 21-month follow-up. This case exemplified the difficulty of treating an intra-articular infection with an implant left *in situ*.

Of the six patients with infected TARAs, three patients underwent CCIS after the removal of unstable tibial and talar implants. After infection control, all three patients underwent antibiotics-mixed cement arthroplasty, and there was no recurrence for 32, 17, and 25 months of follow-up, respectively (Cases 7, 8, and 9).

In the joint fluid analysis, tissue culture, and biopsy results, no bacteria were identified in two of the 12 cases. Patients previously underwent multiple operations and long-term antibiotic treatment at other hospitals. Although the culture results were negative, the symptoms of infection were clear, and antibiotic treatment was necessary. Antibiotics that can cover a broad spectrum of microorganisms were used in consultation with the infectious disease department.

Authors with experience using continuous closed irrigation and suction for the knee, report the use of chest tubes or 6.4-mm Hemovac drains as outflow conduits.[19] However, the volume of the ankle joint is smaller than that of the knee joint, so we used a 4.8-mm JP drain and installed two outflows just in case of outflow obstruction.

Continuous closed irrigation must be carefully performed since fluid leakage out of the joint into the calf muscle can cause compartment syndrome. Inflow and outflow volumes should be kept similar, and if the outflow volume is less than the inflow volume, providers should beware of leg compartment syndrome due to leakage. In this study, the mean daily mismatch between inflow and outflow volume was less than 50 mL, and compartment syndrome did not occur.

The main limitation of this study was that it was a retrospective study with a small sample size. The incidence of septic arthritis was low, and surgically treated intractable cases were not common. A comparative study was not possible since there were only 12 cases encountered over six years.

In conclusion, CCIS for intractable septic ankle arthritis is a good treatment option as it is relatively simple and safe, has good treatment results, and can minimize the number of operations required to achieve cure.

Ethics Committee Approval: The study protocol was approved by the Asan Medical Center Ethics Committee (date: August 19, 2022 no: 2022-1139). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from the patients.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept: L.H.S.; Design: L.H.S., K.T.H.; Control/supervision: C.Y.R.; Data collection and/or processing, analysis and/or interpretation, writing the article, references and funding: K.T.H.; Literature review: K.T.H., B.G.G., K.S.H.; Critical review, materials: K.T.H., K.S.G.

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