Benign anastomotic stenosis after colorectal resection is not an unusual event and occurs in 3–30% of patients [1]. The exact pathophysiology of such stricture is unknown, but use of a stapling device, postoperative anastomotic ischemia, anastomotic leak, pelvic infection, or postoperative radiation are believed to be contributing factors [1]. Traditionally, postoperative colonic stenosis has been managed surgically [1], but endoscopic treatment is now preferred over traditional surgery. Endoscopic balloon dilation (EBD) is presently the simplest therapeutic approach and has a good short-term success rate; however, in some patients, a fibrotic stricture is so inelastic that the balloon technique is ineffective or requires more than 1 dilation. In these patients, repeat procedures are necessary to achieve and maintain clinical success, but can markedly reduce quality of life and add considerably to the overall cost of treatment [1, 2]. The complications of EBD include bleeding and perforation, which occur in up to 5% of patients [1, 2].

The endoscopic radial incision and cutting (RIC) technique was recently developed to treat refractory stenosis and has been effective for treating refractory benign esophageal stricture [3,4]. To the best of our knowledge, there have been few reports on the application of RIC at sites other than the esophagus. Furthermore, few studies have evaluated the effectiveness and safety of RIC for severe benign anastomotic colonic stenosis after surgery for colorectal carcinoma. Here, we evaluated the effectiveness and safety of endoscopic RIC therapy in patients with symptomatic severe anastomotic colonic stenosis.
Case series

3 consecutive patients were treated by RIC for severe benign anastomotic stenosis after surgery for colorectal carcinoma at Hiroshima City Asa Citizens Hospital between May 2014 and December 2016. Severe anastomotic stenosis was defined as (1) failure to pass a colonoscope measuring 11.7 mm in diameter (PCF Q260AZI; Olympus Medical Systems, Tokyo, Japan) through the stricture and (2) dyschezia-related problems such as constipation and/or abdominal distension. The stenosis was assessed radiologically as necessary. Written informed consent was obtained from all patients before RIC was performed.

The RIC procedure was performed as previously described [3,4] using the ITknife nano Electrosurgical Knife (Olympus Medical Systems). Briefly, the blade of the ITknife nano was first inserted into the stenosed area. 4 or more incisions were then made at the site using the knife. Next, the flaps formed by the incisions were removed. Finally, the scar tissue was excised in an arc from the incision along the lumen. The patients received 7.5–15 mg of pentazocine and 2–3 mg of midazolam before RIC to minimize discomfort. The RIC procedure was performed by an endoscopist (SN) who had completed approximately 500 colorectal endoscopic submucosal dissection procedures between December 2006 and December 2016. The electrosurgical unit was set to Dry Cut mode (Effect 2, 30 W, VIO 300; Erbe Elektromedizin GmbH, Tübingen, Germany) for making the incisions at the stricture site and to Swift coagulation mode (Effect 2, 30 W, VIO 300) for cutting the scar tissue. We considered treatment to have been successful if the anastomosis could be passed by the 11.7-mm diameter colonoscope immediately after dilation.

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Patient demographic and clinical characteristics are summarized in ►Table 1. All 3 patients were male, had a median age of 72 years, and had undergone laparoscopically assisted transverse colectomy or anterior resection as additional surgery after endoscopic resection for T1 carcinoma and sigmoid colectomy for advanced colorectal carcinoma. In all patients, the main clinical manifestation of the anastomotic stenosis before RIC was severe dyschezia. 1 of the patients also experienced abdominal pain.

The results of RIC are shown in ►Table 2. 1 patient had undergone 3 EBD procedures before RIC. The median interval from surgery to RIC was 21 months (range 9–29 months) and the median follow-up after RIC was 27 months (range 8–37 months). RIC was successful in all 3 patients and reduced the severity of dyschezia postoperatively according to patients’ subjective verbal reports [►Fig. 2 and ►Fig. 3; ►Video1]. 2 patients experienced improvement after a single RIC session and the third experienced improvement after 6 sessions. All 8 RIC sessions were performed on an inpatient basis with a median stay of 4 days (range 2–5 days). The median RIC procedure time was 22 minutes (range 15–25 minutes). No severe adverse events, such as perforation, severe bleeding, high fever, or severe pain, were observed. No re-stenosis occurred and there was no need for additional dilation in any of the patients during follow-up.

Discussion

In this study, the severity of dyschezia caused by severe benign anastomotic stricture after surgery for colorectal carcinoma was dramatically reduced by RIC in all 3 patients and no severe adverse events occurred. EBD is the simplest therapeutic option for benign anastomotic stenosis, but it is associated with a high recurrence rate and with refractoriness in more than 20% of patients.

In contrast, RIC is less time-consuming and less expensive. EBD can open the lumen of the colon or rectum, but patency is not stably maintained because EBD tears the existing scar tis-
were located at various sites in the colon, and RIC provided re-
genery for lower rectal carcinoma. In our patients, the stenoses
safe for the treatment of severe anastomotic stenosis after sur-
guti et al. [8], RIC was suggested to be feasible, effective, and
nano to perform all RIC procedures in this series; the insulated
method may lie in its usefulness for treating refractory stenosis
of ileus after laparoscopic colectomy. Postoperative anasto-
motic ischemia and leakage were considered to have contributed
to the admission for ileus, and the refractoriness of the anasto-
motic stenosis was attributed to technical difficulties associat-
ed with the RIC procedure.
To our knowledge, this is the first report on the use of RIC for
treating severe benign anastomatic stenosis at various sites in
the colon. There were no severe adverse events and no reopera-
tions were needed.
There are no clear criteria with regard to the indications for
RIC, and individual patients are presently accepted after con-
sultation between the gastroenterologists, surgeons, and par-
ologists. The contraindications are as follows: the blade of
an ITknife nano cannot pass through the stenosis because it is
too narrow; the scar tissue associated with the stenosis is so
firm after electrocautery that an incision using an ITknife nano
cannot be performed; the axial direction of the intestine is not
the same between the anal side and the oral side; and the ste-
nosis is too long for the procedure to be technically feasible.
The main difficulty encountered when using an ITknife nano
to excise scar tissue from an anastomatic site is that the scar
adheres tightly to the intestinal wall. Furthermore, it is impossi-
ble to inject material, including sodium hyaluronate, into an
anastomatic stricture site when severe fibrosis is present.
Therefore, RIC needs to be performed carefully without any in-
jection in the treatment region.

### Table 1 Patient demographic and clinical characteristics.

| Patient | Age, years/sex | Comorbidity | Tumor location | Treatment approach | Surgical procedure | pTNM | Postoperative complications | Adjuvant therapy |
|---------|----------------|-------------|----------------|--------------------|-------------------|------|-----------------------------|-----------------|
| 1       | 68/Male        | AAA         | T/C            | EMR → operation    | LAC               | pT1bN0M0 | Ileus                       | None            |
| 2       | 65/Male        | DM, HTN     | S/C            | Operation          | Sigmoid colectomy | pT4aN1M0 | None                        | Chemotherapy    |
| 3       | 76/Male        | HTN         | S/C            | ESD → operation    | LAR               | pT1bN0M0 | None                        | None            |

AAA, abdominal aortic aneurysm; DM, diabetes mellitus; EMR, endoscopic mucosal resection; ESD, endoscopic submucosal dissection; HTN, hypertension; LAC, laparoscopy-assisted colectomy; LAR, laparoscopic anterior resection; S/C, sigmoid colon; T1b, submucosal invasion depth ≥ 1000 μm; T/C, transverse colon.

### Table 2 Clinical outcomes of RIC.

| Patient | Clinical manifestations | Pretreatment | Interval from surgery to RIC, months | RIC sessions (n) | Operation time, min | Major complications | Hospital stay, days | Follow-up after RIC, months |
|---------|-------------------------|--------------|-------------------------------------|------------------|---------------------|---------------------|--------------------|--------------------------|
| 1       | Abdominal pain, severe dyschezia | BD           | 29                                  | 6                | 15–25               | None                | 3–5                | 34                       |
| 2       | Severe dyschezia         | None         | 9                                   | 1                | 20                  | None                | 2                  | 5                        |
| 3       | Severe dyschezia         | None         | 13                                  | 1                | 15                  | None                | 2                  | 16                       |
| Median  |                         |              | 21                                  | 3.5              | 22                  |                     | 4                  | 25                       |

BD, balloon dilation; RIC, radial incision and cutting.

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Several precautions are necessary to prevent perforation: the oral side of the intestine should be assessed radiologically if necessary before an incision is made using the ITknife nano; the patient should not be sedated too deeply (so that any adverse events that occur can be detected early); the blade of the ITknife nano should be positioned parallel to the lumen directly over the scar tissue; and incisions should be made carefully with the knife perpendicular to the lumen.

It is very important that the amount of scar tissue incised does not exceed the length of the stenosed segment on the oral side because the risk of perforation increases when the stenosis is cut deeply in 1 session. Staples serve as good landmarks for determining the depth of the cutting line. If the staples are exposed, it is important not to cut the scar tissue any further.

Although several studies have demonstrated the feasibility of stent insertion for refractory anastomotic colorectal stric-
ture, this procedure is technically difficult because of stent migration, bleeding, or even perforation. A stent might also need to be removed after placement because of foreign body reaction [9, 10]. Moreover, stent insertion for refractory colorectal stenosis is not covered by the Japanese health insurance system.

Our findings indicate that dilation by RIC is feasible, effective, and safe for the treatment of severe anastomotic stenosis after surgery for colorectal carcinoma. The effectiveness of RIC combined with steroid injection is still controversial and needs further study. RIC is performed at only a few institutions at present, so limited clinical data are available. Large-scale, multicenter, prospective investigations are warranted to evaluate the long-term outcomes of RIC.

Competing interests

None

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