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Restorative Proctocolectomy with Ileal Reservoir: Pouch Configuration and Volume

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Summary. **Restorative proctocolectomy with ileal reservoir has become an accepted form of treatment for ulcerative colitis and familial adenomatous polyposis. Five types of reservoirs have been developed: the S pouch, J pouch, H pouch, W pouch and K pouch. This paper reviews the differences in the clinical and functional outcomes among the various reservoir designs and their sizes. From the results of the reported series, the best clinical function is apparently that associated with a large volume and highly compliant pouch which empties spontaneously. The S pouch has a high rate (35-53%) of catheterization for evacuation. On the other hand, the W and K pouches have larger and wider reservoirs with a higher compliance than of the J pouch. However, since cases in which the K pouch as well as H pouch have been used are few, a larger number of patients will be necessary to reach a conclusion regarding the best treatment. The present conclusion is that the W pouch has the best functional outcome concerning defecation.**

INTRODUCTION

In the past decade restorative proctocolectomy with ileal reservoir has become an established surgical treatment for ulcerative colitis (UC) and most cases of familial adenomatous polyposos (FAP). Until recently, the most popular procedures were a proctocolectomy with ileostomy and a total colectomy with ileorectal anastomosis. The former can remove all the diseased segments in one operation, but can not avoid a permanent ileostomy which creates other difficulties for the patient. While the latter can avoid an ileostomy, it has two major disadvantages: diseased mucosa of the rectum remains and there is a possible development of malignancy.[1-3] By combining colectomy with anorectal mucosectomy and ileoanal anastomosis, a permanent ileostomy can be avoided and all of the diseased mucosa can be removed. The operation is based on the principle that UC and FAP are mucosal diseases and may be cured by excision of all affected mucosa. The sphincter mechanism is preserved so that the normal route of evacuation through the anus is preserved, and anal defecation is voluntary and controlled. However, straight ileoanal anastomosis results in severe urgency, high frequency of defecation, night evacuation and perianal excoriation.[4-5] These symptoms were subsequently indicated to have

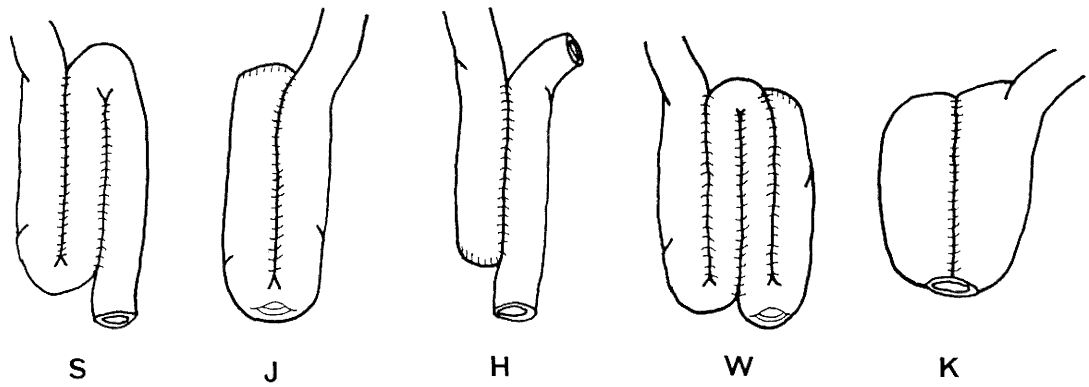

Fig. 1. Reservoir designs. S: triple, J: double, H: lateral isoperistaltic, W: quadruple, K: Kock

been improved by the addition of an ileal reservoir.[5]

Parks was the first to carry out the construction of an ileal reservoir with ileal pouch-anal anastomosis for humans[6] in 1978. He used a 3-loop S reservoir with a distal ileal spout. However, fifty percent or more of those patients having the original S reservoir need to catheterize peranally for evacuation.[7] Radiological studies showed that this was due to the presence of the distal ileal spout.[8] Other configurations were subsequently reported: the 2-loop J reservoir[9] in 1980, the lateral isoperistaltic H reservoir in 1980,[10] the 4-loop W reservoir in 1985[7] and the Kock's K reservoir in 1989.[11] (Fig. 1)

The major benefit of ileal pouch-anal anastomosis is that it successfully restores fecal continence in the great majority of patients, though there are some problems in postoperative complications and defecating function.

It is the aim of this paper to describe the differences in pouch configuration and pouch size.

OPERATIVE TECHNIQUE OF VARIOUS POUCHES

S pouch (triple pouch)

In the original,[6] the terminal 50 cm of ileum is folded into three 15-cm loops, leaving a 5-cm segment of ileum projecting distally (ileal spout). The loops are joined by a continuous seromuscular suture and the lumen is then opened. A second all-layer suture joins the middle to the 2 outside loops and the reservoir is completed by two layer suturing the free edge. The distal ileal segment is subsequently shortened to 2-3 cm as others[12] have done. The ileo-anal anastomosis is made end-to-end between the distal ileal segment and the anal canal at the dentate line.

J pouch (double pouch)

The 2-loop reservoir[9] is made from the terminal 40 cm of ileum folded into two 2-cm segments. After the loops are fixed by a continuous seromuscular suture, a long side-to-side anastomosis is performed using a GIA® autosuture. The ileo-anal anastomosis is made side-to-end at the apex of the reservoir.

H pouch (lateral isoperistaltic pouch)

This reservoir is constructed in two stages.[10] In the first, the terminal ileum is pulled down through the rectal cuff and the ileoanal anastomosis is made end-to-end. The ileum is then divided 20-30 cm proximal and the distal ileal segment closed. The proximal ileum is brought out through the abdominal wall as an end ileostomy. In the second, the ileostomy is mobilized and the ileum passing to ileostomy is then laid alongside the closed segment. A side-to-side anastomosis between the overlapping segments is made. The proximal point of the reservoir is at 5-7 cm from the ileoanal anastomosis. The distal end of the reservoir is brought to the anterior abdominal wall and the catheter is inserted into the reservoir through it for use in postoperative irrigation. The catheter is removed 4-8 weeks later and the cutaneous ileostomy closes spontaneously.

W pouch (quadruple pouch)

Forty-eight cm of terminal ileum are required.[13] They are folded into 4 loops, creating two apices with the second lying 2 cm proximal to the first. Three rows of continuous seromuscular sutures are then made, and the four loops are opened on their antimesenteric border using electrocautery. A continuous all-layer suture is placed between the adjacent loops. The front wall of the reservoir is closed in two layers leaving an opening for side-to-end ileoanal anastomosis.

K pouch (Kock pouch)

Thirty cm of the terminal ileum is used for the reservoir formation.[11] This segment is opened at its antimesenteric border using electrocautery. The opened ileum is placed in a U shape, and the legs of the U are joined together by suturing with a continuous absorbable suture leaving a small opening approximately 2 cm in diameter for the side-to-end ileoanal anastomosis. The reservoir is then formed by folding the intestinal plate upward and by closing the reservoir with one layer of continuous inverting sutures. The corners of the reservoir are then pushed downward between the mesenteric leaves so that the posterior aspect of the reservoir is placed anteriorly.

Table 1 shows the utilized ileum length to create

Table 1. Utilized ileum lengths and anastomotic forms in various reservoirs

Reservoirs	Ileum utilized to create pouch		Ileal pouch-anal anastomosis
	pouch (cm)	spout (cm)	
S pouch	45	5	end-to-end
J pouch	40	0	side-to-end
H pouch	40-60	5-7	end-to-end
W pouch	48	0	side-to-end
K pouch	30	0	side-to-end

Table 2. Postoperative complications in restorative proctocolectomy with ileal reservoir

Author	N	Operative death (mortality)	Failure (pouch removal) N(%)	Anastomotic leak N(%)	Intestinal obstruction (laparotomy) N(%)	Anastomotic stricture N(%)	Type of reservoir (No. of patients)
Rothenberger et al.[12] (1983)	29	0	0	0	4(13.8)	1(3.4)	S(29)
Nicholls and Pezim[7] (1985)	104	0	6(5.8)	20(19.2)	7(6.7)	9(8.7)	S (68) J (13) W (23)
Utsunomiya and Iwama[14] (1985)	45**	1 (2.2)	2(4.4)	14(31.1)	2(4.4)	n.s	J(33)H(2)Straight (10)
Beart et al.[15] (1985)	188	0	10(5.3)	21(11.2)	16(8.5)	22(11.7)	J(183)S(5)
Fonkalsrud[16] (1985)	49	0	2(4.1)	1(2.0)	7(14.3)	7(14.3)	H(49)
Harms et al[17] (1987)	15	0	0	0	1(6.7)	2(13.3)	W(15)
Fleshman et al[18](1988)	179	0	18(10.1)	25(14.0)	16(8.9)	14(7.8)	J(72) S(107)
Keighley et al[19] (1988)	33	0	1(3.0)	1(3.0)	3(9.1)	4(12.1)	J(18) W(15)
Hallgren et al[20] (1989)	33	0	0	3(9.1)	0	3(9.1)	S(11) J(11) K(11)
Hatakeyama et al[21] (1990)	25	0	0	1(4.0)	2(8.0)	3(12.0)	W(25)
de Silva et al[22](1991)	88	0	10(11.4)	4*(6.6)	6*(9.8)	10*(16.4)	J(23) S(15) W(23)
Cumulative total	788	1 (0.1)	49(6.2)	90(11.8)	64(8.9)	75(10.5)	

* of 61 patients on whom detailed analysis was performed
** includes 10 straight ileoanal anastomosis
n.s. not stated

the reservoir and an anastomotic form in the various reservoirs.

OPERATIVE AND POSTOPERATIVE COMPLICATIONS

Operative mortality has been very low,[7,12,14-22] having occurred in only 1 of 788 patients, a rate of 0.1%. (Table 2) This may be because the operation is performed in two or three stages. Failure as defined by the need to remove the reservoir has varied in frequency from 0 to 11.4% (mean 6.2%). These are due to Crohn's disease, incontinence, dysfunction, pelvic sepsis and the discovery of rectal cancer on pathological examination.[23] These series have included the early part of the learning curve with the procedure: with experience postoperative complications have become less frequent.[24] The two most important causes of complications are anastomotic leaks and intestinal obstruction. The former has occurred in 0 to 31% of patients with an average rate of about 12%. Intestinal obstruction requiring laparotomy has occurred in frequency from 0 to 14% with an average rate of about 9%. The figures in Table 2 refer to intestinal obstruction requiring laparotomy after both the reservoir operation and ileostomy closure. The principal late complications are an anastomotic stricture and pouchitis. Many patients have web-like strictures at the ileal pouch-anal anastomosis at the time of ileostomy closure. These are easily dilated and do not recur. However, three to 16% of the patients with an average rate of about 10% had strictures that required repeated dilatation. These usually responded to simple dilatation procedures, and no patients required any operation. Pouchitis as defined by the inflammation of the reservoir has been reported to occur in 7 to 42% of patients.[25] Patients with UC had more pouchitis than the smaller group of FAP patients.[24] The symptomatology of pouchitis was characterized by frequent stooling,

bloody diarrhea, urgency of defecation and sometimes fever. The pathogenesis of pouchitis is still to be determined, but administration of metronidazole (250 mg qid) nearly always results in prompt improvement of symptoms.[26]

Table 3. Mean daily stool frequency after restorative proctocolectomy with and without an ileal reservoir

Author	With a reservoir		Without a reservoir	
	N	Mean daily frequency	N	Mean daily frequency
Martin and Fischer[27] (1981)	14	4	16	8
Neal et al[28] (1982)	10	5	8	9
Taylor et al[5] (1983)	33	7	30	11

FUNCTIONAL RESULTS

Concerning functional results, several groups have demonstrated that some form of pelvic reservoir is superior to a straight ileoanal anastomosis.[5,27,28] (Table 3) In view of these findings, the rest of the discussion applies only to patients with an ileal reservoir.

The defecating function gradually improves with time but tends to stabilize 6 to 12 months after an ileostomy closure.[14,15,21] Therefore the length of follow-up may be important when comparing results within this time range.

The follow-up period and the functional results of the S pouch are shown in Table 4. In these series, the S pouch is associated with a high rate (50-53%[7,22]) of catheterization for evacuation, while all patients with the other pouches could evacuate spontaneously. Concerning the S pouch, this is the major problem due to a function of the distal ileal segment (spout)

Table 4. Functional results after ileostomy closure in S pouch

Author	N	Follow-up months (range)	Daily stool frequency (range)	Night evacuation N (% or range)	Continence			Evacuation catheter N(%)
					Normal N (%)	Minor N (%)	Major N (%)	
Rothenberger et al[30] (1985)	40	16(2-28)	5.7(2-10)	1.4(1-7)	36(90)	3 (8)	1 (3)	14(35)
Nicholls and Pezim[7] (1985)	58	24(3-65)	3.7±1.6(1-9)	15(26)	39(67)	16(28)	3 (5)	29(50)
Hallgren et al[20] (1989)	11	12	4 (2-7)	4 (36)	8 (73)	3 (27)	0	n.s.
de Silva et al[22] (1991)	15	39(23-82)	4 (2-6)	0 (0-1)	11(73)	4 (27)	0	8 (53)

n.s.: not stated

Table 5. Functional results after ileostomy closure in J pouch

Author	N	Follow-up months (range)	Daily stool frequency (range)	Night evacuation N (% or range)	Continence			Evacuation catheter N(%)
					Normal N (%)	Minor N (%)	Major N (%)	
Nicholls and Pezim[7] (1985)	13	13(5-28)	5.5(3-9)	7 (54)	9(69)	3(23)	0	0
Utsunomiya and Iwama[14] (1985)	24	20(3-47)	4.5	n. s.	16(67)	3(13)	2 (8)	0
Beart et al[15] (1985)	157	12(2-29)	7.2	1.2±1.3	75(48)	74(47)	8 (8)	0
Keighley et al[19] (1988)	15	>4	5 (3-7)	1 (0-1)	14(93)	1(7)	0	0
Hallgren et al[20] (1988)	11	12	4 (3-6)	2 (18)	9(82)	2(18)	0	n.s.
de Silva et al[22] (1991)	23	18(6-76)	5 (3-8)	0 (0-1)	18(78)	4(17)	1 (4)	0

n.s.: not stated

which is 5 cm in length.[24] Recent reports of the S pouch with a shorter efferent spout of 3 cm in length have shown a lower incidence of catheterization,[30] but 35% of patients used a catheter one to three times a day, with four times a day being more the average. Results from St Mark's Hospital in which patients with S pouches were radiologically studied both at rest and during straining suggest that an efferent ileal spout of less than 4 cm is unlikely to result in the need for catheter evacuation,[31] but two of nine patients who had pouches with a short (2 cm) efferent spout needed to catheterize their pouches.[22] It seems that all patients with side-to-end ileal pouch-anastomosis and no efferent ileal spout are able to evacuate spontaneously.

In the reported series of the J pouch, there is a range of frequency of defecation from 3 to 9 times with mean values of 4 to 7 times (Table 5). Mean nocturnal frequency was 1 to 2 times, and eighteen to 54% of patients had night evacuation. The difference in mean daily frequency of the J pouch in the series of Utsunomiya and Iwama[14] (4.5 per 24) and Beart et al.[15] (7.2 per 24) is likely to be due to the different ratios of patients with FAP and UC (44/11 versus 11/177).

In the W pouch series, the range of daily frequency was 2 to 7 times, and mean daily frequency, 3.3 to 5 (Table 6). Mean nocturnal frequency was 0 to 2, and 14% of patients had night evacuation. The W pouch seems to have a better function in defecation than the J pouch.

Patients with the K pouch had a mean daily frequency of 4 times with a range of 3 to 6 times, and night evacuation of 0 to 1 times. And patients with the H pouch had mean daily frequency of 4.7 times and night evacuation of 1.6 times (Table 7). These results were similar to those for the W pouch, but the numbers of patients and hospitals in each group were small. A larger number of patients and knowledge of the surgeons experience are necessary in order to make a conclusion concerning this pouch.

Most surgeons performing restorative proctocolectomy have tended to use one particular design of reservoir, and it is difficult to compare the results. At

Table 6. Functional results after ileostomy closure in W pouch

Author	N	Follow-up months (range)	Daily stool frequency (range)	Night evacuation N (% or range)	Continence			Evacuation catheter N(%)
					Normal N (%)	Minor N (%)	Major N (%)	
Nicholls and Lubowski[13] (1987)	51	18.6±8.9	3.3±1.0	7(92)	4(8)	0	0	0
Harms et al[17] (1987)[15]	12	4.8±0.4	0	12(80)	3(20)	0	0	0
Keighley et al[19] (1988)	12	> 4	5 (3-7)	1 (0-1)	11(92)	1 (8)	0	0
Hatakeyama et al[21] (1990)	16	17(6 -28)	4.3±1.2*	n.s.	13(81)	3 (19)	0	0
de Silva et al[22] (1991)	23	19(6 -46)	4 (2 - 7)	0 (0 - 2)	19(83)	2 (9)	2 (9)	1(5)

* indicates 6 months after ileostomy closure
n.s.: not stated

Table 7. Functional results after ileostomy closure in K pouch and H pouch

Author	N	Follow-up months (range)	Daily stool frequency (range)	Night evacuation N (% or range)	Continence			Evacuation catheter N(%)
					Normal N (%)	Minor N (%)	Major N (%)	
Kock et al[11] (1989)	6	3	4 (3 - 5)	0	6(100)	0	0	0
Hallgren et al[20] (1989)	11	12	4 (3 - 6)	1 (9.1)	10(91)	1 (9)	0	n.s.
Fonkalsrud[29] (1985)	38	20(4 -53)	4.7	1.6	n.s.	n.s.	n.s.	0

n.s.: not stated

Table 8. Comparison of functions in various reservoir designs

Author	Reservoir designs	N	Daily stool frequency (range)	Night evacuation N (% or range)	Antidiarrheal medication N (%)	Statistical significance
Nicholls[23] (1987)	S	58	3.6 ± 1.4^{a}	12 (21)	6 $(10)^{a}$	a : $p<0.05$
	J	14	$5.5\pm1.4^{a,b}$	8 (57)	7 $(50)^{a,b}$	b : $p<0.05$
	W	51	3.3 ± 1.0^{b}	7 (14)	10 $(20)^{b}$	
Keighley et al[19] (1988)	J	15	5 (3-7)	1 (0-1)	10 (67)	n.s.
	W	15	5 (3-8)	1 (0-2)	8 (53)	
Hallgren et al[20] (1989)	S	11	4 (2-7)	4	8 (73)	n.s.
	J	11	4 (3-6)	2	8 (73)	
	K	11	4 (3-6)	1	6 (55)	
de Silva et al[22] (1991)	J	23	5 (3-8)	0 (0-1)	12 (52)	n.s.
	S	15	4 (2-6)	0 (0-1)	1 (7)	
	W	23	4 (2-7)	0 (0-2)	5 (22)	

n.s.: not significant

one hospital, however, various reservoirs have been constructed by the same surgeons, making it possible to draw some inferences. Table 8 shows the comparison of defecating function in various reservoir designs at one specific hospital. Nicholls[23] noted that daily stool frequency, night evacuation and the proportion of patients needing to take antidiarrheal medication were significantly greater with the J pouch compared with the S and W pouches. However, Keighley et al.[19] in a prospective randomized trial, recently reported that median stool frequency and other functions were not significantly different between the J pouch using two 20-cm loops and the W pouch using four 10-cm loops. This result may be due to the W pouch utilizing the four loops shorter than the original. Hallgren et al.[20] showed that there was a tendency towards a more favorable overall functional result among patients with K pouch compared to the S and J pouch, though these differences failed to reach statistical significance. On the other hand, no significant difference in stool frequency, degree of continence or urgency among the J, S and W pouches was described by de Silva et al.[22] However, considering that a high proportion of patients with an S pouch could not evacuate spontaneously and that a greater number of patients (52%) with the J pouch needed to use antidiarrheal medication, they concluded that W pouch appears to give the best functional results.

RESERVOIR VOLUME AND COMPLIANCE

Reservoir volume has been measured using a balloon tied over a catheter introduced into the center of the reservoir per anum. On gradual inflation with water in defined volume increments, the maximal tolerated reservoir volume (MTRV) is recorded when the patient has a constant feeling of impending defecation. Comliance can be measured at the same time by recording the intraluminal pressure of the reservoir at eash volume increment.

Nicholls and Pezim[7] were the first to demonstrate a relationship between MTRV and defecating function after restorative proctocolectomy. Their results showed an inverse linear relationship between MTRV and mean daily frequency, indicating the importance of reservoir capacitance and demonstrating furthermore that the pouch is acting as a reservoir. Subsequent investigations[17,20,32,33] have supported their findings (Fig. 2). MTRV gradually increases with the passage of time after ileostomy closure, and the most marked increase in volume occurs within the first 3 months; 80-90% maximal pouch volume over 12 months is reached at this time.[20] Hatakeyama et al.[33] indicated that not only reservoir capacitance but also horizontal width of the reservoir have a major influence on the frequency of defecation (Fig. 3). The bigger and wider reservoirs seem to have less frequency.

Reservoir volume of various reservoirs is shown in Table 9. Nicholls and Pezim[7] reported that the volume of the S and W pouches was significantly larger than that of J pouch, and Hallgren et al.[20] reported that the S and K pouches are larger than the J pouch, though de Silva et al.[22] did not demonstrate significant differences among the J, S and W pouches. A longer-limbed J pouch may afford a similar volume, but the longer the loop, the less mobile the

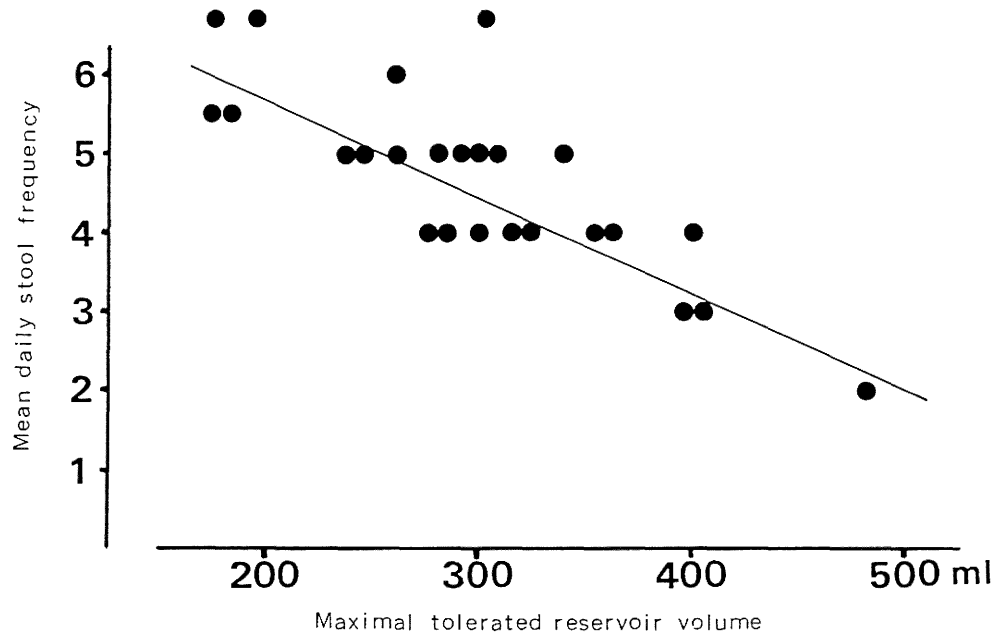

Fig. 2. Relationship between mean daily stool frequency and maximal tolerated reservoir volume. $Y=-0.0121X+8.10$; $r=0.8298$; $p<0.01$.

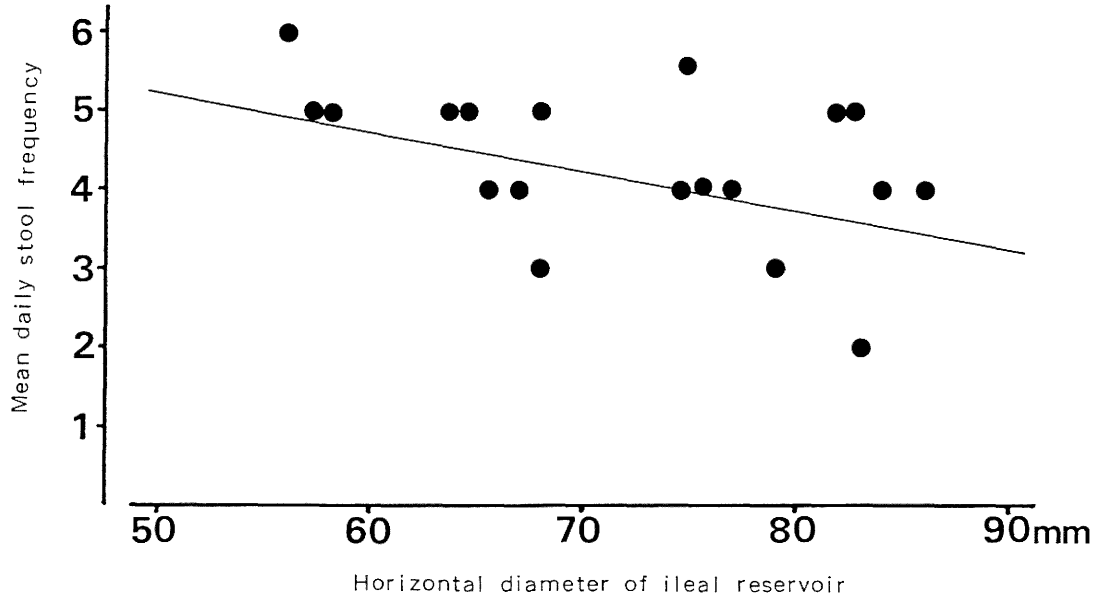

Fig. 3. Relationship between mean daily stool frequency and horizontal diameter of the ileal reservoir at the level of the top of the femoral heads. $Y=-0.0488X+7.762$; $r=0.5007$; $p<0.05$.

Table 9. Reservoir volume among various reservoir designs

Author	Reservoir designs	N	Follow-up (months) N(range)	Reservoir volume ml(range)	Statistical significance
Nicholls and Pezim[7] (1985)	S	8	43	416±176[a](180-800)	a : $p<0.01$
	J	8	8	197±69[a,b](100-300)	b : $p<0.01$
	W	8	5	322±33[b](290-370)	
Hallgren et al[20] (1989)	S	11	12	420(250-570)[c]	c : $p<0.05$
	J	11	12	305(200-445)[c,d]	d : $p<0.05$
	K	11	12	410(244-490)[d]	
de Silva et al[22] (1991)	J	6	58(14-69)	329.5(203-428)	n.s.
	S	10	28(14-72)	321.5(189-450)	
	W	7	18(13-38)	317.0(285-579)	

n.s. : not significant

mesentery supplying the bowel to be used for the ileoanal anastomosis is likely to be. Moreover, a part of the longer J loop protrudes from pelvic cavity. It seems to be important for spontaneous defecation and reservoir emptying for the reservoir to be put into the pelvic cavity.

Reservoir compliance also correlated with a low frequency of defecation.[32] The median compliance for the J pouch is 4.3 ml/cm H_2O (range 7.1-15.6) compared with 10.0 ml/cm H_2O (range 7.1-20.0) for the W pouch with a significant difference.[19] Nicholls[23] also showed that the W pouch compliance differs significantly compared to the J and S pouches, while there were no significant differences between the J and S pouches. On the other hand, the S and K pouches showed significantly higher reservoir compliance than the J pouch, and were superior to the J pouch which is constructed from equal lengths of the small intestine.[20]

CONCLUSION

Restorative proctocolectomy has become an established treatment for diffuse mucosal colonic diseases such as UC and FAP. It is now possible to treat many of these patients with a permanent ileostomy-avoiding procedure resulting in good or satisfactory functions accumalated in most cases. Once fairly high morbidity is decreasing with experience by the surgeons and use of the stage operation. In the more recently reported series, the capacity and configuration in various reservoirs are compared for defecating function. From the results of these series, it seems that the best clinical function is associated with a large volume and highly compliant pouch which empties spontaneously. The S pouch is associated with a high rate of catheterization for evacuation. The W and K pouches have a larger and wider reservoir with higher compliance. However, the cases with K pouch are few, and a larger number of patients are needed for conclusive results. Further investigation on optimal capacity of the reservoir and its functional results in long-term follow-up are also necessary.

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