Studies on the Fibercolonoscopy: with Special Reference to the Latest Procedures

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WATANABE, H., NARASAKA, T. and YAMAGATA, S. *Studies on the Fibercolonoscopy: with Special Reference to the Latest Procedures*. Tohoku J. exp. Med., 1975, 117 (4), 385-396 — The Machida type fibercolonoscope, or FCS, devised by us is an anterior direct vision type of fiberscope. The most important feature of this new fiberscope consists of a tip of 5 cm size which is capable of being directed by flexion up to 120 degrees in any direction and the tip up to 30 cm possessing a fishing-rod-like flexibility and elasticity by means of a special spiral spring. This angle-regulating mechanism makes it possible to insert this instrument along the course of the intestine under direct visual control. The fishing-rod-like construction where the maximal flexibility is greatest at the tip makes it considerably easier to pass sites of marked flexure in the colon. At examination the insertion of the instrument is guided by direct observation and by roentgenoscopy. The results in 200 cases in 1970 and thereafter, when operative techniques No. I, II and III devised previously by us were used, showed that successful insertion into the cecum was possible in 139 out of 173 cases (80%) except 27 cases of pathological stenosis due to cancer and other reasons. Thus fibercolonoscopy now enables the direct observation of the colon beyond the reach of the sigmoidoscope, providing a useful diagnostic procedure. Furthermore, a medium-long fibercolonoscope or FCS-M has been produced by us for examination of the lower portion of the large intestine. This is used in the inverted position without roentgenoscopic guidance as in conventional sigmoidoscopy. When this method, fibersigmoidoscopy, was used in 120 cases, it was possible to examine up to the transverse colon in 19 cases, the splenic flexure in 22 cases and the descending colon in 39 cases without the use of special techniques I, II or III. Thus in the majority of cases it is possible to carry out the examination of the left colon in this manner. The usefulness of fibersigmoidoscopy in the practical clinic is, therefore, rather larger than that of fibercolonoscopy.

——— fibercolonoscopy; fibersigmoidoscopy

Routine diagnostic methods for the lesions locating beyond the reach of the ordinary sigmoidoscope include x-ray examination, exfoliative cytology method and blind aspiration biopsy in our Department. A newly developed fiberoscopic method opens the possibility of direct observation of the areas where ordinary methods sometimes fail in establishing the exact diagnosis.

Ever since 1964, we have been actively engaged in developing the fiberscope capable of observing the area beyond the reach of an ordinary sigmoidoscope.

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TABLE 1. *Specifications*

	Type I	Type II
Whole length	2,000 mm	1,500 mm
Length of apical rigid part	50 mm	30 mm
Diameter of flexible part	10 mm	10 mm
Optical fiber Diameter	18 μ m	15 μ m
image bundle Number	25,000	40,000
Angle of vision (direct)	60°	40°
Focus	Fixed	Adjustable
Angle of deflection	—	—
Light guiding fiber bundle	Inseparable	Inseparable
Observation	Tungsten lamp	Tungsten lamp
Light source Photography	Xenon strobo light	Xenon strobo light
Cinematography	Mirror focus projection lamp	Mirror focus projection lamp
Aiming biopsy	Impossible	Impossible

Thus a fibercolonoscope of type I was devised jointly with the Machida Endoscope Co. in 1964 (Yamagata et al. 1966). Since then, new types of fibercolonoscopes have been introduced such as types II-VII (Table 1) (Watanabe 1972; Watanabe et al. 1972a, b; Yamagata and Watanabe 1974). The technological aspects of the instruments and results of their application were presented previously at the 1st Congress of the International Society of Endoscopy held in Tokyo in 1966, the 2nd World Congress of Gastrointestinal Endoscopy held in Rome and Copenhagen in 1970 and the 5th World Congress of Gastroenterology held in Mexico City in 1974. Nowadays the fibercolonoscope of type VII is widely used in many countries under the name of the Machida type fibercolonoscope or FCS.

Moreover, a fibersigmoidoscope or FSS and a medium-long fibercolonoscope or FCS-M have been developed by us for examination of the lower portion of the large intestine, with almost the same pattern of action, by shortening the fibercolonoscope or FCS.

In this paper, our studies on the fibercolonoscopy, with special reference to the latest procedures, will be presented.

TECHNIQUES AND METHODS

Instrument

The Machida type fibercolonoscope or FCS is the anterior direct vision type with a fixed focus. Its length is about 2 m (Fig. 1). The most important feature of this new fiberscope consists of a tip of 5 cm size which is capable of being directed by flexion up to 120 degrees in any direction by the manipulation of a dial readily accessible to the guiding hand and the tip up to 30 cm possessing a fishing-rod-like flexibility and elasticity by means of a special spiral spring. This angle-regulating mechanism makes it possible to insert this instrument along the course of the intestine under direct visual control.

of fibercolonoscopes

Type III	Type IV	Type V	Type VI	Type VII
About 1,000 mm 30 mm	2,000 mm 60 mm	1,450 mm 15 mm	2,043 mm 17 mm	2,043 mm 17 mm
Less than 8 mm 12 μ m 40,000	11 mm 18 μ m 50,000	7.2 mm 15 μ m 20,000	12 mm 18 μ m 25,000	11 mm 18 μ m 25,000
About 50° Adjustable —	70° Fixed 90°	110° Adjustable 110°	40° Fixed 103°	60° Fixed 120°
Not attached	Inseparable	Inseparable	Inseparable	Inseparable
Tungsten lamp Ordinary flush tube —	Tungsten lamp Xenon strobo light Mirror focus projection lamp	Xenon short arc lamp	Xenon short arc lamp	Xenon short arc lamp
Impossible	Impossible	Impossible	Possible	Possible

Fig. 1. Fibercolonoscope (FCS).

The fishing-rod-like construction where the maximal flexibility is greatest at the tip makes it considerably easier to pass sites of marked flexure in the colon.

On the other hand, the fibersigmoidoscope or FSS is about 1 m in length and the medium-long fibercolonoscope or FCS-M about 1.2 m in length (Fig. 2). These instruments are produced, with almost the same pattern of action, by shortening the FCS.

Preparation of the patients

Preparation of the patients includes a cathartic (initially Castor oil, recently magnesium citrate solution) the evening before and two enemas of 1,000 ml of 2% soapy water that morning. Premedication for patients involves the intramuscular administration of 2 amplex of Buscopan just before examination. The lens of the instrument is siliconed before use.

Fig. 2. Medium-long fiberoptic colonoscope (FCS-M).

Fig. 3. Fiberoptic colonoscopy is carried out.

Techniques for insertion

At examination, the distal 15 cm of the instrument is well lubricated with a water soluble jelly and the instrument is introduced into the rectum while the patient is in the left lateral position. Then the patient lies on his back and the instrument is advanced carefully following the course of the intestine under direct vision, by manipulating the angle of the tip, using minimal air insufflation to distend the intestine in front of the tip of the instrument (Fig. 3). Television-roentgenoscopy is used as required to determine the site of the tip of the instrument (Fig. 3).

The difficult areas for passage are at two sites, the upper part of the sigmoid colon and the hepatic flexure. In the former where the sigmoid colon curves anteriorly and towards the left from posteriorly in its usual course, it is difficult to insert the instrument into the descending colon. Therefore, in cases of such an anatomical course, the technique No. I is used to change the direction.

Operative technique No. I. Twist the instrument counterclockwise after inserting it into the sigmoid colon. By doing so the sigmoid colon will move more centrally and anteriorly. At this time the sigmoid colon is palpable so that an operator-assistant can manipulate its course by hand to run towards the right anterior direction (Fig. 4).

To pass the hepatic flexure, the operative technique No. II or III or the concomitant use of both will be useful.

Operative technique No. II. Upon reaching the hepatic flexure or the middle portion

Fig. 4. Operative techniques for insertion into the cecum and frequency of their use.

of the transverse colon, a concerted hook-like movement is given in the advance direction so that the tip may not slip out of position. Then pull out of the instrument twisting it clockwise. By doing so the flexure of the sigmoid colon will straighten and the descending colon, sigmoid colon and rectum will become a straight line (Fig. 4). Then with further guiding the tip can now be easily advanced deeper. At this time a twisting motion may also help to advance the instrument.

Operative technique No. III. When the hepatic flexure is reached, make the hook-like motion in the direction of the ascending colon so that the tip will not slip out of position. Then withdraw gradually the instrument a little. By doing so, the transverse colon will move upwards and the transverse colon and ascending colon will form an almost straight line and it will follow that the tip will advance by itself by dint of its own elasticity (Fig. 4). At this instant remove the angle and advance the instrument. It can now be easily inserted into the cecum.

When the instrument is advanced from the cecum to the terminal ileum, the location of the ileocecal valve should be identified before the tip is put on the ileocecal valve and then the instrument is inserted further gradually along with inflating with air. When the ileocecal valve could be viewed only from the side, it is difficult to insert further. In this case, the instrument should be inserted deeper into the cecum at first and then pulled out as far as the ileocecal valve can be viewed from the front, manipulating the angle

Fig. 5. Operative techniques for insertion into the ileum.

Fig. 6. Fibersigmoidoscopy is carried out in the inverted position without roentgenoscopic guidance.

towards the direction of the ileocecal valve (Fig. 5). Having reached the ileocecal valve, the tip of the instrument is advanced quickly manipulating the angle and inflating the intestine with air, and then further advance is possible following the course of the ileum under direct vision (Fig. 5).

On the other hand, in the case of fibersigmoidoscopy, FSS and/or FCS-M (or FCS may be used) is used in the inverted position without roentgenoscopic guidance and without the use of special techniques I, II or III as in conventional sigmoidoscopy (Fig. 6).

RESULTS

The results in 200 cases in 1970 and thereafter, when the techniques No. I, II and III were used, showed that successful insertion into the cecum was possible in 139 out of 173 cases (80%) except 27 cases of pathological stenosis due to cancer and other reasons (Fig. 7). The frequency of the use of operative techniques No. I, II and III in 129 successful cases of cecal insertion was 56, 86 and 73 cases, respectively (Fig. 4). (In the other 10 of 139 cases, operative techniques were not noted.) Only 9 cases were completed without the use of any of these techniques. Therefore, cecal observation is easily accomplished by straightening the colonic course by the use of one or more of these techniques. Cecal insertion failed in 14 cases of redundant colon, 14 cases with postoperative adhesions and 6 patients who

Fig. 7. Rate of successful insertion of fiberoptic colonoscope.

Fig. 8. The tip of a fibercolonoscope reaches the terminal ileum. It is easy to insert the instrument into the cecum when the course of the colon becomes so simple.

Fig. 9. The ileocecal valve observed through the fibercolonoscope.

complained of severe pain so that such conditions can be expected to lead to unsuccessful insertion.

The actual insertion of the instrument and the fibercolonoscopic findings of the ileocecal valve are demonstrated in Figs. 8 and 9.

Furthermore, insertion into the ileum was tried in 82 among 139 cases in which successful insertion into the cecum had been done. As a result, the ileum was successfully observed in 66 out of 82 cases, that is 81% (Fig. 7). However, when the instrument was introduced 20–30 cm from the ileocecal valve, manipulation of the angle became very difficult and further insertion became impossible.

On the other hand, in the case of fibersigmoidoscopy, it can be seen from the results in approximately 100 cases examined with the FSS that examination is easily carried out up to about 55 cm from the anus, namely to the upper portion of the sigmoid colon (Fig. 10). When this method was also used in 120 cases with FCS and/or FCS-M, it was possible to examine up to the transverse colon in 19 cases, the splenic flexure in 22 cases and the descending colon in 39 cases without the use of special techniques I, II or III (Fig. 11). Moreover, this method was used under television-roentgenoscopy to identify the position of the tip of the instrument (Fig. 13). 20 cases were thus examined and the similar tendency was noted also under roentgenoscopy (Fig. 12). Hence in the majority of cases it is thought to be possible to carry out the examination of the left colon in this manner.

Meanwhile no complications occurred among 200 fibercolonoscopies and 240 fibersigmoidoscopies in our series.

Finally, the diagnosis of colonic diseases made by the fiberscope will be described. Since 1969 we have carried out fiberscopy in 47 cases of colonic cancer in sites

Fig. 10. Actual distance from the anal ring observed by the fibersigmoidoscope (FSS) in initially examined 20 cases. □, sigmoidoscope; ▨, fibersigmoidoscope.

Fig. 11

Fig. 12

Fig. 11. Achieved distance by the fibercolonoscope when applied in the inverted position.
Fig. 12. Achieved distance by the fibercolonoscope when applied in the inverted position under roentgenoscopy.

beyond the reach of the conventional sigmoidoscope and a diagnosis of cancer was made endoscopically in 39 cases (Table 2). A diagnosis of cancer was made in 33 cases by biopsy and 35 cases by cytology (Table 2). Since the same year we have carried out fibercolonoscopy in 240 cases and fibersigmoidoscopy in 280 cases and detected polyps in 26 cases (11%) and 33 cases (12%) in sites beyond the reach of the conventional sigmoidoscope. In 50 of these cases the histological specimens were obtained by biopsy under direct vision, and 29 cases of adenomatous polyp, 7 cases of hyperplastic polyps and one case of juvenile polyp were confirmed.

TABLE 2. *Diagnostic accuracy in cancer occurring in the colon beyond the reach of a sigmoidoscope*

	Number of cases examined	Number of cases of positive diagnosis	%
Colonoscopy	47	39	83.0
Biopsy	39	33	84.6
Cytology	37	35	94.6

Fig. 13. Fibersigmoidoscopy is carried out under roentgenoscopy to identify the position of the tip of the instrument.

DISCUSSION

In 1964, the intestinal fibroscope of type I was made actually for the purpose of observing duodenal lesion. This is about 2 m in length, and consists of about 25,000 glass fibers 18 μ m in diameter. This is a fixed focus and anterior direct vision type with light guiding fiber bundle attached. The application of this instrument to the colonic diseases, however, failed rather miserably. Only in one occasion, the introduction of the instrument into the descending colon beyond the sigmoid colon was successful.

The types II and III were made in 1965. The type II is about 1.5 m in length, consists of 40,000 glass fibers, has adjustable focus depth, and has more elasticity than type I. The application of this instrument to the colonic diseases, however, was not successful. Even in sigmoid portion, the distance between the observation slit and the mucous membrane, necessary for detailed examination, could not be maintained and only the close-up pictures could be taken.

Type III was improved from the type II fibroscope. In this instrument, the length is shortened to 1 m, and glass fibers used are finer, 12 μ m in diameter. To increase the elasticity of the body of the instrument, light guiding fiber bundle is detached and for illumination two small electric bulbs are attached on the tip of the instrument. As to insertion of this instrument into the colon, it was more easily done as compared with the early types, and in 9 cases of 33 patients subjected

to the examination, that is in 27%, the insertion was successfully made up to the descending colon. However, adjustment of the focus was rather difficult and clear cut view of the surface of the mucous membrane could only be maintained for a few seconds.

In 1966, type IV fiberscope was developed from these experiences. The instrument is about 2 m in length, and consists of 50,000 glass fibers 18 μm in diameter (Table 1). Light guiding fiber bundle is attached, and it is a fixed focus type (Table 1). The most important improvement in type IV is that the tip of the instrument can be bent in any direction about 90 degrees by manipulating the dial. This angle-regulating mechanism makes it possible for the operator to insert the instrument along the course of the colon while observing the surface of the intestine. The shape of the tip portion is also improved to make the insertion more effortless. Air insufflation is, as in the case of early types, necessary, although roentgenoscopic guidance is unnecessary. Therefore the insertion of the instrument is done as in conventional sigmoidoscopy. However, the insertion of type IV into the descending colon beyond the sigmoid colon was successful in only 3 out of 26 cases.

Therefore, some modifications were made and type V fiberscope was introduced in 1968. It is a fibercolonoscope of the focus-adjusting type, 1.45 m in length, consisting of about 20,000 glass fibers 15 μm in diameter (Table 1). It has the following main points of improvement: The outside diameter is reduced to 7.2 mm; the length of the apical rigid part is greatly reduced to 15 mm; the tip of the instrument can be bent in any direction about 110 degrees; an external xenon short arc lamp is used as a luminescent source which can introduce a light almost free from heat. Although these improvements made it possible to take ciné-color pictures, the insertion into the descending colon per se was still difficult.

In 1969, type VI was introduced. It is a fixed focus type, 2 m in length and 12 mm in outside diameter, consisting of 25,000 glass fibers 18 μm in diameter (Table 1). In this type, the main points of improvement are as follows: By using a special spiral spring, the elasticity and flexibility of the main body of the instrument are enhanced to allow the insertion of the instrument into the higher portion of the colon with ease; a slide expansion mechanism, which expands and contracts the covered portion at the tip and base of the instrument, is established to make it possible to have a buffer action to reduce the force exerted upon the instrument at the time of insertion; an aiming biopsy under direct vision can be performed by a flexible biopsy forceps inserted through a tunnel penetrating inside the equipment when needed.

On the other hand, the pattern of the sigmoidoscope, in which the tip of the instrument is pushed forward while watching the lumen of the intestine under direct vision by the aid of the fiberscope, had been adopted for the fibercolonoscopes of types IV and V. In type VI, television-roentgenoscopy is used additionally to locate the position of the tip of the instrument. Then studies were made on the relationship between the lumen direction of the sigmoid colon and the degree of

difficulty in inserting the instrument into the descending colon. It was found difficult to insert the instrument into the descending colon when the sigmoid colon took its usual path, which presented a curve from the posterior into the left anterior position. On the contrary, such an insertion was found to be easier when this course was curved to the right anterior direction and when the operator could manually alter the course of the sigmoid colon to the right anterior direction during the examination. 23 cases were thus subjected to the examination using type VI instrument. Sigmoid colon was successfully observed in all cases. 19 cases were examined beyond the sigmoid colon, and the descending, transverse, and ascending colon were observed successfully in 14, 9, and 2 cases, respectively.

In the fibercolonoscope of type VI, there is a sliding portion between the main body and the cover of the intermediate portion. When this instrument is inserted into the sigmoid colon, it is impossible to help the course of the sigmoid colon change its direction by twisting the inserted instrument. Therefore, the slide-expansion mechanism attached to type VI had not been adopted for the new type VII developed in 1970 (Table 1). In this type, consideration had been given to facilitate the insertion of the instrument into higher portion of the colon by adjusting the elasticity and flexibility of the main body by the aid of a spiral spring, thus the flexibility gradually increases towards the tip of the instrument like a fishing rod.

With type VII, studies on technique to insert the instrument into the cecum were made. In most cases it was found easy to insert the instrument into the ascending colon if the transverse colon was displaced upwards. This was done by inserting the instrument as far as the hepatic flexure. Then the tip was bent to an angle of about 120 degrees, giving a hook action. Then by pulling out the instrument, the transverse colon was moved upwards giving easy entry into the ascending colon. In other cases, when it was impossible to move the transverse colon upwards, the instrument was introduced into the ascending colon by pushing and twisting. However, in this case it was first necessary to straighten the path of the descending colon, sigmoid colon, and rectum, and it was achieved by pulling and twisting.

As a result, it has become very easy to insert the instrument into the cecum by using this type of instrument. When 40 cases were examined by this instrument before the 2nd World Congress in 1970, the descending, transverse, and ascending colon and the cecum were successfully observed in 37, 35, 29, 20 cases, respectively. Particularly, the observation of the cecum was succeeded in 19 out of 21 cases which was the latest series at that time.

Hence, it is concluded that fibercolonoscopy which we had been making efforts to develop since 1964 had almost been completed in 1970 owing to the improvement of the fibercolonoscope and the advancement of techniques for examination. Thus fibercolonoscopy now enables the direct observation of the colon beyond the reach of the sigmoidoscope, providing a useful diagnostic procedure.

Furthermore, the fibersigmoidoscope was developed by shortening the fibercolonoscope of type VII in 1970. It has essentially the same structure as the latter and is used for the examination of the lower portion of the large intestine. It was initially applied to the examination of the upper portion of the sigmoid colon in the same manner as the conventional sigmoidoscopy (Fig. 10). However, recently it has become obvious that examination of the descending colon and even more oral segments of the large intestine can be attained in this manner in about two-thirds of examined cases. Since no particular techniques are required for this purpose, the manipulation is simple, and the instrument is hardly damaged by such a simple manipulation. Moreover, since no roentgenoscopy is demanded, an operator is not liable to be exposed to x-rays. Accordingly, it is stated that the usefulness of this method in the practical clinic is rather larger than that of the fibercolonoscopy.

In conclusion, fibercolonoscopy and fibersigmoidoscopy open new areas in the diagnosis of lesions of the colon beyond the reach of an ordinary sigmoidoscope. Although the importance of these methods in the diagnosis of colonic cancer and polyps is obvious from above stated results, it is also felt that these methods would prove useful in the diagnosis and evaluation of the course of granulomatous colitis.

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