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Reconstruction after abdominoperineal resection with a modified Taylor flap

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Dear Editor,

Please find attached our article called **Reconstruction after abdominoperineal resection with a modified Taylor flap.**

Healing after abdominoperineal resection is often difficult.
We describe and analyze here our surgical technique of perineal reconstructions with modified Taylor musculocutaneous flaps whose reliability leads to a substantial improvement of cicatrisation.

Here we want to discuss and share our experience about reconstruction after abdoperineal resection.

For more than 20 years we practice this type of surgery that we have gradually developed and improved. To date we have made more than 200 Taylor flaps in our center, the largest series ever published.

All authors have made substantial contributions to all the following:

- Conception and design of the study, or acquisition of data, or analysis and interpretation of data.
- Drafting the article or revisiting it critically for important intellectual content.

All of the authors have read, approved submission of the manuscript and meet the Uniform Requirements for Manuscripts Submitted to Biomedical Journals criteria for authorship. This paper is an original work not previously published in any substantial part and not under consideration of publication elsewhere and no portion of the data has been or will be published in proceedings or transactions of meetings or symposium volumes. This work was not supported by any grant.

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

This manuscript, including related data, figures and tables has not been previously published. He's also not under consideration elsewhere.

Thank you for the opportunity to submit this manuscript to Jove.

Yours Sincerely,

David BOCCARA on behalf of all the authors.

TITLE:**Reconstruction After Abdominoperineal Resection with a Modified Taylor Flap****AUTHORS & AFFILIATIONS:**

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KEYWORDS:

Taylor flap, abdominoperineal resection, colorectal cancer, rectus abdominis muscle, musculocutaneous flap, perineal reconstruction

SHORT ABSTRACT:

Healing after abdominoperineal resection is often difficult. We describe and analyze herein a surgical technique of perineal reconstructions using Taylor musculocutaneous flaps whose reliability leads to a substantial improvement in cicatrization.

LONG ABSTRACT:

Healing after abdominoperineal resection is often difficult especially in patients that have undergone radiation therapy. Furthermore, vaginal reconstruction is an important issue for the women that undergo this surgery. The goal of this work is to describe our surgical technique of perineal reconstructions with Taylor musculocutaneous flaps and provide an overview of its results. The technique consists of drawing a skin paddle from the pit of the scapula to the umbilicus. The skin paddle is then harvested with the rectus abdominis muscle. The muscle insertion on the pubic bone is left intact to prevent any tension on the pedicle. Postoperative care concentrates on surveillance of the coloration of the flap and measures that allow patients to stand up as soon as possible. No pressure on the flap is tolerated for the first three weeks.

Between 2000 and 2010, the 68 patients who underwent reconstruction with a Taylor flap, healed within a median time of 30 days. The reoperation rate was 11.7% including 1 for herniation. The principal causes for delayed healing were wound dehiscence, abscess, and partial necrosis. However, no flaps required removal. The mean duration of hospitalization was 23.7 days.

The localization of the skin paddle in an area where anastomosis between the deep inferior epigastric artery, the superior epigastric artery and the lumbar arteries are very dense offers a reliable blood supply. The muscle harvested makes the flap bulky enough to fill the dead space caused by the abdominoperineal resection. Taylor flaps substantially improve the reconstruction of defects resulting from abdominoperineal resection. They enable complete and rapid healing with low morbidity.

INTRODUCTION:

Abdominoperineal resection is a frequently performed procedure in gastrointestinal surgery. It is the reference treatment¹ for lower rectal cancers and can also be necessary after the failure of conservative treatment (e.g., radiation therapy and chemotherapy) of the anal canal, or to treat damage from tumors of the perineum or the pelvis.

The occurrence of sometimes serious complications such as gastrointestinal perforations, infections, and perineal fistulae² led to modification of perineal reconstruction techniques to accelerate healing and limit the sometimes very disabling functional or aesthetic sequelae^{3, 4}. In the most recent series published, the complication rates of resection without reconstruction ranged from 35% to 66%⁵ and resulted in serious degradation of patients' quality of life. There are three major difficulties to resolve: an empty pelvis, closing the defect, and reconstructing the resected organs (e.g., vagina).

Described in 1983 by Taylor^{6, 7}, the rectus abdominis myocutaneous flap is vascularized by the deep inferior epigastric artery and its two collateral veins. These vessels provide numerous perforators that are concentrated around the umbilicus and run through the muscle to vascularize the skin of the abdomen. The rich vascularization of its skin paddles simultaneously enables healing despite earlier irradiation and coverage of the defect, while also making it possible to limit the risk of infection.

Since 2002, the department of Plastic Surgery of St. Louis Hospital in Paris offered reconstruction with flaps to all patients undergoing abdominoperineal resection in treatment of lower rectum or anal canal cancer. The surgery is performed by a team of surgeons from the gastrointestinal surgery department at St. Antoine Hospital and plastic surgeons from St. Louis Hospital. Flaps made of omentum, gracilis, and the gluteus maximum have been used in turn for this purpose; today the Taylor flap is the leading choice for this type of reconstruction. Its reliability and trophicity, and the size of the skin paddle make it the flap of choice for covering defects after abdominoperineal resection. The purpose of this surgical procedure is to provide patients and surgeons an easy and reliable solution to most of the complications that follow the abdominoperineal resection.

PROTOCOL:

This protocol follows the guidelines of our institution's human research ethics committee.

1. Patient installation and preparation

1.1. Install patient in lithotomy position. Perform disinfection and sterile draping using standard procedures while ensuring free access to the perineum, the entire abdomen up the xiphoid appendix and the inferior angle of the scapula.

2. Drawings

2.1. Measure the height and width of the perineal resection with a ruler placed from one skin edge to the other.

2.2. Draw the line from umbilicus to the inferior angle of the scapula. This line is the axis of the flap.

2.3. Draw a flap centered on the previously marked line.

2.3.1. The width of the flap should be the same as the perineum resection. Use a pinch test to make sure that one will be able to close the skin after having harvested the flap.

2.3.2. If there is a need for vaginal reconstruction, make sure that the length of the flap is equal to the length of the vaginal depth plus the height of the perineal resection plus twice the thickness of the flap. One can expand the length of the flap to the inferior angle of the scapula.

2.4. On the abdomen, mark an approximation of the position of the linea alba and the lateral extremity of the abdominis muscle.

3. Harvest of the flap

3.1. Use a surgical blade to incise the skin according to the drawings.

3.2. Use an electric scalpel to progress to the aponeurotic plane all around the flap. Make sure the incision is vertical and does not slip slightly under the flap.

3.3. Cauterize vascular branches as needed.

3.4. Separate the subcutaneous fatty tissue from the underlying aponeurosis using the electric scalpel. Start from the lateral extremity and progress toward the umbilicus until the lateral extremity of the abdominis muscle can be seen, then stop.

3.5. Upon arriving at the lateral extremity of the abdominis muscle, incise the anterior sheath of the aponeurosis of the abdominis muscle with a surgical blade, all around the flap.

3.6. Insert Metzenbaum scissors between the abdominis muscle and the posterior sheath of the aponeurosis, horizontally just above the flap.

3.7. Use the electric scalpel to section the muscle on the scissors. At this point the superior epigastric vessels are visible; these must be either coagulated or ligatured with a multi-filament coated 3-0 surgical suture.

3.8. Use the electric scalpel to separate the abdominis muscle from its anterior aponeurotic sheath in the portion that is caudal to the flap.

3.9. Separate the muscle from its posterior aponeurotic sheath and the fascia transversalis in a cranio-caudal direction.

3.9.1. Use Metzenbaum scissors or a wet gauze for this step.

3.9.2. Notice that the deep inferior epigastric vessels can be seen all along this step.

3.9.3. Notice that the lateral and medial sides of the muscle are not adherent and can be easily separated from the abdominal external oblique muscles and from the linea alba.

3.10. Stop the dissection when on the pubic bone (**Figure 1**).

4. Transposition of the flap

4.1. Handle the flap using the left hand and insert it into the abdominal cavity while a second surgeon pushes the bowel upward.

4.2. Use the right hand, introduced into the perineal defect, to extract the flap (**Figure 2**).

4.3. Make sure there is no tension on the pedicle.

5. Flap modeling for vaginal and perineal reconstruction

5.1. Fold the flap to obtain an **L shape**.

5.2. Use the scapular side of the flap to reconstruct the posterior wall of the vagina.

5.2.1. Suture the lateral extremity of the flap to the cervix uteri with interrupted sutures using a multi-filament coated 3-0 surgical suture.

5.2.2. Progress in a symmetrical fashion to suture the flap to the remaining vaginal wall until arriving at the skin.

5.3. Suture the umbilical side of the flap to the posterior extremity of the perineal resection using the same multi-filament suture.

5.4. Insert a drain in the pelvic cavity.

177
178 5.5. Finish suturing in the same fashion (**Figure 3**).
179

180 **6. Abdominal Closure**

181
182 6.1. Separate the subcutaneous fatty tissue from the aponeurotic plane for about 2 cm in the
183 lateral and cranial position to obtain more cutaneous laxity.
184

185 CAUTION: Do not separate the aponeurosis from the subcutaneous fatty tissue in the caudal
186 direction because it has already been separated from the muscle. Thus, this action could lead to
187 the necrosis of the aponeurosis.
188

189 6.2. Suture the anterior sheath of the abdominis muscle aponeurosis that is under the location
190 from which the flap was harvested, to the linea alba using a running suture with multi-filament
191 coated 1-0 surgical suture.
192

193 CAUTION: Be careful to not strangulate the pedicle with the running suture, if necessary stop the
194 suture a few centimeters before the pubic bone.
195

196 6.3. Close the skin with subcuticular interrupted sutures and a subcuticular running suture using
197 a mono-filament 3-0 surgical suture.
198

199 **7. Postoperative management**

200
201 7.1. Take all measures so the patient stands up as soon as possible.
202

203 7.1.1. Have the patient standing on postoperative day one.
204

205 7.1.2. Take the urinary catheter off as soon as possible between fifth and tenth day.
206

207 7.1.3. Remove drains when they are filled with less than 30 mL a day.
208

209 7.2. Authorize sitting position very progressively until three weeks after surgery. One can
210 prescribe a (floating) round tube so that the sitting position does not lead to excessive pressure
211 on the flap.
212

213 **REPRESENTATIVE RESULTS:**

214 Out of 68 patients, operated between 2000 and 2010, the results were as follows⁸.
215

216 **Healing:**

217 The mean time to healing was 47.3 days with a range of 13 to 197 days and a median of 30 days.
218 At 3 weeks, 38% of the patients had healed, at 2 months 74%, and 100% at the end of the study.
219 The 5 patients who had no radiation therapy healed in a mean of 28.8 days (range = 15–55 days,
220 median = 19 days). Globally the longer times to healing were due to local complications such as

scar dehiscence, partial flap necrosis, or abscess necrosis. The median duration of hospitalization was 23.7 days (range = 11–64 days, median = 19 days).

Complications:

Two types of complications can occur. The most frequent are those of the recipient site and the flap, followed by those of the donor site. Complications were considered early when they occurred in the 90 days after surgery.

Recipient site and flap

Early complications: We observed dehiscence in 12 patients. Eleven were managed by local care and one required suturing. Three patients had partial necrosis that required only simple surgical debridement. Five patients also had an abscess at the junction between the flap and the recipient area. Two required surgical drainage on day eight and day 10. *Late complications:* Only one single patient had a complication more than 90 days after surgery (D92): cellulitis at the junction between the flap and the thigh. It was handled by antibiotic therapy and surgical lavage. None of these complications ultimately prevented permanent healing.

Complications of the donor site (see Table 1)

Two patients underwent surgical debridement for an area of cutaneous necrosis, followed by sutures. Three abscesses were drained with local care. Of the 68 patients, 4 minimal herniations were observed. A more substantial herniation required surgical revision with placement of a prosthetic mesh because it had disabled the patient more than a year after surgery. In conclusion, no flap was removed and all patients healed.

FIGURE LEGENDS:

Figure 1: Taylor flap on the abdomen. Before modeling the flap, we fully release the Taylor flap.

Figure 2: Abdoperineal resection. Wound defect after abdoperineal resection is shown.

Figure 3: Taylor flap on the perineum. Before modeling the flap, we handle the flap using the left hand and insert it into the abdominal cavity while a second surgeon pushes the bowel upward. We suture the anterior sheath of the abdominis muscle aponeurosis that is under the location from which the flap was harvested, to the linea alba using a running suture with multi-filament coated surgical suture.

Table 1: Flap complications.

DISCUSSION:

Perineal healing is a major issue in terms of quality of life for patients that have undergone abdominoperineal resection. Extensive resection and irradiation together can make this healing extremely uncertain and very lengthy⁹⁻¹². The occurrence of complications such as infections, abscesses, dehiscence, and chronic wounds is quite frequent in these conditions (up to 65%

according to the series^{13,14}). Perineal reconstruction with a Taylor flap can dramatically reduce the incidence of these complications^{13, 14}.

We usually chose the right side of the body to harvest the flap in order to allow the issue of a stoma on the left side. We believe that the muscle insertion on the pelvic bone can be expected bear the weight of the flap and avoid any kind of tension on the pedicle. For the same reason, it is of paramount importance to stop the suture of the aponeurosis a few centimeters before the pelvic bone to avoid strangulation of the pedicle.

One alternative to a Taylor flap is direct closure of an omentoplasty. In the series reported by Lefevre et al.¹⁵, the complication rate, the duration of healing, and the occurrence of a perineal hernia were significantly higher (48.9% vs. 26.8%; $P = 0.0336$ and 117 days vs. 18.7 days, $P = 0.0019$; 15.4% vs. 0%) than with a Taylor flap, with nearly identical abdominal hernia rates (9.3%). They concluded that the Taylor flap is a technique that reduces perineal complications and time to healing in patients with an abdominoperineal resection for anal cancer without increasing abdominal wall morbidity.

Other cover flaps can be used, including gracilis¹⁶⁻²⁰, gluteus maximus²¹⁻²⁵ or free deep inferior epigastric perforator (DIEP) flaps. A gracilis flap can be used to reconstruct the posterior vaginal wall. When complete vaginal resection takes place, a second flap of the gracilis muscle can be used to reconstruct the vagina. This flap has numerous disadvantages as compared to the Taylor flap. Its small size prevents its use with large defects. Its reliability is substantially poorer, with necrosis observed in 10 to 25% of cases according to the series^{13,14}; this makes it a second-line flap, to be used only after the failure to construct a flap from the rectus abdominis muscle (or the determination of its impossibility). The gluteus maximum flap is also a second choice, because of its scarring, low mobility, and chronic pain²⁶⁻²⁹. The principal advantage of the DIEP, is the absence of secondary eventration³⁰. However, the complexity and burden of its use for patients who are often already fragile also make it a second-line choice.

The choice of an immediate or secondary reconstruction can also be debated. All patients in our study had immediate reconstructions. Early coverage of the defect diminishes the risk of complications²⁻⁴. The relatively short duration of this procedure (an hour on average) and the low complication rate for the donor site have encouraged us to continue this protocol.

For the women who had a colectomy, reconstruction appears useful not only for healing but also for functional and psychological aspects^{31, 32}. A study published in 2010 by Corte et al.³³ showed a resumption of sexual activity for more than 85% of the women. In our series, 28 of the 37 women with reconstruction of the posterior vaginal wall by a Taylor flap were able to resume sexual activity.

Postoperative management is key to reduce the complication rate to a minimum. All measures should be taken to allow patients to stand up as soon as possible and pressure on the flap is contraindicated for the first three weeks³⁴. Since 2010, we have completed more than 150 perineal reconstruction using a Taylor flap.

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DISCLOSURES:

The authors have nothing to disclose.

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COMPLICATIONS	NUMBERS	REOPERATION
DEHISCENCE	12	1
NECROSIS	6	3
ABSCESS	5	2
CELLULITIS	1	1
ALL	24	7

Name of Material/ Equipment	Company	Catalog Number	Comments/Description
Adson tissue forceps			
Army-Navy retractors			
Electronic scalpel			
Gauze			
Hadson clamp			
Metzenbaum scissors			
Mono-filament 3-0 surgical suture			
Multi-filament coated 1.0 surgical suture			
Multi-filament coated 3-0 surgical suture			
Needle holder			
Straight Mayo scissors			
Surgical blade			
Surgical drain			
Surgical pen			



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Dear Editor,

Thank you for your feedback. We tried to take into account all your remarks and we made all the corrections requested.

Editorial comments:

Changes to be made by the author(s) regarding the manuscript:

1. Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammar issues. **Corrections made.**
2. Please revise lines 22-24 and 33-35 to avoid previously published text.
3. Please provide an email address for each author. **See the first page.**
4. Keywords: Please provide at least 6 keywords or phrases. **We added « musculocutaneous flap » and « perineal reconstruction ».**
5. Please rephrase the Introduction to include a clear statement of the overall goal of this method. **We added « The purpose of this surgical procedure is to provide patients and surgeons an easy and reliable solution to most of the complications that follow the abdominoperineal resection. »**
6. Please include an ethics statement before the numbered protocol steps, indicating that the protocol follows the guidelines of your institution's human research ethics committee. **See protocol.**
7. Please revise the protocol text to avoid the use of any personal pronouns (e.g., "we", "you", "our" etc.). **See protocol.**
8. Please revise the protocol to contain only action items that direct the reader to do something (e.g., "Do this," "Ensure that," etc.). The actions should be described in the imperative tense in complete sentences wherever possible. Avoid usage of phrases such as "could be," "should be," and "would be" throughout the Protocol. Any text that cannot be written in the imperative tense may be added as a "Note." Please include all safety procedures and use of hoods, etc. However, notes should be used sparingly and actions should be described in the imperative tense wherever possible. Please move the discussion about the protocol to the Discussion. **See protocol.**
9. 2.1: Please describe how to measure the height and width of the perineal resection. **See protocol.**
10. Line 246: Table 1 is missing from current submission. Please upload Table 1 to your

Editorial Manager account in the form of an .xls or .xlsx file. Each table must be accompanied by a title and a description after the Representative Results of the manuscript text.

11. Please reference all figures in the manuscript.

12. Discussion: Please discuss critical steps within the procedure. **See paragraph number two of the discussion.**

13. Please ensure that the references appear as the following: [Lastname, F.I., LastName, F.I., LastName, F.I. Article Title. Source. Volume (Issue), FirstPage – LastPage (YEAR).] For more than 6 authors, list only the first author then et al. See the example below:

Bedford, C.D., Harris, R.N., Howd, R.A., Goff, D.A., Koolpe, G.A. Quaternary salts of 2-[(hydroxyimino)methyl]imidazole. Journal of Medicinal Chemistry. 32 (2), 493-503 (1998).

14. Table of Materials: Please revise to include all surgical instruments and sort the items in alphabetical order according to the name of material/equipment.

Table of Materials

- Adson tissue forceps
- Army-Navy retractors
- Electronic scalpel
- Gauze
- Hadson clamp
- Metzenbaum scissors
- Mono-filament 3-0 surgical suture
- Multi-filament coated 1.0 surgical suture
- Multi-filament coated 3-0 surgical suture
- Needle holder
- Straight Mayo scissors
- Surgical blade
- Surgical drain
- Surgical pen

Reviewers' comments:

Reviewer #1:

Manuscript Summary:

This paper seeks to address ongoing concerns regarding healing of the perineal wound in a cohort of patients undergoing APER, the majority of whom have had preoperative radiotherapy. The authors describe the use of a modified Taylor flap to fill the perineal defect in a reasonable large cohort of patients at a single institution. The technique of raising the flap is well described in this paper and the results in this cohort confirm the benefits of the flap. There are a number of points that I would make:

Major Concerns:

Minor Concerns:

- 1) In the long abstract the authors use the term scar dehiscence to describe an acute event - I would think this would more accurately be described as a wound dehiscence. **Correction made.**
- 2) In the protocol the term anterior sheet of the of the aponeurosis / aponeurotic sheet is used - the term should be sheath. **Correction made.**
- 3) At the end of the protocol, section 7.2, I am not sure what the term buoy refers to **Floating round tube.**
- 4) Throughout the paper the authors use the term eventration which is not a common term - I think that a more suitable term would be herniation. **Correction made.**

Reviewer #2:

As the authors write in this manuscript, perineal healing is a major issue for patients undergoing abdominoperineal resection and the healing is often difficult. A rectus abdominis myocutaneous flap which is described by Taylor in 1983 and which the authors call Taylor flap is known as a standard flap for perineal reconstruction. The title of this manuscript contained a word of 'modified Taylor flap', however, what is the modification to the Taylor flap is not written. If the authors have original methods or modifications, they should clarify these things. **All mentions of « modified » Taylor flap have been removed.**

In these days, it has been revealed that skin perforator vessels are essential for viability of skin portion of myocutaneous flaps. However, I cannot find mention about the perforators in the manuscript. **See 4th paragraph of the introduction.**

The authors write three phrases of modified Taylor flap, Taylor flap and Taylor modified flap for the myocutaneous flap they use for the reconstruction. There are some misspellings such as muscle and umbilical side. **All mentions of « modified » Taylor flap have been removed. Corrections have been made.**