# The extent of endosonographic anal sphincter defects after primary repair of obstetric sphincter tears increases over time and is related to anal incontinence

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## Abstract

Objective. To describe and classify endosonographic obstetric sphincter defects at 1 week, 3 months and 1 year after primary repair, and to describe changes in the endosonographic image, anal sphincter pressure, and anal incontinence over time after a primary repair of an obstetric sphincter tear, and to relate the endosonographic results to anal sphincter pressure and to symptoms of anal incontinence.

Methods. Forty-one women who had suffered a third or fourth degree perineal tear at delivery underwent anal endosonography and anal manometry 1 week, 3 months and 1 year after primary suture of the tear. The extent of the endosonographic defects was described using defect scores ranging from 0 (no defect) to16 (maximal defect), the score taking into account the location and the longitudinal and circumferential extent of the defect. The women answered a questionnaire with regard to bowel function 1 and 4 years after delivery, the degree of incontinence being expressed as Wexner score.

Results. Ninety percent (37/41) of the women had endosonographic defects at 1 week, 3 months and 1 year. The endosonographic defect scores increased significantly between the first and second examination and then remained unchanged. At 1 year there was a negative correlation between endosonographic sphincter defect score and sphincter pressure. At 1 and 4 years 54% (22/41) and 61% (25/41) of the women, respectively, had Wexner score $\geq 1$. There was a positive correlation between the endosonographic sphincter defect score at 1 week, 3 months and 1 year and the Wexner incontinence score at 1 year and at 4 years. Endosonographic sphincter defect score at 1 week was the variable that was most predictive of the Wexner score at 4 years ($r = 0.48$, $p=0.002$).

Conclusion. The higher the endosonographic sphincter defect score after primary repair of an obstetric sphincter tear the lower the sphincter pressure and the higher the risk of anal incontinence.

## Introduction

The rate of anal sphincter disruption resulting from obstetric injury has increased in Sweden during the last years from 1% in the early 1980´s to around 2.5% in the 1990s.[1,2,3] In Gothenburg, Sweden, the rate is now 3.3%.[4] A study from Copenhagen, Denmark, showed that partial or total sphincter rupture occurred in 8.4% of primipara in 1998.[5] Anal incontinence has been reported to be common after third and fourth degree perineal lacerations.[6,7,8,9,10,11,12] Anal incontinence is multifactorial. A defect in the sphincter may be an important causative factor, but other factors are important too, e.g., nerve damage, pelvic insufficiency, and the consistency of the stool.[13,14,15,16]

Endosonographic sphincter defects have been found at follow-up in 54% to 91% of women with third or fourth degree obstetric perineal tears but also in 11% to 35% of women after an apparently normal delivery.[17,18,19,20] Not all women with endosonographic sphincter defects have anal incontinence, i.e., incontinence for solid or liquid stool, or flatus incontinence.[14,21] The discrepancy might be explained by minor sphincter defects not resulting in anal incontinence, or by anal incontinence not developing until many years - perhaps as many as 20-30 years - after the tear.

Little is known about a possible association between the extent of endosonographic sphincter defects and the degree of anal incontinence. It is also unknown if the extent of endosonographic sphincter defects changes over time. To facilitate the study of these issues we developed an endosonographic sphincter defect score.[22]

The aims of this study were to describe endosonographic obstetric sphincter defects at 1 week, 3 months and 1 year after primary repair of obstetric anal sphincter tears, to describe changes in the endosonographic image, anal sphincter pressure, and anal incontinence over time, and to relate the endosonographic results to anal sphincter pressure and to symptoms of anal incontinence.

## Methods

The study was approved by the ethics committee of the Medical Faculty, Lund University, Sweden, and written consent was obtained from all participants.

### *Study design*

During a period of 10 months (November 1996 to September 1997), all women who had undergone primary suture of a third or fourth degree perineal tear at delivery at the labor ward of Malmö University Hospital, Malmö, Sweden, were asked to participate in our study. We use the term 'third degree partial sphincter tear' to describe a perineal laceration associated with a rupture in the superficial part of the external sphincter. A 'third degree total tear' means a rupture through the whole external sphincter thickness with or without engagement of the internal sphincter. A 'fourth degree sphincter tear' means a rupture through the full thickness of both the external and internal anal sphincters and of the anal mucosa. Each woman underwent anal endosonography and anal manometry 1 week after delivery, and then 3 months and 1 year after delivery. The women were examined in the left lateral position. Anal manometry was performed immediately before the endosonographic examination, manometry being performed by a laboratory technician and ultrasonography by the first author. The clinical details of each patient's delivery and the clinical extent of their sphincter rupture were unknown to both examiners. At the 1-year follow-up examination the women answered a questionnaire with regard to urinary and anal continence. The same questionnaire was answered by the women after 4 years.

### *Patients*

During the 10 months study period 69 women suffered an anal sphincter tear. Of these, 61 accepted to participate. Two of the 61 women could not be examined within the first week of delivery because of pain. Ten women declined to undergo both the second and third examination, and eight women declined to undergo the third examination. The 41 women

examined three times are included. Characteristics of the women included and excluded are shown in Table I. None of the differences between the two groups is statistically significant, even though the proportion of women with total third degree tears and fourth degree tears is higher among the women excluded. Two women were pregnant again at the 1 year follow-up examination but none had given birth again before the 1 year follow-up examination. At the 4 year follow-up examination 22 women had given birth again: 16 had had one additional vaginal delivery, three had had two more vaginal deliveries, and three had undergone Caesarean section. No woman had suffered another sphincter tear at her second or third delivery.

### *Anal endosonography*

The women were scanned with a B&K Leopard 2001 system (B&K Medical, Gentofte, Denmark) with a Type 1850 endoprobe and a 10-MHz frequency rotating transducer (B & K 6004) covered with a waterfilled plastic cone with a diameter of 12 mm. The cone was covered with a condom. The cone was inserted into the anal canal and manually withdrawn at low speed from the puborectalis level through the anal canal to the anal opening. All examinations were recorded on super-VHS videotapes. After completion of the whole study, sphincter defects were measured and classified off-line by the first author, who reviewed the videotapes twice at 3 - 4 weeks' interval. The second evaluation was done without knowledge of the results of the first one. Any intra-observer disagreement was resolved at a third evaluation a few days after the second one.

An endosonographic sphincter defect was defined as a discontinuity in the endosonographic image of the internal (hypoechoic ring) or external (mixed echoic ring) sphincter (Figure 1a). The longitudinal muscle was included in the measurement of the external sphincter. Scars in the external sphincter are usually of low reflectivity, but their appearance may vary (Figure 1b).[23] Defects engaging less than half of the external sphincter thickness and/or less than half

of the internal sphincter thickness were not classified as defects, those engaging at least half but not the whole sphincter thickness were classified as partial defects, and those engaging the whole sphincter thickness were classified as total defects. The localization and size of any defect of the external or internal anal sphincters were described using a clockwork symbol with the 12 o'clock position anteriorly, the defect being described to extend clockwise (e.g., 'a defect starting at one o'clock and extending $45^0$ clockwise') (Figure 2). In addition, the longitudinal location and extent of the sphincter defect were described (i.e., at least half of the sphincter length, more than half but not the whole sphincter length, the whole length; proximal, distal, or full length defect). The scoring system used for assessment of the extent of the defects is described in Table 2. A score of 0 means no defect, a score of 16 means a maximal defect. In a reproducibility study the difference in score between two observers never exceeded two.[24] A priori, a change in score between two examinations was defined as a minor change (change of 1-3 score), a moderate change (change of 4-6 score), or a major change (change of $\geq$ 7 scores).

### *Anal manometry*

Anal manometry was performed using a water-perfused catheter with a 4 mm outer diameter and with eight sensory ports located 52 mm from the tip and at a distance of $45^0$ from each other (VMC-8 manometric catheter, Medtronic AB, Stockholm, Sweden). We used a continuous pull-through technique with a computer-controlled stepper motor (hardware PC Polygraf HR, Medtronic AB, Stockholm, Sweden). The catheter withdrawal rate was 2.5 mm/s. Technically acceptable pressure curves were stored in a computer for analysis off-line. Three measurements were performed with the anal sphincter at rest, and three measurements were performed while the patient squeezed. Maximum resting pressure, maximum voluntary squeeze pressure, and mean sphincter resting pressure area were calculated. Maximum resting pressure was calculated as the mean of the highest pressures at each of the eight sensory ports.

The mean of three replicate measurements was used in our analyses. Maximum squeeze pressure was defined as the highest pressure at any of the eight sensory ports. The highest maximum squeeze pressure of three replicate measurements was used. The mean sphincter resting pressure area is the mean of eight pressure areas under the curve - one pressure area for each of the eight sensors - during continuous retraction through the sphincter at rest. We used the mean of three replicate measurements. Off-line analysis of the pressure curves was performed using polygram for Windows, version 2.04 (Medtronic AB, Stockholm, Sweden). It was done without knowledge of the endosonographic results and without knowledge of the clinical type of tear.

### *Questionnaires*

The patients answered a questionnaire with regard to bowel function (continence of gas, liquid and solid stool) at 1 and 4 years after delivery. A change in bowel function (after vs. before the sphincter tear) was specifically asked for. Anal incontinence starting after the sphincter tear was defined as 'sphincter tear related incontinence'. The results of the questionnaire were expressed as a fecal incontinence score (Wexner score) as described by Jorge and Wexner.[15] A priori, an incontinence score of 1 or 2 was defined as minor incontinence, a score of 3 as moderate incontinence, and a score of $\geq$4 as major incontinence.

### *Surgical technique and post-operative management*

After the ultrasound images and the pressure curves had been analyzed, the delivery charts and operation records were assessed independently by the three authors. Information was retrieved about the woman's age and parity, the clinical type of sphincter tear, the suture technique, the method of analgesia/anesthesia, the postoperative management, and the experience of the surgeon (specialist in obstetrics and gynecology or doctor in training). Any disagreement (e.g., with regard to the clinical type of tear) was resolved by discussions between the authors. The assessment showed that in every case the surgical repair technique

was an end-to-end approximation of the external anal sphincter muscle with 2/0 Vicryl. In no woman was the internal sphincter sutured separately. General anesthesia was used in 15 % of the women, local analgesia in 85 %. Postoperative treatment was low fiber diet for 3-5 days post partum and stool softeners for 3-4 weeks after discharge from hospital.

### *Statistics*

The statistical significance of differences in continuous data was determined using Student's t-test for paired or unpaired data where appropriate and that of differences in categorical data using Fisher's exact test or the Chi-squared test. Bonferroni's correction was used to correct for multiple comparisons. Linear regression analysis was used to determine a possible correlation between variables. To determine which factors best predicted anal incontinence we used multivariable linear regression analysis with Wexner score as the dependent variable and the following variables as independent ones: endosonographic sphincter defect score, sphincter pressures, clinical type of tear (partial vs. total or fourth degree), and additional vaginal deliveries (yes or no). Additional vaginal delivery was used as an independent variable only when anal incontinence at 4 years was the dependent variable. Each multivariable analysis included endosonographic and manometric results from one follow-up occasion only (i.e., results either after 1 week, or after 3 months, or after 1 year). P-values $\leq 0.05$ were considered statistically significant. Statistical analysis was carried out using StatView 5.0 for Windows (SAS Institute Inc., 1992-1998, USA). The statistical package for social sciences (SPSS Inc., Chicago, USA, version 11) was used for multivariable linear regression analysis.

## Results

### *Endosonographic results*

*Changes in the extent of sonographic sphincter defects over time*

One week after the sphincter tear, four (10%) women had no defects, 23 had a defect score of 3-5, nine had a defect score of 6-9, and five had a defect score of 10-14. The endosonographic sphincter defect scores tended to be related to the clinical degree of the perineal laceration, with the highest scores for the fourth degree tears and the lowest scores for the partial third degree tears, but the differences in endosonographic score between the three clinical types of tear were not statistically significant.

The endosonographic sphincter defect score increased significantly between the first and second examination but did not change between the second and third examination (Figure 3).

In 34% (14/41) of the women the endosonographic sphincter defect score increased between the first and second ultrasound examination, the increase being moderate or major in eight women (20%). In 15% (6/41) of the women the score decreased, the decrease being moderate in one woman (2%) and minor in five.

In 12% (5/41) of the women the endosonographic defect score increased between the second and third ultrasound examination, and in 7% (3/41) it decreased. All of these changes except one (a moderate decrease) were minor.

Improvement in score was not seen in any of the women with score $\geq$10 at the first examination.

Classifying endosonographic sphincter findings as ‘no defect’, ‘external sphincter defect’, and ‘external and internal sphincter defect’, the extent of the defect remained unchanged over time in 71% (29/41) of the women, became worse in 20% (8/41) and improved in 10% (4/41). All but one of these changes occurred between the first and second examination.

### *Anal manometry results*

Resting pressures and squeeze pressures varied substantially between individuals. Pressures were significantly higher at the second and third examination than at the first examination but did not differ between the second and third examination (Figure 4).

### *Symptoms of incontinence*

The incontinence score increased between the 1 year follow-up and the 4 year follow-up (mean 1.1±1.47 vs. 1.6±1.89; p=0.04). This was true even when only women with sphincter tear related incontinence were considered to be incontinent (mean 0.7±1.43 vs.1.2±1.97; p=0.04). Most women had mild gas incontinence only (gas incontinence, Wexner score 1-2), and none was incontinent for solid stool.

At 1 year 22 (54%) women reported problems with anal incontinence, five (12%) having moderate (n = 3) or major (n = 2) problems, 15 having mild gas incontinence (Wexner score 1-2), and two having mild incontinence for liquid stool (Wexner score 1). Eleven women (27%) had Wexner score ≥ 2. Twelve (29%) women reported their incontinence problem to have started after the tear, the problem being moderate in one and major in two, corresponding to 7% of all women in our study having moderate or major sphincter tear related anal incontinence at 1 year.

At 4 years 25 women (61%) reported anal incontinence, 12 (29%) having moderate (n = 7) or major (n=5) problems, 10 having mild gas incontinence only (Wexner score 1-2), and three having mild incontinence for liquid stool (Wexner score 1). Seventeen women (41%) had Wexner score ≥2. Fifteen (37%) women stated that their problems had started after the sphincter tear, the problem being moderate in five women and major in five, corresponding to 24% of all the women in our study having moderate or major sphincter tear related incontinence at 4 years.

Anal incontinence score remained unchanged between the 1 year follow-up and the 4 year follow-up in 21 (51%) women, become worse in 16 (39%), and improved in four women (10%). Six of the 19 women with no anal incontinence at 1 year had problems at 4 years, and three of the 22 women with incontinence at 1 year reported no problems at 4 years (Figure 5). Four women gave inconsistent answers. Even though they reported no incontinence at 1 year, they reported incontinence unrelated to the sphincter tear at 4 years. Among the women with no change or improvement in symptoms of anal incontinence between 1 and 4 years 48% (12/25) had given birth vaginally at least once between the two examinations. The corresponding figure for women with worsening symptoms was 44% (7/16) (p=1.0).

### *Correlation between endosonographic defect score and sphincter pressure*

There was a negative correlation between endosonographic sphincter defect score and rest pressures after 1 week, 3 months and 1 year, i.e., the higher the defect score the lower the pressures. This correlation was strongest at 1 year (rest pressure: $r = -0.61$, $p < 0.001$; resting pressure area: $r = -0.54$, $p < 0.001$). A statistically significant negative correlation between endosonographic sphincter defect score and squeeze pressure was seen only at 1 year ($r = -0.40$, $p < 0.01$).

### *Correlation between endosonographic defect score and Wexner incontinence score*

The correlations between endosonographic defect score and incontinence score are shown in Table 3. There was a statistically significant positive correlation between the endosonographic defect score at 1 week, 3 months and 1 year and the incontinence score at 1 year, i.e., the higher the defect score the higher the incontinence score. If only women with sphincter tear related incontinence were considered incontinent, then the correlation was statistically significant for endosonographic sphincter score at 1 week but not for endosonographic sphincter score at 3 months and 1 year.

There was also a positive correlation between the endosonographic defect score at 1 week, 3 months and 1 year and the incontinence score at 4 years. This correlation remained statistically significant when only those women with sphincter tear related incontinence were considered incontinent.

### *Correlation between sphincter pressure and Wexner incontinence score*

The correlations between sphincter pressure and Wexner incontinence score are shown in Table 3. There was a negative correlation between sphincter rest pressures and Wexner incontinence score at 1 year and 4 years, the correlations being strongest for pressure results obtained at 3 months and 1 year. A negative correlation was also seen between squeeze pressure and Wexner incontinence score, but the results with regard to squeeze pressure were less consistent.

### *Prediction of anal incontinence at 1 and 4 years using multivariable linear regression*

Neither the type of clinical tear nor additional vaginal deliveries were predictive of the Wexner score. Both the endosonographic defect score and the squeeze pressure 1 week after primary suture contributed to explain the Wexner score at 4 years when only those women with sphincter tear related incontinence were considered incontinent (endosonographic sphincter score: r=0.46, p=0.002; squeeze pressure: r=-0.28, p=0.046; $r^2$ of model=0.32)

Both the endosonographic defect score and the rest pressure area at 3 months predicted the Wexner score at 4 years (endosonographic sphincter score: r=0.32, p=0.039; resting pressure area: r=-0.32, p=0.044; $r^2$ of model=0.29).

All the other multivariable analyses showed that only one variable explained the Wexner score. The correlation coefficients for these variables are shown in bold in Table 3.

## Discussion

In agreement with other research teams we found a high frequency of endosonographic sphincter defects after primarily sutured sphincter tears.[4,8,20,25] By using an endosonographic defect scoring system we quantified the sphincter damage and described its change over time. A substantial worsening of the endosonographic defects was seen in 20% of the women 3 months after the primary repair of the sphincter tear, but after that most defects remained unchanged. Substantial improvement in endosonographic score over time was seen in only 5% (2/41) of the women. The anal pressures increased during the first 3 months after the primary suture and then stabilized. Low endosonographic sphincter defect scores were associated with higher anal sphincter pressure and lower anal incontinence scores than high defect scores. As early as within 1 week after primary suture of an obstetric sphincter tear the endosonographic sphincter defect score predicted future anal incontinence.

In order not to overdiagnose normal variation of sphincter thickness as partial sphincter defects, we decided to classify 'defects' in the internal or external sphincter extending through less than half of the sphincter thickness as no defect.

The increase in sphincter defect score/extent of the defects during the first 3 months after repair might be explained either by inevitable scarring, or by true worsening of the defects, possibly due to inadequate suturing. We suspect that the largest defects (score $\geq$10 at the first examination) - of which none improved over time - were explained by poor suturing and not by scarring. Sultan and coworkers[26] believe that suturing the external sphincter using the overlap technique and separate repair of the internal sphincter - if torn - would result in fewer and smaller endosonographic defects, but this was not confirmed by Fitzpatrick and coworkers.[27] The overlap technique was not used in our study. Our suture technique was not standardized, and the condition of the internal sphincter was not described in any operation

report, which is a limitation in our study, but according to the operation reports the suture technique was the same in all cases.

We expected the endosonographic sphincter scores to be related to the clinical degree of the tear, but we found no statistically significant difference in the endosonographic score between partial and total third degree tears / fourth degree tears. This might be explained by difficulties with correctly classifying the tear at surgical repair and / or by lack of statistical power, there being only three fourth degree tears in our study. Nazir and colleagues found endosonographic defects to be significantly larger in a group of women with a total third degree tear or a forth degree tear than in a group with a partial third degree tear.[25]

In agreement with other studies[6,9,11,17,18] we found large variations in sphincter pressure. The increase in sphincter pressure during the first few months after delivery probably reflects recovery from overstretching of the muscles in the pelvic floor and of the pudendal nerve. At 1 year after delivery all three sphincter pressures correlated quite strongly with the endosonographic defect score, i.e., the higher the defect score the lower the pressure. Thus, there is reason to believe that the endosonographic sphincter defect score is related to sphincter function - at least to some extent. The relation between endosonographic sphincter defects and sphincter pressure has been studied by others,[6, 11, 25] but only Nazir and coworkers graded the endosonographic defects[25]. Our results are in agreement with theirs: categorizing endosonographic sphincter defects into three groups according to their extent Nazir and colleagues found low sphincter pressures only in women with large endosonographic sphincter defects.

Fifty-four percent of the women in our study reported anal incontinence after 1 year, and 61% reported anal incontinence after 4 years. Others studying incontinence at 3 to 12 months or at 1 to 5 years after primary repair of an obstetric sphincter tear found similar results with 40 - 59% of the women having anal incontinence.[2,6,9,11,12,21] In our study the incontinence

score increased with time. Only three of 22 women (14%) with anal incontinence and only one woman with sphincter tear related incontinence had transient incontinence. Subsequent vaginal delivery did not worsen anal incontinence. Our results disagree with those of two other reports. [7, 10] Bek and coworkers[7] found that in most cases with anal incontinence after a sphincter tear the incontinence was transient, and that transient incontinence predicted anal incontinence after subsequent vaginal delivery. Poen and colleagues[10] who found anal incontinence in 40% of women 5 years after primary repair of a sphincter tear also stated that subsequent vaginal delivery increased the risk of anal incontinence. The reasons for the discrepant results are not clear.

According to published studies most women with anal incontinence after an obstetric sphincter tear are incontinent for gas only (gas incontinence/stool incontinence= 5:1)[8,12,21,28] In a 30-year retrospective study of women in three groups (obstetric anal sphincter tear, episiotomy, caesarean delivery),[16] a surprisingly large number of middle aged women had anal incontinence. The proportion of women with bothersome flatus incontinence was higher in the sphincter disruption group than in the others, whereas bothersome stool incontinence was similar in all three groups. In our study, too, most women had mild gas incontinence only, and none was incontinent for solid stool. This might be explained by the small number of women with fourth degree tears. On the other hand, an unequivocal relationship between clinical type of tear and subsequent type of anal incontinence has not been established.[21,24,27]

Ten of the 22 (45%) women in our study with anal incontinence at 1 year had problems with gas incontinence also before the delivery. To the best of our knowledge, information on anal incontinence before an obstetric sphincter tear was collected in only one published study.[12] In that study 15% of the women were incontinent before the tear (13% reporting flatus incontinence and 2% fecal incontinence), which is less than in our study. The discrepancy might be explained by differences in the definition of incontinence and / or by difficulties

with obtaining reliable information on bowel function retrospectively. It may be difficult to remember previous minor incontinence problems, especially if bowel function (amount of flatus, consistency of stool) has varied over the years.

Multivariable linear regression analysis showed close relationships between endosonographic sphincter defect scores and sphincter rest pressures, and both predicted the Wexner incontinence score. The best predictor of Wexner incontinence score at 4 years was the endosonographic defect score at 1 week, but the endosonographic defect scores at 3 months and 1 year were also related to the 4-year Wexner score. The best predictors of Wexner score at 1 year were the rest pressures (with the exception that sphincter defect score at 1 week was the best predictor of sphincter tear related incontinence at 1 year). The relationship between squeeze pressure and Wexner score was less consistent, probably because squeeze pressure is strongly dependent on the woman's ability to cooperate.

Because the **extent** of an endosonographic anal sphincter defect after primary repair of an obstetric anal sphincter tear is related to the future Wexner anal incontinence score, proper repair is important. In a previous study we found that an ultrasonographic sphincter defect is likely to be smaller if a specialist has performed the primary repair of the laceration than if a doctor in training has done it. [22] We would like to speculate, that it might be valuable to check the result of primary repair with anal endosonography immediately after the repair and to re-suture if a large defect is still seen.

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**Table 1.** Characteristics of the women included and excluded

| | Included (n=41) | Excluded (n=20) | p-value |
|---|---|---|---|
| Age, years; mean ± SD | 28 ± 4.4 | 27± 6.7 | 0.46 |
| Primipara; n (%) | 33 (80) | 19 (95) | 0.13 |
| Clinical type of tear; n (%) | | | |
| partial third degree | 30 (73) | 11 (55) | 0.16* |
| total third degree | 8 (20) | 8 (40) | —— |
| fourth degree | 3 (7) | 1 (5) | —— |
| Repaired by specialist in obstetrics and gynecology | 30 (73) | 11 (55) | 0.51 |

SD = standard deviation

* partial third degree vs. others

**Table 2.** Scoring system for endosonographic sphincter defects

| | Score | | | |
|---|---|---|---|---|
| **Extent** of defect | 0 | 1 | 2 | 3 |
| External sphincter | | | | |
| length of defect | none | half or less | more than half | whole |
| depth of defect | none | partial | total | — |
| size of defect | none | $\leq 90^0$ | $91^0 - 180^0$ | $>180^0$ |
| Internal sphincter | | | | |
| length of defect | none | half or less | more than half | whole |
| depth of defect | none | partial | total | — |
| size of defect | none | $\leq 90^0$ | $91^0 - 180^0$ | $>180^0$ |

**Table 3.** Correlation (r) between sphincter defect score and Wexner score, and between sphincter pressure and Wexner score

| | Wexner score at 1 year | | Wexner score at 4 years | |
|---|---|---|---|---|
| | All women reporting Incontinence considered incontinent | Only women who became incontinent after the tear considered incontinent. | All women reporting incontinence considered incontinent | Only women who became incontinent after the tear considered incontinent |
| 1 week examination | | | | |
| Defect score | 0.39** | **0.39**** | **0.48***** | **0.49****** |
| Rest pressure | -0.28 | -0.19 | -0.29 | -0.29 |
| Rest pressure area | **-0.44***** | -0.34* | -0.35* | -0.29 |
| Squeeze pressure | -0.13 | -0.14 | -0.28 | **-0.33*** |
| 3 month examination | | | | |
| Defect score | 0.35* | 0.22 | **0.46***** | 0.36* |
| Rest pressure | -0.39** | -0.30* | -0.38** | -0.32* |
| Rest pressure area | **-0.51****** | **-0.44***** | **-0.45***** | **-0.38**** |
| Squeeze pressure | -0.36* | -0.41** | -0.29 | -0.31* |

Cont.

**Table 3.** Cont

| | Wexner score at 1 year | | Wexner score at 4 years | |
|---|---|---|---|---|
| | All women reporting incontinence considered incontinent | Only women who became incontinent after the tear considered incontinent. | All women reporting incontinence considered incontinent | Only women who became incontinent after the tear considered incontinent. |
| 1 year examination | | | | |
| Defect score | 0.37* | 0.26 | **0.47*** ** | **0.39** ** |
| Rest pressure | **-0.51**** ** | **-0.43*** ** | -0.38** | -0.33* |
| Rest pressure area | -0.45*** | -0.40** | -0.39** | -0.31* |
| Squeeze pressure | -0.46*** | -0.37* | -0.37* | -0.30 |

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.005$; **** $p \leq 0.001$

Figures in bold denote those variables that best predicted the Wexner score according to multivariate linear regression analysis. $r^2$ values of model are given in the text

## Legends

**Figure 1**. Images of a normal and a defect sphincter. The 12 o´clock position is anterior. a) Normal anal canal. Black arrow=the hyperechoic external sphincter, black double arrow=the longitudinal muscle, white arrow=the hypoechoic internal sphincter, bent white arrow=the hyperechoic anal mucosa b) Defect (hypoechoic) in the external sphincter starting at twelve o'clock and extending $40^0$ clockwise. Scar tissue (hyperechoic) is seen inside the defect and outside the defect at one o'clock (arrow).

**Figure 2**. Images of defects in the external and internal sphincters. The 12 o'clock position is anterior. a) Partial defect of the external sphincter starting at eleven o'clock and extending $75^0$. The defect engages at least half but not the whole external sphincter thickness b) Total external sphincter defect starting at ten o'clock and extending $120^0$. The defect is hypoechoic from ten to twelve o'clock and anechoic from twelve to two o'clock c) Partial defect of the internal sphincter starting at elleven o'clock and extending $90^0$. The defect engages at least half but not the whole internal sphincter thickness d) Total internal sphincter defect starting at ten o'clock and extending $100^0$. No hypoechoic internal sphincter is seen anteriorly e) A combined total internal and external sphincter defect. The internal sphincter defect starts at nine o'clock and extends $180^0$, the external defect starts at twelve o'clock and extends $90^0$.

**Figure 3**. Endosonographic sphincter defect score at 1 week, 3 months and 1 year after delivery. Mean value and $\pm$ standard deviation are shown. The p-values were calculated using Bonferroni's correction.

**Figure 4**. Anal sphincter pressure at 1 week, 3 months and 1 year after delivery (n=41). a) resting pressure, b) squeeze pressure. Mean value ± standard deviation are shown. The p-values were calculated using Benferroni's correction.

**Figure 5**. Changes in incontinence symptoms over time.

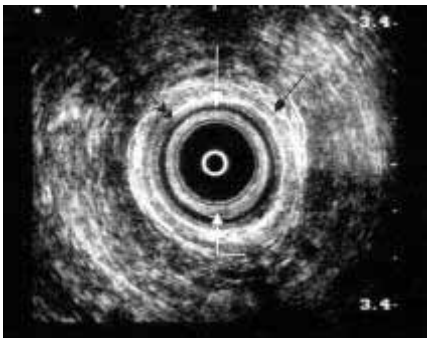


**Fig. 1a**

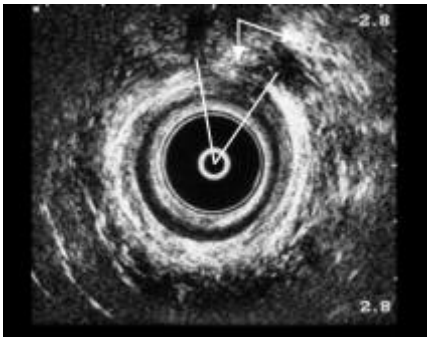


**Fig. 1b**

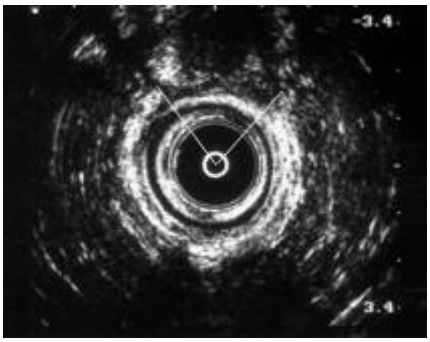


**Fig. 2a**

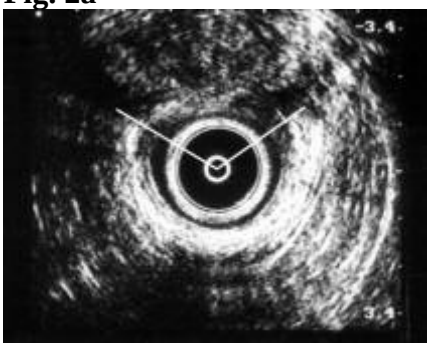


**Fig. 2b**

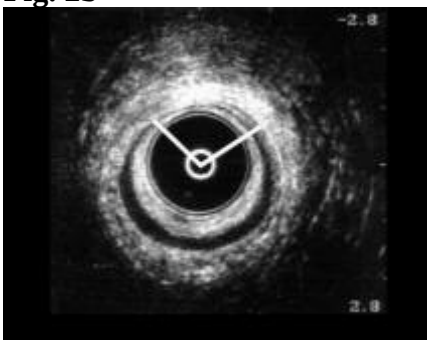


**Fig. 2c**

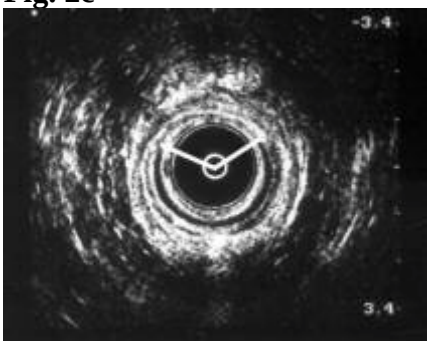


**Fig. 2d**

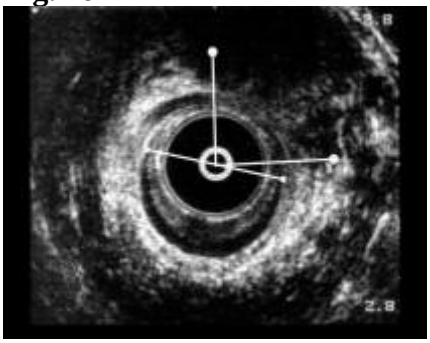


**Fig. 2e**

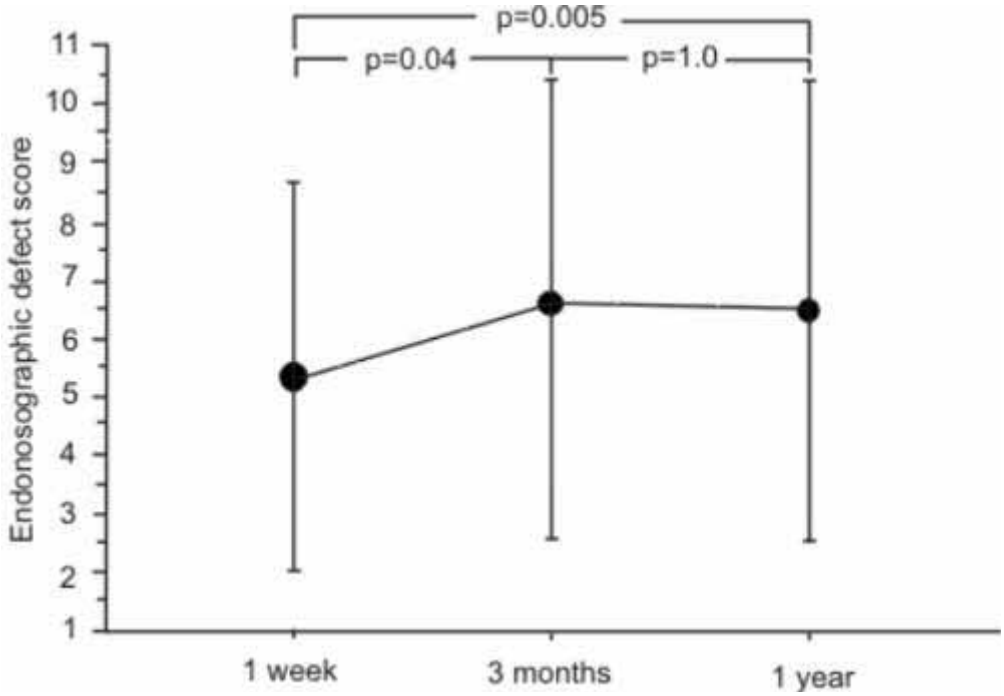
p=0.005
p=0.04
p=1.0
Endonosographic defect score
11
10
9
8
7
6
5
4
3
2
1
1 week
3 months
1 year

**Fig. 3**

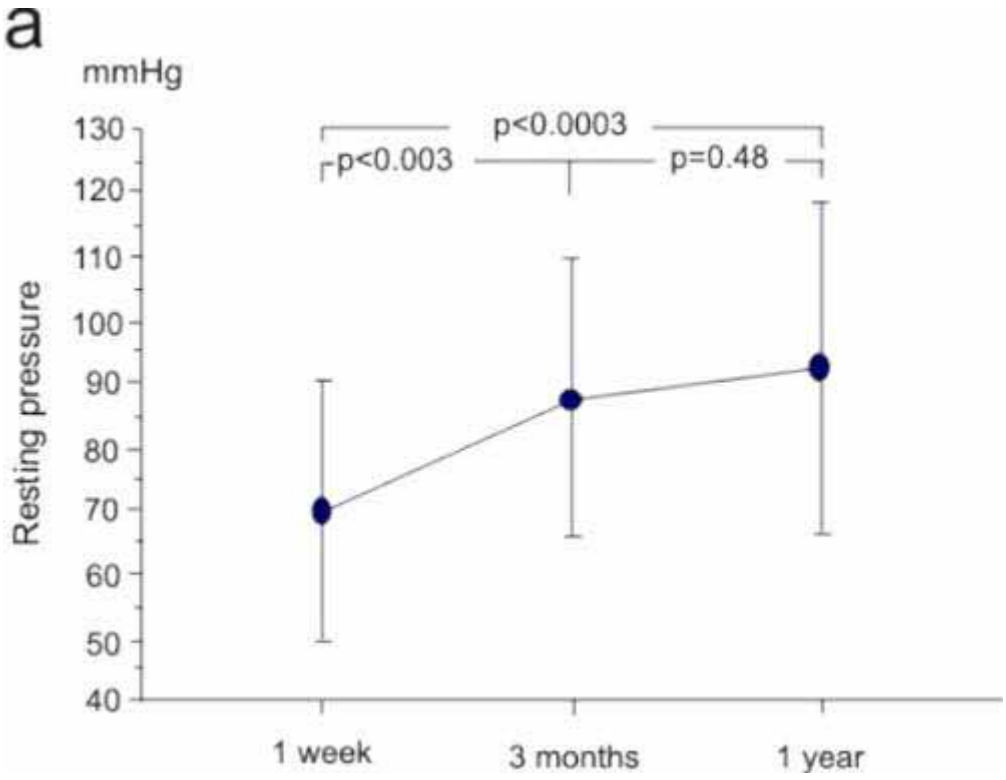
a
mmHg
Resting pressure
130
120
110
100
90
80
70
60
50
40
p<0.0003
p<0.003
p=0.48
1 week
3 months
1 year

**Fig.4a**

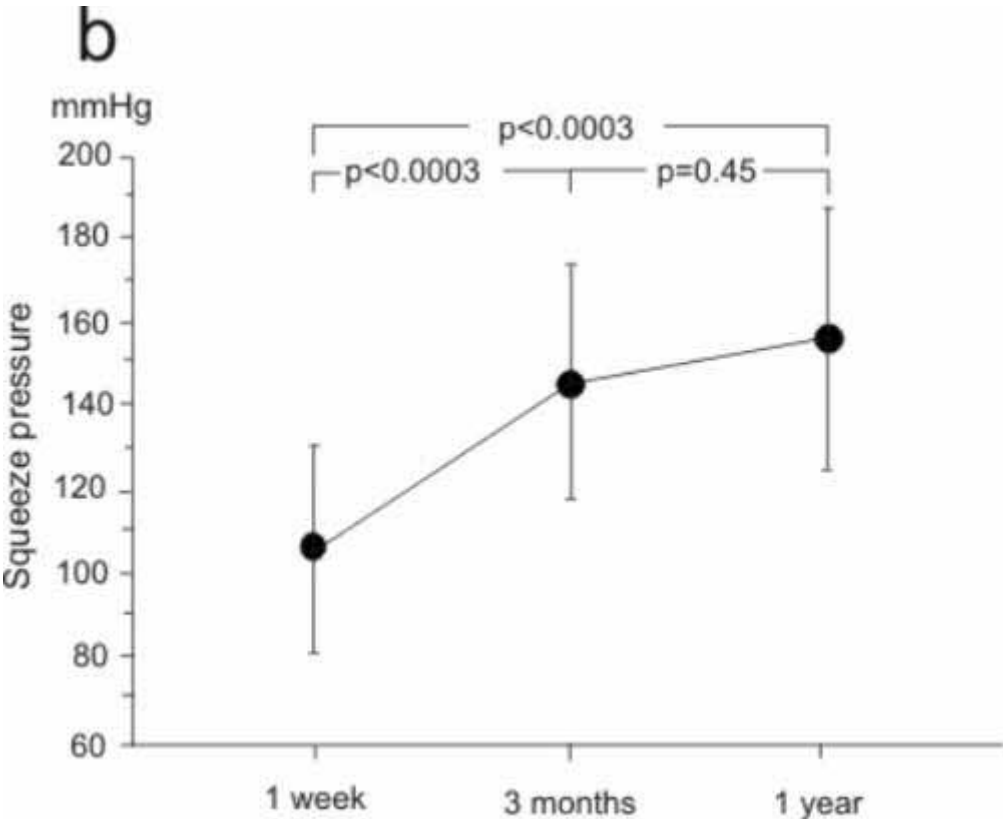
b
mmHg
Squeeze pressure
200
180
160
140
120
100
80
60
p<0.0003
p<0.0003
p=0.45
1 week
3 months
1 year

**Fig.4b**

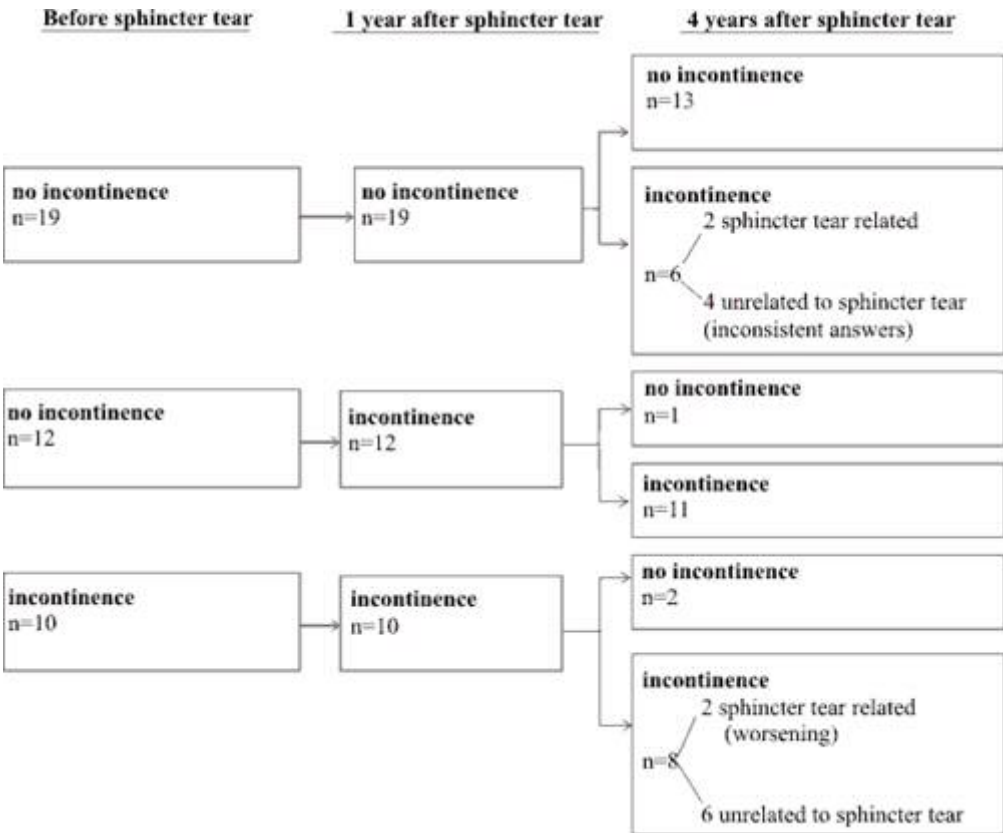
Before sphincter tear
1 year after sphincter tear
4 years after sphincter tear
no incontinence
n=19
no incontinence
n=19
no incontinence
n=13
incontinence
2 sphincter tear related
n=6
4 unrelated to sphincter tear
(inconsistent answers)
no incontinence
n=12
incontinence
n=12
no incontinence
n=1
incontinence
n=11
incontinence
n=10
incontinence
n=10
no incontinence
n=2
incontinence
2 sphincter tear related
(worsening)
n=8
6 unrelated to sphincter tear

**Fig.5**