THE RELATIONSHIP OF OBSTETRIC FACTORS TO ASPECTS OF PELVIC FLOOR TRAUMA AND DYSFUNCTION
20 YEARS POST-DELIVERY

A Masters Thesis Presented

By

Dr Sylvia Lin
FRANZCOG, MBCHB, BHB

Submitted to the Faculty of Medicine, the University of Otago Faculty of Medicine for the degree of

MASTER OF MEDICAL SCIENCE

DECEMBER 2015
Abstract

Background
The pelvic floor (levator ani and covering endopelvic fascia) has an important role in supporting the bladder, vagina, uterus and rectum. Pelvic floor trauma in women may result in urinary and faecal incontinence, and also pelvic organ prolapse. It is a very common problem affecting around half of women having at least one type of pelvic floor dysfunction, particularly later in life. The aetiology of pelvic floor dysfunction is likely to be multifactorial, although childbearing is probably the most significant predisposing factor in women – vaginal delivery resulting in stretching and avulsion of levator ani muscles, damage to anal sphincter, along with nerve trauma are important factors.

The development of functional imaging has revolutionised our understanding of the pelvic floor during and after birth. There is however a lack of information on the long-term relationship between obstetric factors with pelvic floor trauma and the relationship between these obstetric injuries and long-term pelvic floor function.

Objectives
To investigate the relationship between obstetric history and the clinical and ultrasound diagnosis of levator avulsion (LA) and damage to the anal sphincter 20 years after childbirth. We also aimed to examine the relationship of these obstetric injuries to symptoms and signs of pelvic floor dysfunction and to compare digital palpation of LA with ultrasound diagnosis.

Design
Twenty-year longitudinal study.

Setting
Maternity unit in Dunedin.

Population
Women dwelling in the community.

Methods
Data from women were collected 20 years after an index birth by postal questionnaire, and women were invited for examination and ultrasound assessment. Logistic regression investigated associations between ultrasound diagnoses and symptoms and signs of pelvic floor dysfunction.

Main outcome measures
Objective measures of prolapse (POP-Q) and ultrasound confirmation of LA and obstetric anal sphincter injuries (OASIS). Subjective report of pelvic floor dysfunction measured by the pelvic organ prolapse symptom score (POP-SS), Prolapse/Urinary Incontinence Sexual Questionnaire (PISQ-12) score, any urinary and faecal incontinence.
**Results**

Of 1248 women at initial recruitment, 1191 questionnaires were sent and 464 (39%) returned questionnaires at 20 years. 196 of these returned for clinical assessment. The mean age for the examined respondents was 50.8 years. The overall LA rate was 15.2% and OASIS rate was 12.5%. Agreement between palpation and transperineal ultrasound diagnosis of LA was 91% (kappa 0.32).

Forceps delivery was associated with significantly greater LA rate compared with vaginal delivery (26% vs. 13%, OR 2.45, 95% CI 1.04-5.08, p=0.04); as well as higher OASIS rate but that did not reach significance (21% versus 11%, OR 2.2, 95% CI 0.87-5.59, p=0.098).

LA was significantly associated with more objectively measured POP-Q, “bothersome” prolapse and faecal incontinence, but had no association with prolapse symptoms by POP-SS. LA was significantly associated with greater sexual dysfunction by PISQ-12 scores (mean difference 2.3, 95% CI 0.2-4.4; p=0.015), less adequate vaginal tone for woman’s satisfaction and poorer pelvic muscle strength.

Women with OASIS had a higher prevalence of urinary and faecal incontinence but this did not reach statistical significance. OASIS is associated with significantly greater sexual dysfunction by PISQ-12 scores (mean difference 3.65, 95% CI 5.9-1.4, p<0.001), but no significant difference in vaginal tone or pelvic floor muscle strength.

**Conclusions**

Forceps delivery has a long term deleterious effect on pelvic floor structures, particularly with LA. Sonographic evidence of LA is strongly linked with long term pelvic floor dysfunction including objective and bothersome prolapse, and faecal incontinence. Both LA and OASIS were significantly associated with sexual dysfunction in our group of perimenopausal women. The association of sexual dysfunction with both LA and OASIS 20 years after delivery has not been previously described and further studies are indicated to validate these findings.
PREFACE

Acknowledgements

Primary Supervisors
Professor Don Wilson
Department of Women’s and Children’s Health
Dunedin School of Medicine

Professor Peter Herbison
Department of Preventive and Social Medicine
Dunedin School of Medicine

Co-Investigator
Dr Ixora Kamisan Atan
Gynaecologist and Research Fellow
University of Sydney

Adjunct Academic Support
Professor Cathryn Glazener (ProLong Study Group)
Health Service Research Unit
University of Aberdeen

Professor Peter Dietz*
University of Sydney

* Unrestricted educational grant, GE Medical

Research Co-ordinator
Ms Gaye Ellis
Department of Women’s and Children’s Health
University of Otago
1. INTRODUCTION.............................................................................................................. 1
2. LITERATURE REVIEW..................................................................................................... 3
  2.1. Prevalence and Costs of Pelvic Floor Dysfunction .............................................. 3
  2.2. Pelvic Floor Dysfunction and Mode of Delivery ................................................. 4
    2.2.1. Urinary Incontinence ....................................................................................... 4
    2.2.2. Anal Incontinence .......................................................................................... 6
       2.2.2.1. Diagnosis of Trauma to Anal Sphincter .................................................. 7
    2.2.3. Pelvic Organ Prolapse .................................................................................... 7
    2.2.4. Sexual Dysfunction ........................................................................................ 9
  2.3. Levator Ani and Pelvic Floor Trauma from Child Birth ........................................ 12
    2.3.1. Risk factors for levator ani injuries .................................................................. 12
    2.3.2. Pelvic Floor Dysfunction and Levator Ani Injuries ....................................... 13
       2.3.2.1. Pelvic Muscle Strength .............................................................................. 13
       2.3.2.2. Stress Urinary Incontinence .................................................................... 13
       2.3.2.3. Anal Incontinence ................................................................................... 14
       2.3.2.4. Pelvic Organ Prolapse ............................................................................ 14
    2.3.3. Diagnosis of Levator Ani Injury ..................................................................... 14
       2.3.3.1. Clinical Examination ................................................................................ 14
       2.3.3.2. Diagnosis by Ultrasound Imaging ............................................................ 15
       2.3.3.3. Diagnosis by MRI .................................................................................... 15
       2.3.3.4. Comparison of MRI and Ultrasound ....................................................... 16
    2.3.4. Prevention of Levator Ani injuries ................................................................. 16
  3. STUDY OBJECTIVES .................................................................................................... 18
4. METHODS....................................................................................................................... 19
  4.1. Study Design .......................................................................................................... 19
    4.1.1. Study Questionnaires ..................................................................................... 19
    4.1.2. POP-Q assessments ....................................................................................... 20
    4.1.3. Transperineal Ultrasound ............................................................................ 21
  4.2. Statistical Analysis ................................................................................................... 23
5. RESULTS ....................................................................................................................... 25
  5.1. Demographics ......................................................................................................... 25
  5.2. Relationship of Obstetric Factors with Levator avulsion and OASIS ............... 28
List of Tables and Figures

Table 1  Conclusions of main epidemiological studies to date ........................................... 11
Table 2  Baseline characteristics of respondents and non-respondents at 12 years .......... 25
Table 3  Characteristics of women and pelvic floor dysfunction 20 years after delivery . 26
Table 4  Comparison of questionnaire and hospital records ............................................. 27
Table 5  Obstetric factors with levator avulsion and OASIS .............................................. 28
Table 6  Levator avulsion and pelvic floor dysfunction ...................................................... 30
Table 7  OASIS and pelvic floor dysfunction ................................................................. 31
Table 8  Levator avulsion diagnosis by palpation and translabial tomographic ultrasound 32

Figure 1  Incidence rates of stress urinary incontinence surgery in relation to mode of
delivery and time since first childbirth ................................................................. 6
Figure 2  Incidence rates of pelvic organ prolapse surgery in relation to mode of delivery
and time since first childbirth ............................................................................. 9
Figure 3  Determination of hiatal area on translabial/transperineal ultrasound ............. 22
Figure 4  Diagnosis of levator avulsion on tranlabial/transperineal tomographic ultrasound
......................................................................................................................... 22
Figure 5  Major anal sphincter trauma on translabial/transperineal tomographic ultrasound
......................................................................................................................... 23
1. INTRODUCTION

The pelvic floor [levator ani muscles and covering endopelvic fascia] has an important role in supporting the bladder, vagina, uterus and rectum. Pelvic floor dysfunction refers to a wide range of symptoms that can develop due to various pelvic floor disorders; its many aspects were outlined in the 2010 International Urogynecological Association (IUGA)/International Continence Society (ICS) Joint Report on the Terminology for Female Pelvic Floor dysfunction (1), with symptoms ranging from urinary incontinence, pelvic organ prolapse, sexual and anorectal dysfunction, other bladder symptoms, urinary tract infection and pain. For the remainder of this study upon referencing pelvic floor dysfunction, our main focus will be on aspects of pelvic floor dysfunction including urinary and anal incontinence, pelvic organ prolapse, pelvic floor trauma of levator ani and anal sphincter and sexual dysfunction.

It is a very common problem, with over 46% of women having some form of major pelvic floor dysfunction and is of epidemic proportions in later life. Approximately 11% of women undergo surgery for this condition during their lifetime, 7% for prolapse alone (2). It not only has a significant impact in the quality of life for a large number of women, but also has significant cost implications for health services throughout the world. Consequently it is of great importance to identify possible aetiological factors with a view to subsequent prevention or reduction of its impact.

Aetiology of pelvic floor dysfunction is multifactorial. Childbearing is likely the most significant predisposing factor for pelvic floor dysfunction in women (3). Vaginal delivery with the stretching of the puborectalis muscle and avulsion of its insertion are important factors along with damage to the anal sphincter. There is however no consensus on reducing this risk and evidence is conflicting whether the condition can be prevented or alleviated by aspects of obstetric practice, in particular, caesarean section (4).

In 1993-94, the ProLong, longitudinal study commenced, looking at the relationship of childbirth and subsequent pelvic floor dysfunction. This involved nearly 8000 women in Dunedin New Zealand, Birmingham and Aberdeen in the United Kingdom and is the largest ongoing prospective study in this field. Just over 50% of participants in this cohort study, returned questionnaires at 3 months, six and 12 years. Women were also examined at the 12-year follow up (5).

In the ProLong study at 12 years after delivery, urinary incontinence was common, affecting just over 50% of women. Exclusive caesarean section delivery appeared to confer partial protection against urinary incontinence compared to women who delivered vaginally [Odds ratio (OR) 0.46, 95% Confidence Interval (CI) 0.37-0.58], but not if they had a combination of caesarean section and vaginal births (5). A similar reduction in urinary incontinence was seen at 20 years after delivery in the SWEdish Pregnancy Obesity Pelvic floor [SWEPOP] study (6) following just over 5000 primiparous women who delivered in 1985-1988 with no further births [vaginal delivery 40.3% and caesarean section 28.8%].

In contrast, there is no evidence to date of a protective effect from exclusive caesarean section towards reduced likelihood of anal incontinence (7). However one or more forceps
deliveries appears to be associated with long-term faecal incontinence [FI, any loss of solid or liquid stool] (5). Long-term sexual dysfunction appears to be similarly unaffected by modes of delivery; however women with urinary or faecal incontinence scored lower on sexual satisfaction questionnaires (8).

In the ProLong study (9), caesarean section appeared to confer greater protection against pelvic organ prolapse compared to urinary incontinence. Exclusive caesarean section was associated with a reduced risk of objectively measured signs of prolapse at the 12-year follow up [vaginal delivery 29% versus caesarean delivery 5% OR 0.11; 95% CI 0.03-0.38]. Symptoms of prolapse 20 years after delivery in SWEPOP study (10) were similarly associated with mode of delivery [vaginal delivery 14.6% versus caesarean delivery 6.3% OR 2.55; 95% CI 1.98-3.28]. Both studies showed older maternal age at first birth and higher parity to be risk factors for pelvic organ prolapse.

The development of functional imaging has revolutionised our understanding of the pelvic floor during and after birth. The levator ani muscle plays a major role in childbirth, as it is the most substantial soft tissue structure defining the dimensions and biomechanical properties of the birth canal. With modern imaging, the diagnosis of levator avulsion can be accurately obtained by 3D/4D translabial and transperineal ultrasound, endovaginal ultrasound or magnetic resonance imaging [MRI] (11)(12).

There is growing evidence of the anatomic significance of levator ani in maintaining pelvic floor function. Levator avulsion in particular is associated with pelvic organ prolapse and prolapse recurrence. Levator ani injuries sustained during childbirth at least may partly explain the missing link between vaginal delivery and pelvic organ prolapse. There is a paucity of data on the long-term relationship between obstetric factors with levator ani injuries (13).

At present there is little published information on the natural history of postpartum pelvic floor dysfunction, nor of the long-term relationship with obstetric practice. Many publications have shown that pelvic floor dysfunction is more prevalent among women who have delivered at least one child. (14) This is further emphasized in at least two studies of twin pregnancies that showed despite the similar genetic background the parous twin sister has a three to four times higher risk of developing pelvic floor dysfunction (15) (16).

Our study examines the relationship between obstetric history and the clinical and ultrasound diagnosis of levator avulsion and damage to the anal sphincter 20 years after delivery in the Dunedin arm of the ProLong study. The relationship of these ultrasound parameters will also be compared with the symptoms and signs of pelvic floor dysfunction.
2. LITERATURE REVIEW

To examine what is already known in this area, the following literature review was carried out.

The literature search was performed using OVID interface accessing databases including MEDLINE, Pre-MEDLINE, EBM Reviews, Cochrane Database of Systematic Reviews, CINAHL and EMBASE. Search was limited to humans and English publications and from year 2000 to ‘current’.

Keywords of pelvic floor trauma, urinary incontinence, anal incontinence, faecal incontinence, pelvic organ prolapse, sexual dysfunction, pregnancy, delivery, childbirth, levator ani muscle injury, levator avulsion, prevention of levator ani injury, were used for conducting the search. In addition, these documents were hand searched for additional citations.

Studies and abstracts included in the review were published in peer-reviewed journal issues. The papers were analysed according to the quality of evidence with the descending hierarchical influence of: systematic reviews and meta-analysis of randomised controlled trials, randomised controlled studies, non-randomised cohort studies, case control studies, case series and expert opinion.

2.1. Prevalence and Costs of Pelvic Floor Dysfunction

Pelvic floor disorders are very common and strongly associated with aging, pregnancy, parity and instrumental delivery. The prevalence of all types of self-reported urinary incontinence is 35.3% in a cross sectional survey including ages 15-97 years, with reported prevalence of up to 51.9% in women aged 70-74 years (2). Pregnancy beyond 20 weeks, regardless of the mode of delivery, greatly increased the prevalence of major pelvic floor dysfunction (2).

The prevalence of pelvic organ prolapse based on a sensation of a mass bulging into the vagina was fairly consistent, ranging between 5 and 10% (2) (17) (18) (19). A higher prevalence of 23% was recorded in a study including, in the definition of pelvic organ prolapse, pelvic heaviness or digital pressure on the perineum or in the vagina to aid with defaecation (20).

The prevalence of anal incontinence is likely around 2-5% for community-dwelling persons and may rise with increasing age to greater than 10%, among nursing home residents the prevalence approaches 50% (21). A meta-analysis stated 77-83% [depending on parity] of anal incontinence in parous women was due to anal sphincter disruption after vaginal delivery. However, the Cochrane Review involving seven studies has shown a lack of protective effect of caesarean section on anal incontinence (7).

The lifetime risk of undergoing a single operation for prolapse or incontinence by the age of 80 years in the USA is 11% (22) (23), with a reoperation rate of 30%. Over 225,000 women underwent prolapse operations in the USA, resulting in an annual expenditure of over US $1 billion, making this one of the most common indications for surgery in women (22). The financial burden of these disorders includes both direct [routine care, medical visits and medical treatments] and indirect [loss of productivity] costs.
In addition, with the aging population, prevalence of prolapse and continence surgery numbers are likely to increase substantially. Therefore not only does this have significant cost implications for health services throughout the world, but it also has a significant effect on the quality of life for a large number of women. Consequently, it is of great importance to identify possible aetiological factors with a view to subsequent prevention or reduction of its impact.

2.2. Pelvic Floor Dysfunction and Mode of Delivery

Despite the great achievements made in modern obstetric practice in developed countries during the last 100 years, delivery remains the most stressful event the female pelvic floor is submitted to during a woman’s lifespan.

During pregnancy, muscular, connective and nervous pelvic structures are subjected to anatomical, morphological, functional and hormonal changes. During vaginal delivery, the pelvic floor further undergoes an enormous amount of stretching to allow the passage of the newborn through it.

Childbearing is the most significant predisposing factor for many aspects of pelvic floor dysfunction in women, although there is ongoing debate as to whether it is caused by pregnancy or delivery (4) (24) (18) (25). There is also no consensus on reducing this risk and evidence is conflicting where this condition can be prevented or alleviated by aspects of obstetric practice, in particular caesarean section.

Modern imaging techniques of 3D/4D ultrasound and MRI have shown that trauma and avulsion, in particular, to the levator ani muscle, have been reported in 20-40% of primipara. Damage to the pudendal nerve and endo pelvic fascia have also been described with vaginal birth (13).

The growing knowledge of the consequences of childbirth and pregnancy on the pelvic floor, offers the chance to develop prevention and treatment strategies. It is important that contributing obstetric factors are identified and their occurrence minimised, in order to focus efforts on preventable risk factors (3).

2.2.1. Urinary Incontinence

The International Urogynecology Association [IUGA] and International Continence Society [ICS] jointly define urinary incontinence as the ‘complaint of involuntary loss of urine’ (1).

Urinary continence is sustained by bladder pressure remaining lower than urethral closure pressure; urinary incontinence may result from bladder or urethral impairment, when closure pressure is lower than bladder pressure, leakage occurs. Three types of incontinence are generally distinguished: stress urinary incontinence, urge urinary incontinence and mixed urinary incontinence, which is a combination of stress and urge urinary incontinence (26).
The pathophysiology of urge urinary incontinence has yet to be clearly elucidated. It appears to be connected with poor transmission or processing of information between the bladder and the nervous system. The main identified disorders with regard to stress urinary incontinence are impaired urethral support and sphincter deficiency (27).

The aetiology of urinary incontinence is likely multifactorial, but obesity and ageing, as well as obstetric trauma during childbirth, are known to be three of the most important risk factors (28).

In the ProLong study, at the 12 year follow up, women who delivered exclusively by caesarean section were less likely to have urinary incontinence in comparison to women who delivered vaginally [vaginal delivery 55% versus caesarean 40%, OR 0.46, 95% CI 0.37–0.58], but not if they had a combination of caesarean and spontaneous vaginal births (5).

A similar reduction was seen at 20 years after delivery in the Swedish National Survey of pelvic floor dysfunction, the SWEdish Pregnancy Obesity Pelvic floor [SWEPOP] study. This involved just over 5000 primiparous women who delivered in 1985–88 with no further births and returned a questionnaire in 2008. In that study, the prevalence of urinary incontinence after vaginal delivery was 40.3% in comparison to delivering by caesarean section, which was 28.8% [OR 0.60, 95% CI 0.52–0.69] (6).

Both studies showed that there was no difference with an emergency or elective caesarean section. Other risk factors for urinary incontinence are older maternal age at first birth, having four or more babies and higher BMI. Age at delivery increased the urinary incontinence risk by 3% annually, and there was an 8% increased risk of urinary incontinence per current BMI unit in the SWEPOP study. Increased infant birth weight, ≥4500g, by vaginal delivery is also associated with a significant risk of urinary incontinence. (6)

However, the difference in prevalence of urinary incontinence attributed to mode of delivery may diminish in older women. In a large cross-sectional Norwegian study [EPICONT], parity was most notably associated with urinary incontinence in young women between the ages of 20 and 34 years [Risk Ratio (RR) 2.2, 95% CI 1.8–2.6], but this association disappears in postmenopausal women older than 65 years. In the large Swedish population-based cohort study (25), the incidence rates for stress urinary incontinence surgery also shows a steady increase with age [Figure 1], however, the rate of increase with age appears more blunted in the exclusive caesarean section group.

Exclusive caesarean section delivery would appear to offer only partial protection for urinary incontinence, as 40% of these women still report incontinence in the 12 year follow up of the ProLong study, suggesting a significant pregnancy effect. (5).
Anal Incontinence

Anal incontinence can be socially crippling and have a dramatic influence on the quality of life for many women. One of the difficulties in a literature review is comparing studies using varying definitions of incontinence.

The International Urogynecology Association [IUGA] and International Continence Society [ICS] (1) defines anal incontinence as ‘complaint of involuntary loss of faeces or flatus’. Faecal incontinence on the other hand describes ‘complaint of involuntary or loss of faeces (including liquid, solid, passive, and coital)’ and flatus incontinence as ‘involuntary loss of flatus’. Some studies also included mucoid discharge into these definitions (29).

De-novo anal incontinence symptoms after childbirth are reported in up to 26-38% of women between 6 weeks-6 months postpartum (30) (31) (32) (33) (34) (35). Childbirth has been associated with the development of anal incontinence, and is thought by some to be the principal inciting factor (29) (36) (37).

Anal incontinence in the postpartum is multifactorial. Mechanisms include muscular damage from either direct trauma or ischaemic damage and pudendal nerve damage. Direct trauma and laceration of the anal sphincter complicates 2–16% of vaginal deliveries (38) (39). Injury to the anal sphincter with third- or fourth- degree laceration, even with recognition and repair, is strongly associated with anal incontinence.

However, any protection offered by caesarean delivery may be short term [while the vagina is healing] and wane over time. The most convincing evidence so far comes from a Cochrane review and large-scale epidemiological studies, which suggest there is no significant difference between caesarean section and vaginal delivery beyond 4 months (7).

Figure 1 Incidence rates of stress urinary incontinence surgery in relation to mode of delivery and time since first childbirth (25)
Forceps delivery appears to be a risk factor for persistent faecal incontinence [defined as loss of control of bowel motion occurring with any level of frequency]. One or more forceps delivery would appear to be a significant risk factor for persistent faecal incontinence (OR 2.08, 95% CI 1.53-2.85) (5).

Other modifiable factors such as prolonged second stage, increased BMI, and constipation have been demonstrated as independent risk factors of postpartum faecal incontinence (40) (41) (42). These factors should be taken into consideration when counselling women in relation to obstetric practice. Focus should be on methods to identify women at risk, prevention and effective management of anal sphincter injury (41).

2.2.2.1. Diagnosis of Trauma to Anal Sphincter

Obstetric anal sphincter injuries [OASIS] are considered important risk factors for faecal incontinence. Injuries to the anal sphincter are commonly identified among women with anal incontinence in later life. A meta-analysis of 717 vaginal deliveries showed an incidence of anal sphincter defects of 26.9% in primiparous women on endo-anal ultrasound. Of such defects, 87% were undiagnosed clinically. This may be due to missed diagnosis or clinically occult trauma (43). This highlights the importance of imaging as clinical findings are often limited.

Endo-anal ultrasound is considered the gold standard of anal sphincter evaluation (44) (45). However, this technique can be perceived as invasive, involving the insertion of the ultrasound probe into the anal canal. The anal ultrasound probe can also distort anatomy and bias dynamic evaluation of the sphincter and mucosa on sphincter contraction. These issues probably hamper its routine use in clinical practice (45).

Exo-anal or transperineal ultrasound on the other hand, bypasses the above mentioned barriers towards traditional endo-anal ultrasound while offering the additional advantages of combined imaging of other pelvic floor structures including the the levator ani muscles (46) (47).

In a recent study of 55 women comparing 3D transperineal ultrasound and 2D endo-anal ultrasound in the detection of anal sphincter defects, there has been good agreement between the two techniques [Cohen’s kappa coefficient for external anal sphincter was 0.63 and for the internal sphincter was 0.78] (46).

2.2.3. Pelvic Organ Prolapse

Pelvic organ prolapse is defined as the descent of the pelvic organs resulting in protrusion of the vagina, uterus, or both (48). It is thought that 50% of parous women will have some degree of prolapse (49), although objective prolapse severity is weakly correlated with symptom burden (50). Significant prolapse beyond the hymen [Pelvic Organ Prolapse-Quantified (POP-Q) Stage ≥2b] is associated with an increase in symptoms (51). A woman’s lifetime risk of surgery for pelvic organ prolapse is as high as 19% (52); an estimated 13% of patients who have surgery will need repeat surgery within 5 years (48).
The cause of pelvic organ prolapse is likely to be multifactorial. Vaginal childbirth, advancing age and increasing BMI are the most consistent risk factors, with vaginal birth being the one most frequently associated with prolapse (48). Vaginal childbirth, particularly operative vaginal delivery, increases the risk of POP-Q Stage ≥2 (24). The occurrence rate of pelvic organ prolapse stage ≥2 in the first 3-6 months post vaginal birth has been described in between 18.1-56% (49), compared with 7% of women who had caesarean birth (53).

In the large population-based cohort Swedish study [Figure 2] (25), an increased incidence for prolapse surgery after vaginal delivery was found, reaching its peak close to three decades after first delivery at 27 cases per 10,000 person-years. Conversely, for exclusive caesarean delivery, the incidence rate showed little variation over time, starting to notably diverge from the vaginal delivery cohort around 10 years after first birth and remained around 1-2 cases per 10,000 person-years throughout the observational period (25).

With modern functional imaging techniques such as magnetic resonance and 3D/4D ultrasound, identification of pelvic floor trauma following childbirth, particularly of injuries sustained during delivery to the levator ani muscles has become a hot topic. Levator ani trauma may be one factor to account for the missing link between childbirth and prolapse and carries great implications for obstetric practice and potential impact on future treatment modality. This important aspect will be explored in greater detail under Section 2.3 Levator Ani and Pelvic Floor Trauma from Child Birth.

The majority of studies in the literature demonstrate a relationship between vaginal parity and the development of pelvic organ prolapse. Several studies support that the actual mode of delivery is more pivotal than the process of labour with little difference seen in acute versus elective caesarean section delivery (24) (54).

In the ProLong Study at the 12 year follow up, exclusive caesarean section was associated with a reduced risk of objectively measured prolapse [vaginal delivery 29% versus caesarean section 5%, OR 0.11, 95% CI 0.03-0.38] (9). In the SWEPOP study caesarean section was associated with fewer symptoms of prolapse [vaginal delivery 14.6% versus caesarean 6.3%, OR 0.39, 95% CI 0.30-0.51] (10).

In women aged over 30 years at first delivery, having increased BMI and having one or more forceps deliveries were associated with higher symptomatic pelvic organ prolapse (9). In the SWEPOP study, symptomatic prolapse increased 3% with each unit increase of current BMI and by 3% with each 100g increase of infant birth weight. Short maternal stature ≤160cm in conjunction with infant birth weight ≥4000g after vaginal delivery had a nearly double prevalence of symptomatic prolapse [24.2% versus 13.4%, OR 2.06, 95% CI 1.19-3.55]; however the effect of birth weight was not observed in women >160cm (10). Increased parity is strongly associated with a higher risk of requiring surgery for symptomatic prolapse (55).

Other factors such as history of conditions of deficient connective tissue, family history of prolapse, heavy lifting at work, presence of constipation, hard stools, or difficult evacuation are reported to be linked independently, positively to the presence of symptomatic prolapse (56).
The effects of parity and mode of delivery should be differentiated with long-term prospective studies to provide the data that are necessary to quantify the excess risk of pelvic floor dysfunction that can be attributed to vaginal delivery. Caesarean delivery itself cannot reverse all other risk factors for prolapse, although delivery exclusively by caesarean section has a significantly reduced risk of objectively measured prolapse 12 years after delivery (9) and reduced symptoms by 20 years (10). Thus maternal request for elective caesarean section after careful counselling has been acknowledged in the updated UK’s National Institute for Health and Care Excellence [NICE] recommendation (57) (58). Future focus needs to be placed on identifying women at risk, and tailoring preventive and curative interventions.

![Figure 2](image.png)

Figure 2 Incidence rates of pelvic organ prolapse surgery in relation to mode of delivery and time since first childbirth (25)

2.2.4. Sexual Dysfunction

Research surrounding sexual dysfunction and obstetric history is complicated with varying definitions of sexual dysfunction, lack of randomised controlled trials, differences in outcome measured and multiple confounding factors. The American Foundation for Urologic Disease recognises four types of female sexual dysfunction: low libido, problems with sexual arousal, inability to achieve orgasm, and dyspareunia (59).

Postpartum sexual function may be influenced by many significant changes in anatomy, hormonal environment, family structure and partner relationships that accompany childbirth (60). Anatomically, perineal trauma may contribute to dyspareunia and has important effects on both the timing and quality of the resumption of sexual relations during the initial postpartum months. Breast feeding may affect sexual function as a result of vaginal dryness caused by the high levels of prolactin and reduced oestrogen levels. Family structure and changing sleep patterns decrease the likelihood of the woman and her sexual partner having the time and privacy to re-establish intimacy. Cultural and societal expectations regarding resumption of sexual activity may influence individual couples.
Postpartum depression with accompanying loss of sexual desires or secondary loss of function due to antidepressant medications may also contribute to postpartum sexual dysfunction (60).

Perineal pain is the most common obstetric complaint in the immediate postpartum (61). It is thought that sexual dysfunction in the short and longer term postpartum may result from childbirth impacting on the muscles and nerves of the pelvic floor (62). This may result in disturbed sensation, arousal or orgasm in women.

Whether or not caesarean deliveries may reduce postpartum female sexual dysfunction has been explored by numerous studies, with most of the current literature suggesting no significant difference between vaginal births and caesarean deliveries (63).

In the six-year ProLong follow up of 2765 women who completed the Golombok and Rust [Reference Inventory of Sexual Satisfaction] (64) women who suffered from urinary or faecal incontinence scored lower on all questions pertaining to sexual function. Type of delivery, however, appeared to have only a small effect, except that women having caesareans reported better vaginal tone than those having other types of delivery (8).

A recent prospective questionnaire based cohort study recruited 444 primigravid women, in the first trimester, and set out to investigate the effect of modes of delivery on sexual function at 12 months postpartum. At 12 months postpartum there was no difference in sexual function between the vaginal delivery and the caesarean section group. Decreased orgasm, however, remained significant at 12 months in women with episiotomy (65).

Although there are no specific RCTs exploring the topic, Hannah et al 2004 explored maternal outcomes 2 years postpartum for 917 women randomly assigned to vaginal births or caesarean deliveries for breech presentations. The authors found no difference in self-reported sexual problems between the groups (66). Whether or not this research can be generalised to vertex presentations is unknown.

To date there have been no Cochrane reviews, however a recent review article explored papers on postpartum sexual dysfunction in women (63). The meta-analysis found that episiotomy was a risk factor for short-term sexual dysfunction, however there was little evidence to demonstrate caesarean deliveries would reduce sexual dysfunction postpartum. Limitations of this study are its reliance on data from observational studies (63).

Despite the findings mentioned above, some studies have demonstrated a difference between mode of delivery and sexual dysfunction. However, the literature is far less compelling. Safarinejad et al. explored sexual function in 912 women and their partners in the 8 weeks postpartum. Results demonstrated lower rates of sexual function in women with assisted and spontaneous vaginal delivery, compared to elective caesarean delivery (67). This result is not unsurprising, however, given the pelvic floor would still be healing at 8 weeks and families would be adjusting to the inclusion of a new child. A major limitation of this study is the short follow up time.

Handa et al concluded that sexual function is worse in women with symptomatic prolapse but not in women with asymptomatic prolapse (68). Pelvic floor symptoms are significantly associated with reduced sexual arousal, infrequent orgasm, and dyspareunia.
The odds of infrequent orgasm were increased more than three times for women with a stage 3-4 prolapse \([p=0.02]\) (68). Interestingly women with anatomical stage 2 descent were not more likely to report any sexual complaint than women with stage 0 support; in contrast, in women with prolapse symptoms [as related by a high score on the prolapse scale of the Pelvic Floor Distress Inventory] were more likely to report sexual complaint (68).

In summary [Table 1], the overall literature suggests there is no significant difference between female sexual function and spontaneous vaginal delivery or elective caesarean delivery in the long term. There may be some difference in the short term while any insult to the perineum heals, however this does not appear to be significant in the longer run. Women who have more significant trauma to the pelvic floor, poor perceptions of their birthing experience and those who suffer from urinary or anal incontinence have significantly reduced sexual function compared to those who have uncomplicated caesarean delivery or vaginal delivery. Focus of research should turn to identifying women at risk of sustaining perineal trauma during vaginal delivery, and methods of prevention and treatment.

Table 1  Conclusions of main epidemiological studies to date

<table>
<thead>
<tr>
<th>Urinary Incontinence</th>
<th>Faecal Incontinence</th>
<th>Prolapse</th>
<th>Sexual Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>The proportion of women who experience urinary incontinence increases from around a third soon after delivery to over half 12 years later.</td>
<td>The risk of long-term faecal incontinence is significantly higher after having had one or more forceps deliveries.</td>
<td>Stage 2 prolapse is 'normal' for parous women. Exclusive caesarean delivery significantly reduces risk of objectively measured prolapse 12 years after delivery and a reduced risk of symptoms by 20 years.</td>
<td>Minimal effect of mode of delivery on sexual satisfaction. Urinary or faecally incontinent women scored worse than continent women for all sexual satisfaction questions.</td>
</tr>
<tr>
<td>Partial protection from delivery by caesarean section exclusively, but prevalence is still high. Effect is diminished in older women.</td>
<td>No evidence of a reduced likelihood of long-term faecal incontinence for women who had delivered exclusively by caesarean section.</td>
<td>Having a first baby at over 30 years of age increases risk of prolapse. Second and subsequent babies increase risk of prolapse.</td>
<td></td>
</tr>
<tr>
<td>No difference between elective and emergency caesarean sections.</td>
<td></td>
<td>Women having only vaginal deliveries, in particular, forceps delivery, have an increased risk of prolapse surgery.</td>
<td></td>
</tr>
<tr>
<td>Protection is lost with a subsequent vaginal delivery.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other risk factors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Older maternal age at first birth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Having four or more babies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Higher BMI</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3. Levator Ani and Pelvic Floor Trauma from Child Birth

The pubococcygeus-puborectalis complex of levator ani forms the clinically relevant “pelvic floor muscle” responsible for anatomical support. This V-shaped muscle complex originating on the inferior pubic rami and surrounding the anorectal angle posteriorly, marks the most substantial soft tissue structure defining the biomechanical properties of the birth canal. The levator hiatus, which is the space between the arms of the V-shaped sling, contains some of the most important structures maintaining pelvic functions – the urethra anteriorly, the vagina centrally and the anorectum posteriorly (13).

During vaginal delivery, this musculature undergoes a substantial distension of as much as a three-fold increase in muscle stretch (69). It has been shown that in passive muscles single stretches of 50% are necessary to produce significant injury and skeletal muscle will not stretch to greater than twice its length without tearing (70). It is thus surprising that around half of women suffer no discernible change in the distensibility or morphological appearance after vaginal birth, which may be due to hormonal influence.

Prospective studies have shown that macroscopic injuries to levator ani occur in 13-36% of women who delivery vaginally (71) (72) (73) (74). In high risk groups such as forceps delivery, levator ani injuries can be detected in 64% using 3D translabial/transperineal ultrasound (75) and 66% by MRI (76).

There are numerous definitions of levator ani injuries depending on the mode of assessment; namely clinical palpation, ultrasonography and MRI. Comparison between these studies can be difficult particularly due to a lack of consistency in the definition and classification of levator ani injuries.

Although it is widely believed that nulliparous women do not have levator injuries (77), a study comparing MRI of nulliparous and primiparous women found levator ani abnormalities in 18% of nulliparous women (78). This is supported by another study where the origin of the levator ani from the pubic bone was not visible bilaterally in 10% and absent unilaterally in 10% of nulliparous women (79). This could be the result of technical limitations or a reflection of the anatomic variation of levator ani insertion.

2.3.1. Risk factors for levator ani injuries

It is generally agreed that forceps delivery is one of the main risk factors for levator ani injuries (13). DeLancey et al showed that forceps delivery leads to an adjusted odds ratio of 3.4, while Kearney et al demonstrated an odds ratio of 14.7 (80). Using transperineal ultrasound, levator ani injuries have been demonstrated in 35% to 64% of women after forceps delivery (75).

Vacuum extraction does not appear to be a risk factor (76). There is evidence that a prolonged second stage of labour is associated with damage to the levator ani muscles (71) (81) (73) (72). One study reported women with levator ani injuries have a 78min longer second stage of labour (82). Another study reported an odds ratio of 2.27 for levator
injuries when the second stage was >110min (71). Fetal head circumference appears to be an independent risk factor -- in one study when the head circumference was greater than 35.5cm, the odds ratio for levator injury increased to 3.34 (71). In contrast, another study found no association between fetal head circumference and levator ani muscle injury (80).

Epidural analgesia has been shown to be protective against levator ani injury (73). There is evidence for increased maternal age at first delivery being associated with levator muscle injury, although no association was found by others (80) (83). The role of maternal BMI remains unclear. Shek et al found women with a lower BMI had a greater risk of sustaining levator ani injury but the clinic significance is questionable as the BMI was 27.85 versus 30.01 (73).

There may be racial variation in levator ani volume. Hoyte et al. found a significantly greater levator ani volume among African American women compared with White American (84). Furthermore, the puborectalis attachment was closer to the symphysis in African American than in White American women and concluded that this may protect African American women against pelvic floor dysfunction. However, this study had a small sample size of 12 and 10 respectively (84). In a larger study [n=234] found no racial differences in levator ani thickness but found African American women who delivered with intact anal sphincter had more pelvic floor mobility (85).

2.3.2. Pelvic Floor Dysfunction and Levator Ani Injuries

2.3.2.1. Pelvic Muscle Strength

Pelvic floor muscle strength can be measured, e.g. using the Oxford grading (86) (87) (88), transperineal ultrasound imagining (89) and perineometry (90). Steensma et al found that underactive pelvic floor muscle strength (defined as absent or weak pelvic floor muscle contraction on ultrasonography resulting in no or only minimal changes in the reduction of the levator hiatus) occurred more often in patients with an avulsion injury (89). Levator ani muscle injuries were present in 53.8% with underactive pelvic floor muscle strength compared to 16.1% with a normal pelvic floor muscle contraction. This finding is consistent with another study (86), in which women with levator avulsion had lower Oxford grading scores.

2.3.2.2. Stress Urinary Incontinence

The relationship between levator ani injury and stress urinary incontinence is controversial. Women suffering from stress urinary incontinence have been shown to be twice as likely to have a levator injury (77) and those levator ani injuries worsened postpartum (72). DeLancey et al (27) on the other hand found no relationship with levator ani muscle injuries while others have found a negative relationship (91) (92).

Morgan et al found that women with major levator ani defects were less likely to experience stress urinary incontinence whereas the risk increased in those with minor
levator ani defects [OR 0.27 versus 3.1]. Furthermore, they found an increased risk of urge urinary incontinence in the minor levator ani defects group [OR 4.0] (93).

2.3.2.3. Anal Incontinence

There appears to be a relationship between levator ani defects and older women with faecal incontinence (94), highlighting the importance of an adequately functioning external anal sphincter as well as levator ani (95). This concurs with another case control study in which more puborectalis muscle abnormalities [as identified by transperineal 3D ultrasound] were seen in faecal incontinent cases compared to controls (96). In contrast to this, Chantarasorn et al did not find an association between levator ani defects and faecal incontinence (97). However, data on anal sphincter injury was not available in their study, which might explain this surprising result (97).

2.3.2.4. Pelvic Organ Prolapse

It has been established that levator ani injuries increase the risk of pelvic organ prolapse (98). Levator avulsion appears to double the risk of significant anterior and central compartment prolapse with less effect on posterior compartment prolapse (86). There is a direct correlation between the size of the defect and the symptoms and/or signs of prolapse (99) and women with bilateral avulsion are more likely to suffer from uterine prolapse (86). It is unclear why all women with levator ani injuries do not develop prolapse.

In a case-control study of 151 women with pelvic organ prolapse and 135 controls with normal support, DeLancey et al found an adjusted odds ratio of 7.3 [95% CI 3.9-13.6, p<0.001] for a major levator ani muscle defect, but an equal number for minor defects (98). Both short-term operative results and risks of recurrence of prolapse [cystocele] are worse after an operation in women with major levator ani defects (100) (101) (102). Another study (103) reported a similar finding of an OR of 5.99 for greater than stage 2 POP-Q after hysterectomy, an OR of 4.35 after incontinence or prolapse surgery, an OR of 3.37 after anterior repair and 4.33 after colposuspension. Increased hiatal area is again associated with vaginal delivery, particularly in women with altered levator ani integrity (104).

2.3.3. Diagnosis of Levator Ani Injury

2.3.3.1. Clinical Examination

Acute levator ani injuries can be diagnosed clinically by direct visualisation and digital examination when associated with a large vaginal tear (105). Chronic detachment of the levator ani from the inferior ramus of the pubic bone can be evaluated by palpation (105).

To palpate levator muscles, the index finger is placed parallel to the urethra, with the tip of the finger at the bladder neck, and its palmar surface adjacent to the posterior/dorsal surface of the os pubis. An intact muscle leaves just enough room to fit the palpating finger between the urethra medially and insertion of the puborectalis muscle laterally. If there is no muscle palpable and if this finger can be moved over the inferior pubic ramus without
encountering muscle for 2-3cm, then a diagnosis of levator avulsion is made. Palpation should be made at rest and during contraction to aid identification of muscle bulk. Poor contraction strength can alert the examiner to an increased likelihood of avulsion (106).

Avulsion can also cause asymmetry of the hiatus on inspection (107). On Valsalva, the anus and perineum are displaced towards the intact side, pushed by a prolapse descending on the side with avulsion. On pelvic floor muscle contraction, perineum and anus are pulled by the contralateral intact muscle, again resulting in displacement towards the undamaged side (11) (107).

The extent of avulsion varies and there are several types of incomplete injuries such as thinning, partial avulsion of either inferior or cranial aspects of the muscle palpable as a hole, slit or gap in the continuity of the structure. Some advocate a schematic visual recording system for findings to also include strength grading and resting tone bilaterally (13).

There is good, blinded, correlation of palpation and translabial/transperineal ultrasound assessment ranging between good, moderate and poor (86) (105) (108). Interobserver correlation between palpations by different observers also reveals moderate correlation. Whilst avulsion is most commonly diagnosed by tomographic ultrasound or MRI, diagnosis by palpation can very likely be as valid as imaging (13).

2.3.3.2. Diagnosis by Ultrasound Imaging

While MRI was historically the first method used to assess the levator ani, it is more costly, less accessible and limited by other issues such as ferrous implants, patient claustrophobia and the lack of dynamic imaging capabilities and correct plane of definition. Ultrasound on the other hand is less restricted by these factors (13).

3D/4D translabial/transperineal ultrasound using the GE Voluson system with 8-4 MHZ curved array volume transducer [with an acquisition angle up to 85 degrees] is popular for diagnosing levator ani injuries. Women are examined in the supine position after emptying the bladder. Volume acquisition is performed at rest, on maximum Valsalva and on maximal pelvic floor contraction (109).

Hiatal anteroposterior and coronal diameters, circumference and areas are measured at the plane of minimal hiatal dimensions as defined in the midsagittal plane, evident as the minimal distance between the hyperechogenic posterior aspect of the symphysis pubis and the hyperechogenic anterior boarder of the levator ani just posterior to the anorectal angle (11). Tomographic ultrasound images with slices obtained in the axial plane at 2.5mm slice intervals, from 5mm below the plane of minimal hiatal dimensions to 12.5mm above and rendered volumes are used to diagnose levator avulsion (13).

The importance of establishing the diagnostic accuracy of vaginal assessment and ultrasound assessment against the reference standard of MRI is highlighted in a protocol for a Cochrane Diagnostic Test Accuracy systematic review that is currently underway (110). (see also 2.3.3.4 Comparison of MRI and Ultrasound)

2.3.3.3. Diagnosis by MRI
Using MRI 16% of patients complaining of stress urinary incontinence and/or prolapse have been shown to have defects in the pubovisceral portion of the levator ani muscle (111). In addition a missing connection of the levator ani at the symphysis pubis has been demonstrated in 20% of asymptomatic nullipara. There is a 2-3 fold inter-individual difference in levator ani morphometry (79).

Labour itself probably adversely affects pelvic floor muscles independent of fetal head crowning as Novellas et al found a 2.7 fold increase in abnormalities among women delivered by caesarean sections in labour compared with those scheduled prior to onset of labour (112). The abnormalities were seen as hypersignal of the puborectalis more than that of iliococcygeus and a change in the orientation of iliococcygeus from convex to flat or concave in the early postpartum period. Another study (77) found similar results in which most of the trauma was identified in the pubovisceral portion rather than the iliococcygeus part of the levator ani muscles. Furthermore, those who sustained injuries of the puborectalis and iliococcygeous did not recover by six months after delivery where as those with isolated damage to the puborectalis recovered. Moreover, white primiparous women who were younger than 30 years of age had a better recovery at 6 months when compared to those older than 30 years. However, larger sample sizes are needed to confirm these findings (78).

2.3.3.4. Comparison of MRI and Ultrasound

Very few comparative studies exist that utilise MRI and 3D translabial/transperineal ultrasound to detect levator injuries.

Majida et al used 18 female volunteers to compare biometric measurements of the pubovisceral muscle at rest. They found very good agreement with interclass correlation coefficients [0.80-0.97] and concluded that 3D translabial/transperineal ultrasound scans could be used instead of MRI for evaluation of static pelvic floor anatomy in women without prolapse at rest (113).

A study of 27 asymptomatic nulliparous women compared biometric measurements of the pelvic floor using 3D transperineal ultrasound and MRI (114). Kruger et al (114) defined the plane of minimal hiatal dimensions on ultrasound according to Dietz (115) with a comparable definition used for MRI. Moderate to substantial agreement between the two methods for all parameters except for hiatal area on Valsalva was found. It was concluded that this was the result of difficulties of identifying the plane of minimal hiatal dimensions on MRI due to poorer temporal resolution compared with ultrasound imaging (114).

Although either of the imaging modalities are able to detect levator ani injuries, there is a substantial learning curve in performing and interpreting images. More comparative studies of MRI and 3D/4D ultrasound on the same patients are awaited. There is currently a protocol for a Cochrane Diagnostic Test Accuracy systematic review, aiming to determine the diagnostic accuracy of MRI, ultrasound and vaginal assessment of major levator ani muscle avulsion; the group’s finding will be of great interest (110).

2.3.4. Prevention of Levator Ani injuries
Pelvic organ prolapse is a common condition, which is found in up to 41% of women between 50 to 79 years of age and is one of the most common indications for gynaecological surgery (48). The strong associations between pelvic organ prolapse and obstetric levator ani injuries should encourage the obstetric care providers to identify and institute preventive strategies (109).

Forceps delivery is a known risk factor for levator ani injuries. Its use should thus be restricted. Forceps [as opposed to vacuum extraction] is a modifiable risk factor for both levator avulsion and anal sphincter injury and should be avoided where possible (13).

It has been suggested that during instrumental delivery, the rate of pelvic muscle stretch and delivery of the head should be gradual (116). However a recent multicentre prospective RCT of 660 participants did not find any evidence for a protective effect of the antenatal vaginal balloon device, the Epi-No, on pelvic floor structures in primiparae giving birth at term after uncomplicated pregnancies (117). An epidural may exert a protective effect (118).

As levator avulsion and obstetric sphincter trauma are exclusively caused by vaginal childbirth, elective caesarean delivery would be expected to completely prevent such trauma. However, caesarean section has other potential disadvantages for both mother and infant, thus other forms of preventive measures need to be investigated and verified in randomised controlled trials (13).

**Conclusion:**

Prospective studies have shown that levator ani injuries occur in 13-36% of women who deliver vaginally. Levator ani injuries increase the risk of cystocele and uterine prolapse but its relationship to posterior wall prolapse, faecal and urinary incontinence is less clear. Although it is possible to detect levator ani injuries with MRI and 3D/4D ultrasound, there is a substantial learning curve in performing and interpreting images. Further, the numerous definitions of levator ani injury make it difficult to perform comparisons and draw conclusions. Further research should focus on risk factors identification and preventive measures.
3. STUDY OBJECTIVES

The main research objectives were:

1. To examine the relationship of obstetrical factors with levator avulsion and OASIS diagnosed by transperineal ultrasound in a cohort of women 20 years after index delivery.
2. To examine the relationship of levator avulsion and OASIS with symptoms and signs of pelvic floor dysfunction in this group of women.
3. To determine the diagnostic performance of digital palpation of avulsion compared to tomographic translabial/transperineal ultrasound.
4. METHODS

4.1. Study Design

This is a longitudinal cohort study involving the women in the Dunedin arm of the ProLong study, who delivered 20 years ago at Queen Mary Maternity Centre. Questionnaires were sent to all women delivering between October 1993 and December 1994 [These deliveries were the “index” births]. Excluded were those women who requested no further contact and those who had died.

Enquiry was made about symptoms of pelvic floor dysfunction [urinary incontinence, faecal incontinence, pelvic organ prolapse] and sexual dysfunction. Details of any subsequent pregnancy and delivery were also ascertained. The obstetric and maternal data from the index birth had been obtained from the hospital case notes and had been computerised.

If the first questionnaire was not returned a second was sent. The electoral roll and telephone directories were searched and letters written to “contact persons” from the previous ProLong questionnaires requesting addresses of non-respondents.

All women were also invited to have a translabial and transperineal 3D/4D ultrasound to assess levator ani integrity, pelvic organ descent and anal sphincter complex and to have a clinical prolapse assessment carried out [POP-Q, Pelvic Organ Prolapse – Quantified].

The women in this study were those who returned questionnaires and consented to have both the ultrasound and clinical prolapse assessment carried out.

The study was approved by Health and Disability Ethics Committee [HDEC], approval number LRS/05/04/009/AM01.

4.1.1. Study Questionnaires

Questions on pelvic floor dysfunction [urinary incontinence, faecal incontinence, pelvic organ prolapse] and performance of pelvic floor muscle exercise were those used in previous ProLong studies for consistency [Appendix A]. The questions were in accordance with the International Continence Society definitions (1).

Information was also recorded on the frequency, severity and impact on quality of life of these pelvic floor dysfunction symptoms. The SF12 was also included to assess generic health-related quality of life (119). This 12-item tool was included for consistency with the previous 12-year follow up ProLong study questionnaires (41).

A separate pull-out section of the questionnaire, on sexual function, was also sent out to eligible women. There were twelve questions based on The Pelvic Organ Prolapse/Urinary
Incontinence Sexual Questionnaire [PISQ] and its short form version, the PISQ-12 (120), the only currently validated condition-specific female sexual function questionnaires purposively developed to assess sexual function in women with urinary incontinence and/or pelvic organ prolapse. Scores were calculated by totalling the scores for each question with 0=never, 4= always. Reverse scoring was used for items 1, 2, 3 and 4. [Appendix B]
A further global quality and condition specific question [D16] from PISQ-IR [IUGA-Revised] was included. [Appendix B]. PISQ-IR published in 2013 and has been evaluated for internal consistency, validity and reliability (121).

Two further questions on vaginal tone were based on the Golombok Rust Inventory of Sexual Satisfaction [GRISS] related to sexual function (64) [Appendix B]. These were scored on a 5 point Likert scale [Not adequate = 1, Less than adequate = 2, Adequate = 3, More than adequate = 4, Very adequate = 5]. The GRISS score has demonstrated acceptable internal consistency and good reliability for vaginismus and vaginal tone (8).

The questionnaire data relating to delivery details and in particular the type of caesarean section and assisted delivery were compared with the hospital notes to assess the accuracy of the questionnaire data.

4.1.2. POP-Q assessments

The clinical examination including the POP-Q assessments was recorded using a standardised form [Appendix C].

POP-Q measurements (122) were obtained on maximal Valsalva with effort duration of at least 6 seconds, in order to achieve maximal pelvic organ descent. Pb and Gh lengths were measured at rest. For consistency with previous ProLong publications, we dichotomised leading edge Stage 2 prolapse into two categories: measurements above the hymen [<0cm, stage 2a], to indicate no prolapse, and measurements at the hymen or beyond [≥ 0cm, stage 2b], to indicate significant prolapse. The latter measure was also chosen to define objective anterior or posterior vaginal wall prolapse, or apical prolapse. (9)

Pelvic floor muscle strength was assessed using Modified Oxford Score (123) [Appendix D]. Pelvic muscle tone was assessed using the definitions in Deitz et al (13)[Appendix D].

Levator Ani integrity was also palpated bilaterally and recorded as Intact, Partial or Complete Avulsion. The examinations were performed by a single experienced operator [the main author] blinded to participant’s obstetric history.
4.1.3. Transperineal Ultrasound

All participants were further invited for a translabial and transperineal 3D/4D ultrasound for the assessment of levator ani integrity, pelvic organ descent and anal sphincter complex.

This was done using a GE Kretz E8 Expert [GE Medical Systems, Zipf, Austria], after bladder emptying, in the supine position, with the knees flexed and hips slightly abducted at rest and on maximum pelvic floor contraction and Valsalva as previously described (124). The volume acquisition angle was set to the system maximum of 85° to ensure visualisation of all three compartments. Levator ani co-activation on Valsalva manoeuvre was avoided with meticulous observation and patient education by visual biofeedback. At least three volume cine loops on Valsalva were acquired. The scanning was performed by a single experienced operator who was blinded to the patient’s obstetric history.

Off-line analysis of ultrasound data sets was undertaken at a later date on a desktop PC for pelvic organ descent, dimensions of levator hiatus and integrity of levator and anal sphincter complex using the proprietary software 4D View version 7.0 [GE Medical Systems] blinded against all clinical data.

The volume on maximum Valsalva manoeuvre resulting in the greatest degree of pelvic organ descent was used for analysis of the pelvic organ descent and hiatal area. Significant cystocoele on ultrasound was defined as bladder descent to 10mm or more below the symphysis pubis [SP], significant uterine descent to the level of SP and significant rectal ampulla descent to 15mm or more below the SP. A diagnosis of a true rectocoele, i.e. diverticulum of the rectal ampulla indicative of a defect in the rectovaginal septum [RVS] was made in the presence of a discontinuity in the anterior contour of internal anal sphincter and anterior anorectal muscularis (99) (125) (126).

Hiatal area was measured as previously described [Figure 3]. In brief, the plane of minimal hiatal dimensions was identified in the midsagittal orthogonal plane, where the distance between the hyperechogenic posterior aspect of the symphysis pubis and hyperechogenic anterior border of the levator ani muscle, just posterior to the anorectal muscularis, is shortest. Hiatal area was measured in rendered volumes of 1-2 cm thickness containing this plane of minimal hiatal dimensions (115) (12).
Figure 3  Determination of hiatal area. A: demonstrates the plane of minimal dimensions between the symphysis pubis (SP) and the levator ani in the midsagittal plane [arrows] in a volume obtained upon maximal Valsalva. A rendered volume of 1-2cm is placed at this level to measure hiatal area B: illustrates the levator hiatus in the axial plane, and outlined by the dotted line

The levator and anal sphincter complex integrity were assessed by tomographic ultrasound imaging, at maximum pelvic floor muscle contraction. Levator integrity was assessed as previously described (124), at a 2.5mm inter-slice interval. A ‘complete avulsion’ was defined as abnormal levator muscle insertion on the inferior pubic rami in all three central slices on translabial tomographic ultrasound [Figure 4].

Figure 4  “A” shows a translabial/transperineal tomographic ultrasound of intact levator ani. “B” shows a unilateral levator avulsion on the right on the 3 central slices [Slices 3, 4, 5 as marked by an *]

Significant OASIS [Figure 5] as defined as the presence of a defect of ≥30 degrees in the circumference of the external anal sphincter [EAS], in ≥ 4/6 slices on translabial/transperineal tomographic ultrasound, encompassing the entire EAS (47) (127) (128) (129).
4.2. Statistical Analysis

Returned questionnaires were checked, coded and computerised for analysis. For analysis purposes the variable delivery mode history was categorised into: spontaneous vaginal deliveries only [reference], caesarean section only, one or more forceps deliveries, one or more vacuum extractions without no forceps; and the remainder as a combination of only spontaneous vaginal deliveries and caesarean sections. The forceps and vacuum categories could include women who also had spontaneous vaginal deliveries or caesarean sections. Replies with missing values in the mode of delivery history were omitted from the analysis.

Univariate analyses followed by a logistic regression were carried out to assess the independent effects of delivery mode history on symptom outcome, examination and sonographic assessment of levator ani integrity and to adjust for and report on other independent predictors. All regression variables were included and retained in the models.

Subsidiary regression models to explore type of caesarean section and more severe symptoms were also undertaken. In all models, adjustment was made for age at first birth [<25/25-29/30-34/35+], total number of births [one/two/three/four or more], ethnic origin, and BMI [<18.5/18.5-24.9/25-29.9/30+/not available]. Replies with missing values in the other variables in the models were omitted from the analysis.

For outcome measures of urinary incontinence, women were asked, “Do you ever lose urine when you don’t mean to?” and if yes, “In the last month how often has this happened on average?”, with optional responses from less than twice a month to three or more times a day. More severe urinary incontinence was defined as that occurring at least weekly.
To assess faecal incontinence, women were asked, “Do you ever lose control of bowel motions (stool/faeces) from your back passage in between visits to the toilet?” Optional responses were ‘never’, ‘occasionally’, ‘sometimes’, ‘most of the time’ and ‘all of the time’. More severe faecal incontinence was defined as that occurring more often than ‘occasionally’.

Urinary incontinence and faecal incontinence were defined as occurring with any level of frequency. Women who did not answer the primary incontinence question and who had no subsidiary answers that indicated symptoms were recorded as not symptomatic. Women who answered ‘no’ to the primary question but gave subsidiary answers that indicated symptoms were recorded as being symptomatic.

For prolapse symptoms, subsidiary regression models were also conducted to explore two of the individual questions, ‘feeling of something coming down’ and ‘uncomfortable feeling in vagina’, and the effect of removing the women who had already had pelvic surgery.

A parallel analysis was performed using the same variables; binary logistic regression was used to assess their effects on the presence of objectively measured prolapse [i.e. at hymen or beyond, stage 2b or beyond].

The sexual function questions were treated as if they were continuous and analysed by a 3-way analysis of variance for each question with mode of delivery history, pelvic floor muscle exercise and incontinence as factors. Extra analysis of variance models were run that included interaction terms between pelvic floor muscle exercise and incontinences [both urinary and faecal], and some models adjusted for parity as well.

Clinical POP-Q examination results were analysed separately for each anatomical compartment [anterior, posterior and apical] and prolapse findings categorised into ‘clinically significant prolapse’ [leading edge at or beyond hymen, POP-Q Stage ≥ 2b] and ‘no clinically significant prolapse’. Women with prior pelvic floor surgery were analysed separately.

Levator avulsion and anal sphincter injury are defined categorically as previously described under, Chapter 4.1.3 Transperineal Ultrasound.

We performed analysis of “bothersome” pelvic organ prolapse as a composite variable consisting of symptoms, objectively measured significant prolapse, and/or having had surgery. A positive response was where any item on the Pelvic Organ Prolapse Symptom Score [POP-SS] was equal to 4, or there was an operation from prolapse, or the POP-Q leading edge was Stage ≥ 2b. Composite outcome variables combining subjective pelvic floor symptoms and objective reports such as prior surgery had been similarly reported in other studies (130) (131) of pelvic floor dysfunction, most notably a very recently published long-term cross-sectional study in the BJOG (130).

Categorical data are analysed using the Chi-squared test. Comparisons of the means of continuous data were performed using the Student t-test. A p-value <0.05 was considered statistically significant.
5. RESULTS

5.1. Demographics

A total of 1250 women gave birth at Queen Mary Maternity Centre from October 1993 to December 1994, called the “Index birth”. Of those, 1248 women had information from the index birth collected from hospital records. 938 women returned the initial questionnaire at 3-months postpartum. 57 women were known to have died and were excluded from the study.

A total of 1191 questionnaires were therefore sent out and 464 were returned by the cut-off date, with a response rate of 39%. Of these, 425 women returned the pull-out sexual health questionnaire.

Baseline data on maternal and obstetric characteristics were obtained for all index births and used to compare respondents with non-respondents [Table 2]. Respondents were significantly older than the non-respondents [28.9 versus 27.2 years, p<0.001]. There were no other significant differences in other background characteristics at index birth in terms of their parity, mode of delivery, induction of labour rates, urinary and faecal incontinence symptoms at 3 months postpartum of their index births.

Table 2  Baseline characteristics of respondents and non-respondents at 12 years

<table>
<thead>
<tr>
<th></th>
<th>Non-Respondents at 20 years (n = 784)</th>
<th>Respondents at 20 years (n = 464)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Died, moved away or withdrew from follow up</td>
<td>57/1248</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at index birth, mean years (SD)</td>
<td>27.3 (5.6)</td>
<td>28.9 (5.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Parity at index delivery (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primarous</td>
<td>318 (40.6%)</td>
<td>186 (40.1%)</td>
<td>0.520</td>
</tr>
<tr>
<td>Multiparous</td>
<td>466 (59.4%)</td>
<td>278 (59.9%)</td>
<td>0.869</td>
</tr>
<tr>
<td>Mode of delivery (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caesarean section</td>
<td>127 (16)</td>
<td>93 (20)</td>
<td>0.385</td>
</tr>
<tr>
<td>Forceps/breech</td>
<td>74 (9.5)</td>
<td>30 (6.5)</td>
<td></td>
</tr>
<tr>
<td>Vacuum</td>
<td>25 (3.2)</td>
<td>18 (3.9)</td>
<td></td>
</tr>
<tr>
<td>Spontaneous vaginal delivery</td>
<td>557 (71.1)</td>
<td>323 (69.6)</td>
<td></td>
</tr>
<tr>
<td>Induced at index delivery (%)</td>
<td>183/781 (23.4)</td>
<td>110 (23.8)</td>
<td>0.748</td>
</tr>
<tr>
<td>Urinary Incontinence at 3 months postpartum (%)</td>
<td>197/517 (38)</td>
<td>145/421 (34)</td>
<td>0.246</td>
</tr>
<tr>
<td>Incontinent</td>
<td>247</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Not known</td>
<td>145</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Faecal Incontinence at 3 months postpartum (%)</td>
<td>29/469 (6.2)</td>
<td>33/378 (8.7)</td>
<td>0.157</td>
</tr>
<tr>
<td>Incontinent</td>
<td>269</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>Not known</td>
<td>269</td>
<td>86</td>
<td></td>
</tr>
</tbody>
</table>
Of the respondents, 209 women consented to a clinical assessment, 196 returned in person for clinical assessment — one participant agreed to a clinical POP-Q examination but not the ultrasound assessment.

The 196 women who were examined differed from those who were not examined with more prolapse surgery [6.7% versus 2.2%, p=0.017]. The examined women were slightly older and had a higher prevalence of urinary incontinence, prolapse symptoms [POP-SS] and sexual dysfunction [PISQ-12] compared to women who were not examined, although not significantly so [Table 3].

Table 3  Characteristics of women and pelvic floor dysfunction 20 years after delivery

<table>
<thead>
<tr>
<th>N = 464</th>
<th>Respondents at 20 years (n=464)</th>
<th>Respondents not examined at 20 years (n = 268)</th>
<th>Respondents examined at 20 years (n = 196)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at 20 years follow up (SD)</td>
<td>49.6 (4.97)</td>
<td>49.3 (0.30)</td>
<td>50.8 (0.38)</td>
<td>0.117</td>
</tr>
<tr>
<td>Number of births (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>29 (6.3)</td>
<td>19 (7.1)</td>
<td>10 (5.1)</td>
<td>0.613</td>
</tr>
<tr>
<td>2</td>
<td>189 (40.7)</td>
<td>109 (40.7)</td>
<td>80 (40.8)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>159 (34.3)</td>
<td>86 (32.1)</td>
<td>73 (37.2)</td>
<td></td>
</tr>
<tr>
<td>4 or more</td>
<td>87 (18.8)</td>
<td>54 (20.1)</td>
<td>33 (16.8)</td>
<td></td>
</tr>
<tr>
<td>Mean number of births (SD)</td>
<td>2.78 (1.23)</td>
<td>2.79 (1.43)</td>
<td>2.80 (1.37)</td>
<td>0.940</td>
</tr>
<tr>
<td>Mode of delivery (%) Only spontaneous vaginal delivery</td>
<td>220 (47.4)</td>
<td>124 (46.3)</td>
<td>96 (49.0)</td>
<td>0.524</td>
</tr>
<tr>
<td>Only Caesarean</td>
<td>56 (12.1)</td>
<td>38 (14.2)</td>
<td>18 (9.2)</td>
<td></td>
</tr>
<tr>
<td>Any forceps</td>
<td>123 (26.5)</td>
<td>68 (25.4)</td>
<td>55 (28.1)</td>
<td></td>
</tr>
<tr>
<td>Any vacuum</td>
<td>22 (4.7)</td>
<td>14 (5.2)</td>
<td>8 (4.1)</td>
<td></td>
</tr>
<tr>
<td>Spontaneous vaginal and caesarean delivery</td>
<td>43 (9.3)</td>
<td>24 (9.0)</td>
<td>19 (9.7)</td>
<td></td>
</tr>
<tr>
<td>Current BMI (SD)</td>
<td>27.3 (6.17)</td>
<td>27.8 (6.8)</td>
<td>27.6 (5.7)</td>
<td>0.693</td>
</tr>
<tr>
<td>Ethnicity (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZ European</td>
<td>423 (91.2)</td>
<td>242 (90.3)</td>
<td>181 (92.3)</td>
<td>0.516</td>
</tr>
<tr>
<td>Non-NZ European</td>
<td>41 (8.8)</td>
<td>26 (9.7)</td>
<td>15 (7.7)</td>
<td></td>
</tr>
<tr>
<td>Current Urinary Incontinence (any) (%)</td>
<td>277 (59.7)</td>
<td>154 (57.5)</td>
<td>123 (62.8)</td>
<td>0.216</td>
</tr>
<tr>
<td>Any current faecal incontinence (%)</td>
<td>95 (20.5)</td>
<td>55 (20.5)</td>
<td>40 (20.4)</td>
<td>0.589</td>
</tr>
<tr>
<td>POP-SS (SD)</td>
<td>2.9 (3.8)</td>
<td>2.8 (3.9)</td>
<td>3.0 (3.7)</td>
<td>0.488</td>
</tr>
<tr>
<td>PISQ-12 (SD)</td>
<td>10.0 (0.60)</td>
<td>9.6 (0.4)</td>
<td>10.5 (0.4)</td>
<td>0.098</td>
</tr>
<tr>
<td>Prolapse surgery by 20 years (%)</td>
<td>19 (4.1)</td>
<td>6 (2.2)</td>
<td>13 (6.6)</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Baseline characteristics including age at follow up, parity, mode of delivery, current BMI and ethnicity, did not differ significantly between the responders who were examined and those who did not return for examination, except for prolapse surgery [Table 3].
Table 4 Comparison of questionnaire and hospital records

<table>
<thead>
<tr>
<th>Mode of Delivery (n)</th>
<th>Agreement (%)</th>
<th>Kappa Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous vaginal delivery (371)</td>
<td>96.5</td>
<td>0.912</td>
</tr>
<tr>
<td>Caesarean delivery (82)</td>
<td>97.8</td>
<td>0.856</td>
</tr>
<tr>
<td>Ventouse (13)</td>
<td>98.4</td>
<td>0.706</td>
</tr>
<tr>
<td>Forceps (52)</td>
<td>97.2</td>
<td>0.850</td>
</tr>
<tr>
<td>Breech (5)</td>
<td>99.0</td>
<td>0.541</td>
</tr>
<tr>
<td>Other delivery factors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Episiotomy</td>
<td>89.6</td>
<td>0.545</td>
</tr>
<tr>
<td>Tears, no episiotomy</td>
<td>80.0</td>
<td>0.539</td>
</tr>
<tr>
<td>Tears, no repair</td>
<td>88.3</td>
<td>0.169</td>
</tr>
<tr>
<td>Intact perineum (no tear)</td>
<td>81.7</td>
<td>0.639</td>
</tr>
</tbody>
</table>

The result of the comparison between questionnaires and hospital records is shown in Table 4.

Overall there was very good agreement regarding the various modes of delivery [range 96.5 to 99%], despite some of the kappas being low on account of the low prevalence. There was reasonable agreement regarding other delivery factors [range 80-89.6%].
5.2. Relationship of Obstetric Factors with Levator avulsion and OASIS

Of the 196 women who had a POP-Q and ultrasound assessment, 4 had missing data and one declined translabial/transperineal ultrasound assessment, leaving 191 for analysis in this section. The results are summarised below in Table 5.

Mean age of this group was 50.8 [range 36.9-66.5, SD 0.38] years with a mean BMI of 27.6 [range 18.3 – 54.3, SD 5.7]. The mean parity was 2.8 [SD 1.37]. They were seen on average 23 years after their first birth.

**Levator avulsion**

On translabial/transperineal tomographic ultrasound, levator avulsion was diagnosed in 29 [15.2%], of these, 9 women [4.7%] had bilateral avulsion. Twenty four women [12.6%] were diagnosed with significant OASIS on ultrasound. One case of significant anal sphincter defect was diagnosed in a woman who delivered exclusively by caesarean section.

Using women who delivered exclusively by spontaneous vaginal delivery as comparison, levator avulsion was significantly associated with one or more forceps delivery [OR 2.45, 95% CI 1.04-5.08, p=0.041]. None of the 17 women who had exclusive caesarean section caesarean delivery had sonographic evidence of levator avulsion.

**OASIS**

Those who delivered exclusively by caesarean section had a lower rate of OASIS compared to exclusive vaginal deliveries and those who had forceps delivery had almost twice the rate of OASIS than those who had spontaneous vaginal delivery only, 21% vs 11%, respectively. However neither reached statistical significance (OR 2.2, 95% CI 0.87-5.59, p=0.098).

**Table 5 Obstetric factors with levator avulsion and OASIS**

<table>
<thead>
<tr>
<th></th>
<th>Levator avulsion (n=29)</th>
<th>OASIS (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>Only spontaneous vaginal delivery (n=94)</td>
<td>12 (13%)</td>
<td>1</td>
</tr>
<tr>
<td>Only caesarean delivery (n=17)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Spontaneous vaginal &amp; caesarean delivery (n=19)</td>
<td>3 (16%)</td>
<td>1.28 (0.32-5.06) p = 0.724</td>
</tr>
<tr>
<td>Any forceps (n=53)</td>
<td>14 (26%)</td>
<td>2.45 (1.04-5.08) p = 0.041</td>
</tr>
<tr>
<td>Any vacuum (n=8)</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
5.3. Relationship of Levator avulsion and OASIS with pelvic floor dysfunction

5.3.1. Levator avulsion and Pelvic Floor Dysfunction

The relationship of levator avulsion and various parameters of pelvic floor dysfunction is summarised in Table 6.

Urinary and Faecal Incontinence

Levator avulsion was significantly associated with faecal incontinence [OR 2.8, 95% CI 1.06-7.03, p=0.008]. Levator avulsion however was not found to be statistically associated with urinary incontinence.

Pelvic Organ Prolapse

Levator avulsion was significantly associated with objectively measured prolapse in the anterior compartment [OR 6.1, 95% CI 1.2-28.3, p=0.0025].

Of the 70 women with significant organ descent on ultrasound, levator avulsion was associated with more bladder, uterine and rectal ampulla descent and an increased hiatal area on Valsalva in comparison to women without avulsion. Levator avulsion is strongly associated with sonographically determined pelvic organ prolapse.

More women had prolapse surgery in the levator avulsion group [13.8%], than in those with no levator avulsion [5%], but not statistically significantly so (OR 3.06, 95% CI 0.62-12.4, p=0.072). However, the composite score for ‘bothersome’ prolapse [when any item in the POP-SS is equal to 4, or if had previous prolapse surgery, or if POP-Q at or greater than Stage 2b for any compartment] was significantly associated with levator avulsion (OR 3.68, 95% CI 1.42-9.20, p=0.002).

Sexual Function

Regarding sexual function, the PISQ-12 scores were significantly higher, i.e. greater sexual dysfunction symptoms, in women with levator avulsion [PISQ-12 scores of 12.3 versus 9.9, difference of means -2.3, 95% CI -0.2 to -4.4, p=0.015].

Reported vaginal tone for own satisfaction also appears to have significant association with levator avulsion. There was significantly less adequate tone reported in women with levator avulsion for own satisfaction (OR 3.7, 95% CI 1.1-11.0, p=0.008) [Table 6]. On the contrary, there was no statistically significant difference on vaginal tone for perceived partner’s satisfaction (OR 1.9, 95% CI 0.3-8.4, p=0.370).

Levator avulsion was significantly associated with less than satisfactory pelvic floor muscle strength with a Modified Oxford score of equal to or less than 3 (right side OR 11.6, 95% CI 4.2-32.2; left side OR 10.1, 95% CI 3.7-27.8, both p<0.001).
### Table 6  Levator avulsion and pelvic floor dysfunction

<table>
<thead>
<tr>
<th></th>
<th>No Levator Avulsion (n = 163)</th>
<th>Levator Avulsion (n = 30)</th>
<th>OR# or difference of means* (95% CI)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Any urinary incontinence (%)</td>
<td>107 (66.0)</td>
<td>15 (51.7)</td>
<td>0.56 (0.23-1.38)</td>
<td>p=0.160</td>
</tr>
<tr>
<td>Any faecal incontinence (%)</td>
<td>30 (18.5)</td>
<td>12 (40)</td>
<td>2.8 (1.06-7.03)</td>
<td>p=0.008</td>
</tr>
<tr>
<td>POP-SS (SD)</td>
<td>3.1 (0.3)</td>
<td>2.7 (0.6)</td>
<td>0.44 (-1.1-1.9)</td>
<td>p=0.283</td>
</tr>
<tr>
<td>POP-Q, Clinical Stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior ≥ 2b (%)</td>
<td>5 (3.2)</td>
<td>5 (16.7)</td>
<td>6.1 (1.2-28.3)</td>
<td>p=0.0025</td>
</tr>
<tr>
<td>Apical ≥ 2b (%)</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Posterior ≥ 2b (%)</td>
<td>10 (6.3)</td>
<td>4 (13.3)</td>
<td>2.3 (0.5-8.6)</td>
<td>p=0.180</td>
</tr>
<tr>
<td>Leading edge ≥ 2b (%)</td>
<td>13 (8.2)</td>
<td>8 (26.7)</td>
<td>4.1 (1.5-10.9)</td>
<td>p=0.005</td>
</tr>
<tr>
<td>Transabdominal Ultrasound:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonographically significant organ descent (n=70)</td>
<td>49 (30%)</td>
<td>21 (68%)</td>
<td>4.9 (2.1-11.1)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Bladder descent (SD)mm</td>
<td>2.2 (12.4)</td>
<td>-9.8 (16.6)</td>
<td>12.0 (5.6-18.4)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Uterine descent (SD)mm</td>
<td>22.4 (12.4)</td>
<td>5.5 (15.9)</td>
<td>16.9 (10.1-23.7)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Rectal Ampulla descent (SD)mm</td>
<td>-1.1 (16.8)</td>
<td>-9.7 (15.7)</td>
<td>8.6 (2.3-14.9)</td>
<td>p&lt;0.009</td>
</tr>
<tr>
<td>Hiatal area on Valsalva (SD)cm2</td>
<td>21.4 (6.8)</td>
<td>30.0 (7.7)</td>
<td>-8.6 (-11.6 to -5.6)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Previous prolapse surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- yes (%)</td>
<td>8 (5)</td>
<td>4 (13.8)</td>
<td>3.06 (0.62-12.4)</td>
<td>p=0.072</td>
</tr>
<tr>
<td>&quot;Bothersome&quot; Prolapse^ (%)</td>
<td>25 (15.3)</td>
<td>12 (40)</td>
<td>3.68 (1.42-9.20)</td>
<td>p=0.002</td>
</tr>
<tr>
<td>PISQ-12 (SD)</td>
<td>9.9 (0.4)</td>
<td>12.3 (1.1)</td>
<td>-2.3 (-0.2 to -4.4)</td>
<td>p=0.015</td>
</tr>
<tr>
<td>Vaginal tone (less than adequate)</td>
<td>16 (12.7)</td>
<td>8 (34.8)</td>
<td>3.7 (1.1-11.0)</td>
<td>p=0.008</td>
</tr>
<tr>
<td>for own satisfaction (%)</td>
<td>20 (15.0)</td>
<td>3 (25.0)</td>
<td>1.9 (0.3-8.4)</td>
<td>p=0.370</td>
</tr>
<tr>
<td>Pelvic floor muscle Strength</td>
<td>49 (30.1)</td>
<td>25 (83.3)</td>
<td>11.6 (4.2-32.2)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>(Oxford score &lt; 3)</td>
<td>left side (%)</td>
<td>54 (33.1)</td>
<td>10.1 (3.7-27.8)</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

Categorical data expressed as n (%) and analysed using the Chi-squared test#.
Continuous data presented as mean (SD). Comparison of the means were performed using the Student t Test*.

^ "Bothersome" Prolapse – a composite outcome variable; positive when any POP-SS is equal to 4, or if had previous prolapse surgery, or if POP-Q Stage ≥ 2b.
5.3.2. OASIS and Pelvic Floor Dysfunction

The relationship of OASIS and various parameters of pelvic floor dysfunction is summarised in Table 7.

Women with OASIS had a higher prevalence of urinary, flatus and faecal incontinence in comparison to women with no OASIS; however this was not statistically significant (urinary incontinence OR 2.99, 95% CI 0.94-12.5, p=0.046; flatus incontinence OR 2.33, 95% CI 0.74-9.70, p=0.126; faecal incontinence OR 2.11, 95% CI 0.71-5.76, p=0.111).

OASIS was not associated with either symptoms (OR 0.41, 95% CI 1.24-2.07, p=0.311), objective signs (OR 0.75, 95% CI 0.02-5.87, p=0.788), or ‘bothersome’ prolapse (OR 0.57 95% CI 0.10-2.08, p=0.375), in comparison to women with no OASIS.

Sexual function PISQ-12 scores were significantly higher, i.e. greater sexual dysfunction symptoms, in women with OASIS (difference of means -3.65, 95% CI -5.9 to -1.4, p<0.001). Women with OASIS also reported less than adequate vaginal tone in comparison to women with no OASIS; this was close to statistical significance (OR 2.87, 95% CI 0.97-9.37, p=0.05). However OASIS was not associated with perceived partners’ satisfaction or clinical pelvic floor strength (OR 0.62, 95% CI 0.01-4.8, p=0.654).

Table 7 OASIS and pelvic floor dysfunction

<table>
<thead>
<tr>
<th></th>
<th>N = 193</th>
<th>No OASIS (n = 167)</th>
<th>OASIS (n = 24)</th>
<th>OR# or difference of means* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any urinary Incontinence (%)</td>
<td></td>
<td>102 (62.6)</td>
<td>20 (83.3)</td>
<td>2.99# (0.94-12.5) p 0.046</td>
</tr>
<tr>
<td>Any faecal incontinence (%)</td>
<td></td>
<td>34 (20.1)</td>
<td>8 (33.3)</td>
<td>2.11# (0.71-5.76) p 0.111</td>
</tr>
<tr>
<td>POP-SS (SD)</td>
<td></td>
<td>3.1 (0.30)</td>
<td>2.7 (0.63)</td>
<td>0.41* (1.24-2.07) p 0.311</td>
</tr>
<tr>
<td>POP-Q, Clinical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior &gt;2b (%)</td>
<td></td>
<td>9 (5.5)</td>
<td>1 (4.2)</td>
<td>0.75# (0.02-5.87) p 0.788</td>
</tr>
<tr>
<td>Apical &gt;2b (%)</td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Posterior &gt;2b (%)</td>
<td></td>
<td>14 (8.6)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Previous prolapse surgery (%)</td>
<td></td>
<td>11 (6.6)</td>
<td>1 (4.2)</td>
<td>0.62# (0.08-4.97) p 0.646</td>
</tr>
<tr>
<td>“Bothersome” composite variable^ (%)</td>
<td></td>
<td>34 (20.1)</td>
<td>3 (12.5)</td>
<td>0.57# (0.10-2.08) p 0.375</td>
</tr>
<tr>
<td>PISQ-12 (SD)</td>
<td></td>
<td>9.9 (4.5)</td>
<td>13.5(5.4)</td>
<td>-3.65*(-5.9 to -1.4) p&lt;0.001</td>
</tr>
<tr>
<td>Vaginal tone (less than adequate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for own satisfaction (%)</td>
<td></td>
<td>18 (13.9)</td>
<td>6 (31.6)</td>
<td>2.87# (0.97-9.37) p 0.050</td>
</tr>
<tr>
<td>for partner’s satisfaction (%)</td>
<td></td>
<td>11 (8.7)</td>
<td>1 (5.6)</td>
<td>0.62# (0.01-4.8) p 0.654</td>
</tr>
<tr>
<td>Pelvic Floor Muscle Strength (Oxford score &lt; 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>right side (%)</td>
<td></td>
<td>64 (38.1)</td>
<td>10 (41.7)</td>
<td>1.17# (0.49-2.79) p 0.737</td>
</tr>
<tr>
<td>left side (%)</td>
<td></td>
<td>69 (40.8)</td>
<td>10 (41.7)</td>
<td>1.04# (0.43-2.46) p 0.938</td>
</tr>
</tbody>
</table>

Categorical data expressed as n (%) and analysed using the Chi-squared test#.
Continuous data presented as mean (SD). Comparison of means were performed using the Student t Test*.
^“Bothersome” Prolapse – a composite outcome variable; positive when any POP-SS is equal to 4, or if had previous prolapse surgery, or if POP-Q Stage ≥ 2b.

5.4. Levator avulsion Diagnosis – Digital Palpation and Translabial Tomographic Ultrasound

On digital palpation, levator defects were detected in 16 (8.2%), all unilateral. On translabial tomographic ultrasound, levator defects were diagnosed in 31 (16%), bilateral in 9 (4.6%) and unilateral in 22 (11.3%).

The overall agreement between digital palpation and ultrasound on blind assessment was 91% (352/388), yielding a Cohen’s kappa of 0.32 (95% CI 0.148-0.480), signifying ‘fair agreement’ although this may be lower than the real agreement as less than 10% had levator avulsion. This gives a sensitivity of 25% and specificity of 98%, with a positive predictive value of 63% and negative predictive value of 92%. (Table 8). Separate analysis of the first and the last 20 palpations demonstrated 95% and 88% agreement respectively, indicating no improvement during the 13-day study period.

Table 8  Levator avulsion diagnosis by palpation and translabial tomographic ultrasound

<table>
<thead>
<tr>
<th>Levator Ani</th>
<th>Ultrasound – Avulsion</th>
<th>Ultrasound – no avulsion</th>
<th>Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palpation – avulsion</td>
<td>10</td>
<td>6</td>
<td>Positive 62.5%</td>
</tr>
<tr>
<td>Palpation – no avulsion</td>
<td>30</td>
<td>342</td>
<td>Negative 91.9%</td>
</tr>
<tr>
<td>Sensitivity = 25.0%</td>
<td>Specificity 98.3%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. DISCUSSION

6.1. Principal Findings

Our primary research questions were firstly the relationship of obstetrical factors with ultrasound diagnosed levator avulsion and OASIS 20 years after delivery and secondly, the relationship of both levator avulsion and OASIS with symptoms and signs of pelvic floor dysfunction at this time. Our cohort’s levator avulsion rate (15.2%) and OASIS rate (12.5%) are in keeping with previous reports (109) (132).

Levator avulsion was significantly associated with one or more forceps delivery in comparison to vaginal delivery. Forceps delivery had an avulsion rate of 26% when compared with vaginal delivery 13% avulsion rate [Odds Ratio 2.45, 95%CI 1.04-5.8]. There was no levator avulsion diagnosed in the exclusive caesarean delivery group.

Forceps also resulted in almost twice the prevalence of OASIS in comparison to normal delivery [21% versus 11%] and more than Caesarean delivery [1/17, 6%]. These were not statistically significant but this may reflect lack of power in this present study and may have reached significance with larger numbers.

Levator avulsion was found to be significantly associated with more objectively measured pelvic organ prolapse [cystocele], ultrasound measurements of prolapse, “bothersome” prolapse and more faecal incontinence.

We found levator avulsion was associated with more sexual dysfunction [as indicated by PISQ-12 scores] and less adequate tone for the woman’s satisfaction, but not for her partner’s perceived satisfaction. Levator avulsion was significantly associated with less than satisfactory pelvic muscle strength on clinical examination.

Women with OASIS had a higher prevalence of urinary, faecal and flatus incontinence in comparison to women with no OASIS (33.3% vs 20.1% for faecal incontinence), but this did not reach statistical significance. Again, this may represent a lack of power in this study to look at this outcome.

Women with OASIS also reported significantly more sexual dysfunction [again as shown by PISQ-12 scores] in comparison to women with no OASIS. Women with OASIS also reported less than adequate vaginal tone in comparison to women with no OASIS [31.6% versus 13.9%] and this was close to significance [P=0.05]. However OASIS was not associated with perceived partner’s satisfaction nor clinical pelvic floor strength.

When evaluating the diagnostic performance of levator avulsion by digital palpation using translabial/transperineal ultrasound as the diagnostic gold standard, we found an overall agreement of 91% and a kappa score signifying ‘fair’ agreement.
6.2. Strengths and weaknesses

The women recruited in Dunedin for this study represented one of 3 arms of the ProLong Study. This is the largest prospective cohort study of community dwelling women [who delivered their babies in 1993/4] and looked at the relationship of obstetrical factors and subsequent pelvic floor dysfunction. This usually becomes troublesome enough to require treatment after the menopause. The long follow up duration meant this cohort is now approaching the more symptomatically relevant phase to investigate clinically important sequelae from their obstetric injuries.

There was a reasonable response rate of just under 40% at 20 years after delivery. The responders were slightly older than non-responders [28.9 versus 27.3 years], however there were no other significant differences in the baseline characteristics. Consequently this difference should have little effect on the relationship of the variables being examined.

The participants were de-identified with study numbers. The main investigators (myself and Dr Ixora Atan) were fully blinded to the participants’ obstetric history to avoid detection bias from this information. Furthermore, the main investigators were also blinded to each other’s assessment findings at the time of the examination.

Although we were only able to examine a relatively small number of women, we were able to draw statistically significant associations on several pertinent parameters. Even though causality cannot be assumed from statistical associations, other studies have also identified childbirth, parity and its associated pelvic floor trauma as significant antecedent factors to pelvic floor dysfunction.

We do not have any nulliparous women in our study, however it is well recognised that the rates of pelvic floor dysfunction (although not non-existent) are considerably lower among this population. Women who were examined had more prolapse surgery (6.7% versus 2.2%, \( p = 0.017 \)) and were slightly older (50.8 versus 49.3 years, \( p = 0.117 \)). They also had a higher prevalence of urinary incontinence, prolapse symptoms and sexual dysfunction, although not significantly so. It is possible that some of these women chose to be examined because they had already started to have symptoms of pelvic floor dysfunction, leading to some selection bias. Our data may thus have led to an overestimate of the prevalence of pelvic floor dysfunction symptoms and signs; however it should not have affected the relationship of obstetric factors with either levator avulsion or OASIS.

We noted a small number of vacuum deliveries compared with forceps deliveries (4.7% versus 26.5%). This reflects the obstetric practice at the time of recruitment in Dunedin. Consequently, with this relatively small number of vacuum deliveries, it was difficult to compare forceps with vacuum and draw definite conclusions regarding these modes of assisted deliveries.

Another weakness was that a validated questionnaire was not used to assess urinary or faecal incontinence, in order to maintain consistency with ProLong Study’s previous methods (9). It was worth noting at the time of initial recruitment (1993-1994) there were no suitably validated questionnaires available.
6.3. Interpretation of results in context of other research

Prolapse symptoms normally become severe enough to require treatment after menopause. The average age of the menopause in New Zealand is 51.5 years (133). The mean age of 50.8 years in our examined participants is therefore likely to have captured a substantial proportion of peri-menopausal women.

In recent years understanding of obstetric pelvic floor trauma has undergone tremendous revolution, with the development of modern functional imaging enabling accessible diagnoses such as levator avulsion and anal sphincter injuries. The introduction of sonographic assessment of levator ani and anal sphincter to our cohort of respondents offered the unique opportunity to further ascertain the impact of these anatomical findings on long-term postpartum pelvic floor function. There has not been any similar long-term prospective research to date. The finding of significant association between forceps delivery and levator avulsion raises concern over the long-term adverse effect of this mode of delivery. Our result further strengthens similar conclusions from previous studies with the reported avulsion rate between 35-64% and OR ranging from 3.4 to 14.7 associated with forceps delivery (109) (134) (104) (75). Forceps delivery has been shown to be an independent risk factor for levator ani trauma. (134)

We identified a significant association between objectively measured pelvic organ prolapse and levator avulsion. This is in keeping with similar findings by several other small studies as well as studies of different design comparing the prevalence of levator avulsion in women with prolapse and asymptomatic controls on scan. (135) (136) (98). We also found levator avulsion to be significantly associated with symptomatic ‘bothersome’ prolapse, a composite variable including previous prolapse surgery, severe prolapse symptoms [POP-SS equal to 4] and clinically significant prolapse [POP-Q Stage $\geq 2b$]. The prolapse symptom scores in our women with levator avulsion were not significantly different to those without major levator avulsion. This may be a reflection of their relative young age and in the ensuing decades of their expected life span, they may become more symptomatic. The relationship between levator avulsion and symptomatic prolapse had been alluded to in several previous studies (99) (136). Furthermore studies have also reported increased risk of prolapse surgery and its subsequent failure with levator avulsion (98) (27) (137).

Forceps delivery was found to be significantly associated with prolapse surgery in a large retrospective cohort in Sweden compared with exclusive caesarean delivery (Hazard Ratio 20.9, 95% CI 5.5-79.9) (25). A recent cross-sectional Norwegian study with comparable long-term follow up to our group demonstrated a significant risk reduction in exclusive caesarean delivery and conversely a significantly increased risk with instrumental delivery (forceps and vacuum) for symptomatic pelvic organ prolapse when comparing to normal vaginal delivery (130). In contrast their group found no significant difference between forceps and vacuum deliveries for pelvic floor dysfunction — this may be due to a selection bias. Their centre allowed vacuum delivery in potentially more difficult assisted deliveries at higher station and/or requiring rotational delivery whereas forceps delivery was only conducted for low or mid-cavity fetal head in occiput anterior or occiput posterior position; rotational forceps delivery was not a recommended practice at their institution. This in turn highlights the potential risks of attempting a difficult assisted vaginal delivery [regardless of method] as regards long-term pelvic floor dysfunction.
Although the number of women having exclusive Caesarean deliveries was relatively small [17], exclusive Caesarean delivery was shown to be totally protective for levator avulsion 20 years after delivery. Further analysis is planned with the larger ProLong database, comparing modes of delivery with all symptoms of pelvic floor dysfunction.

Associations between levator avulsion and urinary incontinence remains controversial, our study is similar to previous reports of non-association (27) (93). On the other hand, levator avulsion appears to have an effect on faecal incontinence, particularly in older women, a finding that is similar to previous studies (94) (138). This highlights the likely importance of an adequately functioning anal sphincter as well as levator ani muscle in maintenance of anal continence.

Although women with OASIS in our cohort had a higher prevalence of flatus and faecal incontinence compared to women with no OASIS (33.3% vs 20.1% for faecal incontinence), this did not reach statistical significance, however this could be explained by the relatively small numbers in this study. A previous prospective study reported a high rate of anal incontinence of 53% in women with OASIS at the 5 year follow up (139). Sphincter tear was found to be associated with anal incontinence at 5 years (OR 2.3, 95% CI 1.1-5.0) (139).

Forceps delivery also appeared to be a risk factor for persistent anal incontinence. We found nearly twice the prevalence of OASIS with forceps delivery compared with normal delivery [21% versus 11%]. The 12-year follow up of this study [ProLong] incorporating deliveries from two larger maternity centres found a significant association between forceps and faecal incontinence (16.7% versus 11.5%, p=0.001) when compared with vaginal delivery (41). While our current relationship between forceps and OASIS did not reach statistical significance, this may well be due to the small numbers in our cohort at a single centre.

There was a single case of anal sphincter injury identified in our exclusive caesarean delivery group [1/17]. A recent article comparing methods of ultrasound imaging of the anal sphincter found transperineal ultrasound, if anything, tended to underestimate occult anal sphincter injuries when compared with endoanal ultrasound (7.9% versus 29%) (140). This suggested a likely genuine pathology of the anal sphincter in this woman albeit unexpected from her delivery history. Her obstetric records were subsequently reviewed and found to be accurate. Her vaginal examination POP-Q findings were also later reviewed to be consistent with having had exclusive caesarean deliveries. There have been previous case reports of severe non-obstetric causes of female anal sphincter trauma including anal intercourse, zoophilia, straddle and impalement injury (141) (142) (143). Presumably this woman may have had a non-obstetric cause for her OASIS.

The association of sexual dysfunction and both levator avulsion and OASIS 20 years after delivery has not been described before. There has been little research to date comparing validated sexual function questionnaires to anatomical defects. The first study published in 2014 investigating the relationship between objectively assessed levator ani trauma on ultrasound with sexual function had a short post-partum average follow-up of 5.2 months, using a modified sexual function questionnaire (144); thus limiting the generalisability of their findings. Thibault-Gagnon et al concluded at this early post-partum period, there is an association of levator avulsion with lower scores in the questionnaire domain of pelvic floor muscle function and integrity but not for the other
questionnaire domains [sexual activity, sensation at intercourse, sexual arousal and orgasm, pelvic floor integrity and function] (144).

Furthermore, while there is evidence in the early post-partum period that OASIS may adversely affect sexual function, particularly in the form of dyspareunia (145), there is a paucity of research of the impact of OASIS on long-term sexual function. In a recent retrospective cross-sectional study with a mean follow up of 5 years, sexual dysfunction was present in the majority of women with OASIS (59%) and worst symptoms [by Female Sexual Function Index scores] in women with the largest anal sphincter injuries (146). A 2014 matched case-control study in Norway used a local questionnaire to assess sexual problems with OASIS. At the mean follow-up of 34.5 months, the group concluded that there was a significant association of sexual desire problems with OASIS (OR 7.62, 95% CI 1.30-44.64, p = 0.02) but not for other domains of sexual problems such as orgasm or pain (147). The results from this study had several limitations as OASIS was only diagnosed at the time of delivery instead of on scan, which can lead to selection bias due to its frequent under-diagnosis at delivery. The questionnaires were also not validated and there was a much shorter follow up than our study.

In a large retrospective study of over 1000 women, levator avulsion was found to have marked effect on reducing pelvic muscle strength in overall Oxford grading (2.07 versus 2.81 p<0.001) (86). Our prospective long-term follow up result showing a similarly significant association between pelvic muscle strength and levator avulsion confirms the importance of levator ani integrity in maintaining pelvic floor muscle function.

Objective pelvic floor muscle strength appears to be positively associated with better sexual function by validated questionnaire in a recent study (148). Furthermore, based on the responses from 2,756 women from their large cross-sectional survey (8), Dean et al reported that at 6 years women who delivered exclusively by caesarean section scored significantly better on questions relating to their perception of vaginal tone for their own and their partner’s sexual satisfaction. Our findings are thus novel in giving a unique insight into the likely anatomical aetiology leading to long-term sexual dysfunction.

Our results also highlight the permanence of significant anatomical injuries sustained during vaginal births. This is supported by a previous study, which demonstrated minimal ‘healing’ of major levator avulsion in the post-natal population with up to 2-3 years follow up (149). With our levator avulsion rates comparable to other published prospective studies of short post-natal follow up, this suggests the likely irreversible nature of a significant injury once sustained. A recent study reported apparent ‘healing’ of levator ani trauma however this is mostly with ‘partial’ avulsion (150). While women with major or ‘complete’ levator avulsion, using similar diagnostic criteria as our cohort, are less likely to have improved anatomical findings over time.

We found 91% overall agreement between digital palpation and transperineal ultrasound of levator avulsion [352/388, Kappa 0.32]. Our finding is in keeping with previous studies and also with a recent longitudinal cohort of 191 primipara women examined at 13 weeks postpartum (108). Their group found an overall agreement of 92% [Kappa 0.34] between transperineal scan and palpation (108). Diagnosis of levator avulsion by palpation is therefore feasible but may require substantial training while poor contractility of pelvic floor muscles can help further alert the examiner to an increased likelihood of its diagnosis.
7. CONCLUSION

Our study provides longitudinal epidemiological evidence that obstetrical intervention may impact on pelvic floor function later in life, 20 years after delivery. Forceps delivery was associated with long-term evidence of levator avulsion in particular and also OASIS. Levator avulsion was shown to be associated with objective and bothersome prolapse. Levator avulsion was also significantly associated with faecal incontinence. Both levator avulsion and OASIS were significantly associated with sexual dysfunction in our group of perimenopausal women.

This association of sexual dysfunction with both levator avulsion and OASIS 20 years after delivery has not been described previously and further studies are now indicated to validate these findings. Further comparative studies comparing vacuum and forceps are also required to help advise on the method of choice for assisted vaginal deliveries.
8. REFERENCES


83. Dietz H, Simpson J. Does delayed child-bearng increase the risk of levator injui in


99. Dietz H. Quantification of major morphological abnormalities of the levator ani.


117. Dietz H, Langer S, Kamisan A, Shek K, Caudwell-Hall J, Guzman R. Does the Epi-


467-474.


p. 1266-73.

9. APPENDICES

Appendix A         Postal Questionnaire

Identification Number:  

CONFIDENTIAL

The Relationship of Pregnancy and Delivery with Incontinence, Prolapse and Sexual Function

The ProLong Study:
PROlapse and Incontinence:  LONG-term research

Twenty Year Follow Up Questionnaire – Dunedin Arm

If you would like any further information or have queries about the study, please contact:

Prof Don Wilson  Prof Peter Herbison  Ms Gaye Ellis  Dr Sylvia Lin
Professor of  Biostatistician  Research Co-ordinator  Gynaecologist/
Obstetrics &  Dept Preventive &  Dept Women’s &  Research Fellow
Gynaecology  Social Medicine  Children’s Health  University of Otago
University of Otago  University of Otago  University of Otago

Date questionnaire filled in  

49
Your date of birth

Which ethnic group do you belong to? Mark the spaces that apply to you.

NZ European
Maori
Samoan
Cook Island Maori
Tongan
Niuean
Chinese
Indian
Other (such as Dutch, Japanese, Tokelauan)

Please specify below

HOW TO FILL IN THIS QUESTIONNAIRE

Most questions can be answered by putting numbers or a tick in the appropriate box or boxes. Please print your answers carefully within the boxes like this

eg

2 7 OR A N N E OR

If you make any errors while completing this form, shade out the box completely and mark the correct one like this
Some of the questions ask for answers in your own words, please write these in the boxes provided. In some questions we would like you to think about different time periods, such as during the last week, during the last four weeks or before having your first baby. Please check the time periods carefully.

Sometimes the box you tick tells you to skip forward so that you miss out questions which do not apply to you.

There are no right or wrong answers, but please try to complete the whole questionnaire.

**You do not have to answer any question if you do not want to.**

Thank you for your time in completing this questionnaire.

Your answers will be treated with complete confidentiality, and will only be used for research aimed at improving Women’s Health.
Section A1  Urine Symptoms (leakage)

Many women have problems with bladder control and leak urine some of the time. We are trying to find out how many women who have had children leak urine, and how much this bothers them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the LAST FOUR WEEKS.

A1  At present, do you ever lose any urine when you don't mean to?

Yes  No  Go to A2

A1a  If you do ever lose any urine, when did it FIRST start?

Did it start before your first pregnancy?  Yes  No

Did it start during your first pregnancy?  Yes  No

Did it start after your first birth (delivery)?  Yes  No

Did it start at some other time?  Yes  No
(please give details of when *)?

* Details

A1b  In the last 4 weeks how often have you lost urine, on average?
(tick one box only)

Never  Less than twice a month  Twice per month

About once a week  Two or three times a week  About once a day

Several times a day  All the time

A1c  We would like to know how much urine you think leaks. How much urine do you usually leak (whether you wear protection or not)?
(tick one box only)

None
A small amount
A moderate amount
A large amount

A1d  Do you wear a pad for this?
(tick one box only)
No  (Go to A1e)  Sometimes
All day
All day and all night

A1e  How often would you have to change your pad?
(tick one box only)
Once a day  Twice a day
Three times a day  More than three times a day

A1f  Do you lose urine when you…
(tick one box in each row)

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough, laugh, sneeze</td>
<td></td>
</tr>
<tr>
<td>Run, jump, or play sport</td>
<td></td>
</tr>
<tr>
<td>Feel an urgent desire to pass water and are unable to reach the toilet in time</td>
<td></td>
</tr>
</tbody>
</table>

* Specify

A1g  Overall, how much does leaking urine interfere with your everyday life?
Please tick a number between 0 (not at all) and 10 (a great deal)
### Section A2 Other Urine Symptoms

**A2.** In the past have you had any of the following treatments for urinary incontinence?

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment from a physiotherapist or nurse continence advisor (other than any associated with our previous study in 1993/94)</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Drug treatment for incontinence</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Had an operation for incontinence</td>
<td>☐</td>
<td>☒  (Go to A3)</td>
</tr>
</tbody>
</table>

If YES what type of operation was this **(please tick all that apply)**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension Free Vaginal Tape Sling (TVT), or similar</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Colposuspension</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Not sure which operation</td>
<td>☒</td>
<td>☐</td>
</tr>
<tr>
<td>Other operation (please specify below)</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**A3** On average, how many times during the day do you pass urine?

Enter number of times in box ☐ ☐

**A4** On average, how many times during the night do you pass urine?

Enter number of times in box ☐ ☐

**A5** Do you have any difficulty passing urine?

Yes ☐ No ☐ (Go to A6)

If YES, please specify what difficulty. **(tick one box in each row)**

<table>
<thead>
<tr>
<th>Difficulty</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>I need to strain to pass urine</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It hurts (or burns) when I pass urine</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>My urine does not come with a good flow</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>My bladder does not feel empty even</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
after I have passed urine

Other (please give details)

When did this start?

A6  Can you usually hold on for 5 minutes when you have the desire to pass urine?

Yes  No

A7  Can you stop and start your stream of urine at will?

Yes  No

A8  Do you exercise any of the following areas regularly (twice a week or more often)? (please tick all that apply)

Abdominal (tummy) muscles  Buttock (bottom) muscles

Hip + Thigh muscles  Pelvic floor muscles  None of these

A9  Have you done any pelvic floor muscle exercises over the last month?

Yes  No  Go to Section B

A9a  How often did you do the pelvic floor muscle exercises? (tick one box only)

A few times a month  Once a week

A few times a week  Every day

A9b  On the days that you did exercises during the last month, on average how many pelvic floor muscle contractions would you do per day? (tick one box only)

Less than 5 contractions per day  5 - 25

25 - 50  50 - 100
A9c  How long can you hold a pelvic floor muscle contraction? 
(tick one box only)
Can’t hold at all  □  Less than 5 seconds  □
5 - 10 seconds  □  More than 10 seconds  □

A9d  How hard do you try when you tighten your pelvic floor muscles? 
(tick one box only)
I try to get the strongest contraction I possibly can each time  □
I just contract my muscles and don’t worry about how hard I try  □
Many women experience bowel symptoms some of the time. We are trying to find out how many women who have had children experience bowel symptoms, and how much they bother them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS. (Please tick one box for each question)

**B1a** Do you ever lose control of wind (gas) from your back passage in between visits to the toilet? *(tick one box only)*

- Never
- Occasionally
- Sometimes
- Most of the time
- All of the time

**B1b** Do you ever lose control of bowel motions (stool / faeces) from your back passage in between visits to the toilet? *(tick one box only)*

- Never
- Occasionally
- Sometimes
- Most of the time
- All of the time

**B2** If you do ever lose control of bowel motions (stool / faeces): *(please tick all that apply)*

- Yes
- No

- Did it start before you had your first baby?
- Do you have any problem which might cause it *(e.g. ulcerative colitis, Crohn’s, irritable bowel)*?
- Do you ever leak bowel motion without you being aware of it until it has happened?

**B3** Do you have to strain to pass a bowel motion?

- Never
- Occasionally
- Sometimes
- Most of the time
- All of the time

---

58
B4 Have you had to wear a pad or plug to stop leaking of bowel motions from your back passage in the last 3 months?

Yes  No

B5 Have you had to use constipating medicines to stop leaking of bowel motions from your back passage in the last 3 months?

Yes  No

B6 Can you usually hold on for 5 minutes when you have the desire to open your bowels?

Yes  No

B7 In the past have you:

Had an operation to treat leaking of bowel motions?

Yes  No

Had bowel training or physiotherapy to treat leaking of bowel motions?

Yes  No

B8 Overall, how much do your bowel symptoms interfere with your everyday life?

Please tick a number between 0 (not at all) and 10 (a great deal)

Not Applicable  0  1  2  3  4  5  6  7  8  9  10

Applicable not at all a great deal
Prolapse is a common condition affecting the normal support of the pelvic organs, which results in descent or ‘dropping down’ of the vaginal walls and/or the pelvic organs themselves. This can include the bladder, the bowel and the womb. Symptoms are usually worse on standing up and straining (e.g. lifting, coughing or exercising) and usually better when lying down and relaxing.

Prolapse may cause a variety of problems. We are trying to find out how many women who have had children experience problems which might be from a prolapse, and how much bother they cause. We would be grateful if you could answer the following questions, **even if you do not think you have a prolapse.**

Please think about how you have been, on average, over the **PAST FOUR WEEKS.**

*(Please tick one box in each row)*

<table>
<thead>
<tr>
<th>How often during the last four weeks have you had the following symptoms:</th>
<th>Never</th>
<th>Occasionally</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>All of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 a feeling of something coming down from or in your vagina?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2 an uncomfortable feeling or pain in your vagina which is worse when standing?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3 a heaviness or dragging feeling in your lower abdomen (tummy)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4 a heaviness or dragging feeling in your lower back?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5 a need to strain (push) to empty your bladder?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6 a feeling that your bladder has not emptied completely?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C7 a feeling that your bowel has not emptied completely?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C8 a feeling that your vagina is too loose or lax?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C9 problems with intercourse (sex) due to your prolapse?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C10  Which of the symptoms above (questions C1 to C9) causes you most bother?  

Please enter a number from 1 to 9 in the box, or tick “Not applicable”

C

Not Applicable

How often during the last four weeks have you had:

<table>
<thead>
<tr>
<th>Action</th>
<th>Never</th>
<th>Occasionally</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>All of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>C11 to use your fingers to push up the prolapse to ease discomfort or pain?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C12 to use your fingers to push up the prolapse to help empty your bladder?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C13 to use your fingers to push up the prolapse to help empty your bowel?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C14 to insert a finger into your back passage to help empty stool from your bowel?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C15 to take extra measures to ensure the prolapse does not cause personal hygiene problems?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C16 difficulty keeping tampons in your vagina (if you have periods)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C17 Which of the actions above (questions C11 to C16) causes you most bother?  

Please enter a number from 11 to 16 in the boxes, or tick “Not applicable”

C

Not Applicable

C18 In the past have you had an operation for prolapse?

Yes  No  (Go to C19)

If YES, please specify what operation this was.  
(please tick all that apply)
A vaginal hysterectomy (uterus removed through the vagina)
A vaginal repair of the bladder (anterior prolapse, or cystocele)
A vaginal repair of the rectum/back passage (posterior prolapse, or rectocele)
Not sure which operation
Other operation (please specify below in C26-27)

C19  Do you currently have a pessary or ring inside your vagina for the treatment of prolapse?

Yes  □  No  □

C20  In the past have you had?

Yes  □  No  □

A ring or pessary to treat prolapse  □  □

Other treatments for prolapse  □  □

If YES, please specify what treatment this was.

C21  How long have you been aware that you have a prolapse?

□  □ years  □  □ months  Not applicable □

C22  How long have you been having bothersome symptoms from your prolapse?

□  □ years  □  □ months  Not applicable □

C23  Overall, how much do your prolapse symptoms interfere with your everyday life?

Please tick a number between 0 (not at all) and 10 (a great deal), or not applicable

Not applicable  □  □  □  □  □  □  □  □  □  □

Not at all  □  □  □  □  □  □  □  □  □  □

A great deal
C24 Have any of your blood relatives ever had a prolapse?

Yes  No

C25 If yes, how are they related to you (eg mother, sister)?


C26 Have you had any other type of operation (other than those you have mentioned already) for urine or bowel motion leakage or for prolapse?

Yes  No

C27 If yes, please write in what sort of operation it was, and what it was for.

<table>
<thead>
<tr>
<th>Name of operation</th>
<th>Reason for operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section E  
Background Information

Now could you tell me some background information about yourself that may be related to incontinence or prolapse?

E1  Please give some information about your weight and height. 
(Please use whichever units you are familiar with)

What is your average weight now?  

What is your height?  

E2  Has your weight changed since your baby in 1993/94?

Stayed the same

Increased by

Decreased by
The following questions ask for your views about your health in the last 4 weeks, how you feel and how well you are able to do your usual activities.

Answer every question by selecting the answer as indicated. If you are unsure about how to answer a question please give the best answer you can.

F1 In general, would you say your health is:

(tick ONE box only)

Excellent

Very good

Good

Fair

Poor

F2 During a typical day does your health limit you in moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf? If so, how much?

(Tick ONE box only)

Yes, limited a lot

Yes, limited a little

No, not limited at all

F3 During a typical day does your health limit you in climbing several flights of stairs? If so, how much?

(Tick ONE box only)

Yes, limited a lot

Yes, limited a little

No, not limited at all

F4 During the past 4 weeks, how often have you accomplished less than you would have liked in your work or other regular daily activities as a result of your physical health?

(Tick ONE box only)

All of the time

Most of the time

Some of the time

A little of the time

None of the time

F5 During the past 4 weeks, how often have you been limited in performing any kind of work or other regular daily activities as a result of your physical health?

(Tick ONE box only)
All of the time  
Most of the time

Some of the time
A little of the time
None of the time

**F6** During the **past 4 weeks**, how often have you accomplished less than you would have liked in your work or any other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

*(Tick **ONE** box only)*

All of the time  
Most of the time

Some of the time
A little of the time
None of the time

**F7** During the **past 4 weeks**, how often have you done work or other activities less carefully than usual as a result of any emotional problems (such as feeling depressed or anxious)?

*(Tick **ONE** box only)*

All of the time  
Most of the time

Some of the time
A little of the time
None of the time

**F8** During the **past 4 weeks** how much did pain interfere with your normal work (both outside the home and housework)?

*(Tick **ONE** box only)*

Not at all  
A little bit

Moderately
Quite a bit
Extremely
F9  How much during the past 4 weeks have you felt calm and peaceful?
   (Tick ONE box only)
   All of the time
   Most of the time
   Some of the time
   A little of the time
   None of the time

F10  How much during the past 4 weeks did you have a lot of energy?
   (Tick ONE box only)
   All of the time
   Most of the time
   Some of the time
   A little of the time
   None of the time

F11  How much during the past 4 weeks have you felt downhearted and depressed?
   (Tick ONE box only)
   All of the time
   Most of the time
   Some of the time
   A little of the time
   None of the time

F12  During the past 4 weeks how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?
   (Tick ONE box only)
   All of the time
   Most of the time
   Some of the time
   A little of the time
   None of the time

SF-12v2(tm) Health Survey (c) 2000 by QualityMetric Incorporated - All rights reserved
SF-12v2(tm) is a trademark of QualityMetric Incorporated
Section G  Obstetric History

Finally, please could you tell us a little about all of the births you have had? If any were twins or more, please fill in the next BIRTH record for the second and subsequent babies.

G1  FIRST BIRTH

a. Date of baby's birth  \[ \underline{D} \underline{D} / \underline{M} \underline{M} / \underline{Y} \underline{Y} \underline{Y} \underline{Y} \]

b. Baby's birth weight \[ \underline{\text{lbs}} \underline{\text{oz}} \text{ OR } \underline{\text{Kg}} \text{ Don't know} \]

c. What type of delivery did you have?
   Normal vaginal delivery  \[ \square \]
   Caesarean before labour  \[ \square \]
   Caesarean during labour  \[ \square \]
   Vacuum delivery  \[ \square \]
   Forceps delivery  \[ \square \]
   Breech (vaginal)  \[ \square \]

Did you have stitches to your perineum (tail end)?

Stitches to cut (episiotomy)  \[ \square \]
Stitches to tear (no cut)  \[ \square \]
Tear but no stitches  \[ \square \]
No stitches, no tear (intact)  \[ \square \]

e. Was it a single or multiple birth (eg twins)?  \[ \square \text{Single} \quad \square \text{Multiple} \]

f. Did you have an epidural or spinal anaesthetic for this delivery?  \[ \square \text{Yes} \quad \square \text{No} \]

G2  SECOND BIRTH

a. Date of baby's birth  \[ \underline{D} \underline{D} / \underline{M} \underline{M} / \underline{Y} \underline{Y} \underline{Y} \underline{Y} \]

b. Baby's birth weight \[ \underline{\text{lbs}} \underline{\text{oz}} \text{ OR } \underline{\text{Kg}} \text{ Don't know} \]

c. What type of delivery did you have?
   Normal vaginal delivery  \[ \square \]
   Caesarean before labour  \[ \square \]
   Caesarean during labour  \[ \square \]
   Vacuum delivery  \[ \square \]
   Forceps delivery  \[ \square \]
   Breech (vaginal)  \[ \square \]

Did you have stitches to your perineum (tail end)?

Stitches to cut (episiotomy)  \[ \square \]
Stitches to tear (no cut)  \[ \square \]
Tear but no stitches  \[ \square \]
No stitches, no tear (intact)  \[ \square \]

e. Was it a single or multiple birth (eg twins)?  \[ \square \text{Single} \quad \square \text{Multiple} \]

f. Did you have an epidural or spinal anaesthetic for this delivery?  \[ \square \text{Yes} \quad \square \text{No} \]
### G3  THIRD BIRTH

a. Date of baby's birth
   - D D / M M / Y Y Y Y

b. Baby's birth weight
   - lbs oz OR Kg

- Don't know

c. What type of delivery did you have?
   - Normal vaginal delivery
   - Caesarean before labour
   - Caesarean during labour
   - Vacuum delivery
   - Forceps delivery
   - Breech (vaginal)

Did you have stitches to your perineum (tail end)?

- Stitches to cut (episiotomy)
- Stitches to tear (no cut)
- Tear but no stitches
- No stitches, no tear (intact)

e. Was it a single or multiple birth (eg twins)?
   - Single
   - Multiple

f. Did you have an epidural or spinal anaesthetic for this delivery?
   - Yes
   - No

### G4  FOURTH BIRTH

a. Date of baby's birth
   - D D / M M / Y Y Y Y

b. Baby's birth weight
   - lbs oz OR Kg

- Don't know

c. What type of delivery did you have?
   - Normal vaginal delivery
   - Caesarean before labour
   - Caesarean during labour
   - Vacuum delivery
   - Forceps delivery
   - Breech (vaginal)

Did you have stitches to your perineum (tail end)?

- Stitches to cut (episiotomy)
- Stitches to tear (no cut)
- Tear but no stitches
- No stitches, no tear (intact)

e. Was it a single or multiple birth (eg twins)?
   - Single
   - Multiple

f. Did you have an epidural or spinal anaesthetic for this delivery?
   - Yes
   - No
### G5  FIFTH BIRTH

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Date of baby's birth</td>
<td></td>
<td>/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Baby's birth weight</td>
<td></td>
<td>lbs</td>
<td></td>
<td>oz</td>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>c. What type of delivery did you have?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal vaginal delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caesarean before labour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caesarean during labour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forceps delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breech (vaginal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you have stitches to your perineum (tail end)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stitches to cut (episiotomy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stitches to tear (no cut)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tear but no stitches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No stitches, no tear (intact)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Was it a single or multiple birth (eg twins)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Did you have an epidural or spinal anaesthetic for this delivery?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### G6  SIXTH BIRTH

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Date of baby's birth</td>
<td></td>
<td>/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Baby's birth weight</td>
<td></td>
<td>lbs</td>
<td></td>
<td>oz</td>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>c. What type of delivery did you have?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal vaginal delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caesarean before labour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caesarean during labour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forceps delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breech (vaginal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you have stitches to your perineum (tail end)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stitches to cut (episiotomy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stitches to tear (no cut)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tear but no stitches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No stitches, no tear (intact)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Was it a single or multiple birth (eg twins)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Did you have an epidural or spinal anaesthetic for this delivery?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
G7  If you have had more than 6 babies how many in total have you had?

G8  Are you pregnant at the moment?
Yes  No

If yes, date baby due  D  D /  M  M /  Y  Y  Y  Y

If this questionnaire was sent to the wrong address, please give the correct details here:

Your new address:

Your email address:
We have two more things to ask you:

1. **We would like to write to you in the future** to ask for your help with continuing research into incontinence and prolapse.

   **Are you are willing for us to contact you in the future about further research?** (please tick one box)

   - [ ] Yes
   - [ ] No
   - [ ] We will not contact you again

   We would be grateful if you would give us another contact address (your ‘best contact’, e.g. your parents or another relative) to increase our chances of being able to get in touch with you in a few years’ time.

   **Name of best contact:**
   **Relation to you:**
   
   **Their address:**
   **Phone Home:**
   **Phone Work:**
   **Phone Mobile:**

   **Their email Address:**

   Please could you let this person know that you have given us their details.

2. **We would also like to access your medical or electronic records (such as from the Birth Registry at Dunedin Hospital) for other information about your health.**

   Please tick this box IF YOU AGREE to us accessing these records.

   If you would like a copy of the results of the study, please tick this box:

Thank you for your help.

Your answers will be treated with complete confidentiality, and will only be used for research aimed at improving Women’s Health.
Please send the questionnaire back to us in the postage paid envelope provided
Appendix B  Sexual Function Questionnaire (pull-out section)

Section D  Sexual Function  (separate pull-out section)

Sexual function may be influenced by many factors. We are trying to find out how many women who had children experience sexual dysfunction, how this affects their quality of life and whether this is related to their delivery.

We would be grateful if you could answer this separate pull-out Section D on sexual function.

This is a very sensitive subject and you don’t have to answer these questions if you don’t want to. Your answers, though, would be used to help improve health care for women after they have given birth. Even if you choose not to answer these questions, we would be very grateful if you would send back the rest of the questionnaire as this will still be very useful for the research on its own.

*(Please tick one box in each row)*

D1  Which of the following best describes you?

Not sexually active at all  □  →  Go to D2
Sexually active with or without a partner  □  →  Go to D4

Section 1: For those who are not Sexually Active

☀ If you engage in sexual activity please check this box □ and skip to D4

D2  The following are a list of reasons why you might not be sexually active, for each one please indicate how strongly you agree or disagree with it as a reason that you are not sexually active.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Somewhat Agree</th>
<th>Somewhat Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>No Partner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>No interest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>Due to bladder or bowel problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>Because of my other health problems</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
e  Pain

f  Partner’s health problems

D3  How much does the fear of leaking urine and/or stool and/or a bulging in the vagina (either the bladder, rectum or uterus falling) cause you to avoid or restrict your sexual activity?

(Tick ONE box only)

Not at all
A little
Some
A lot

End of Items for Not Sexually Active
(please go to Section E)
Section 2: For those who are sexually active

The remaining items in the survey are about a topic that one is not often asked to report on in a survey, please answer as honestly and clearly as you possibly can.

Following are a list of questions about you and your partner’s sex life. All information is strictly confidential. Your answers will be used only to help doctors understand what is important to women about their sex lives. Please tick the box that best answers the question for you. While answering the questions, consider your sexuality over the past SIX MONTHS.

(Please tick one box in each row)

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Always</th>
<th>Usually</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>D4</td>
<td>How frequently do you feel sexual desire?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5</td>
<td>Do you climax (have an orgasm) when having sexual intercourse with your partner?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D6</td>
<td>Do you feel excited (turned on) when having sexual activity with your partner?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D7</td>
<td>How satisfied are you with the variety of sexual activities in your sex life?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D8</td>
<td>Do you feel pain during sexual intercourse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D9</td>
<td>Are you incontinent (leak urine) with sexual activity?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D10</td>
<td>Does fear of incontinence (either stool or urine) restrict your sexual activity?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D11</td>
<td>Do you avoid sexual intercourse because of bulging in the vagina (bladder, rectum or vagina falling out)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D12</td>
<td>When you have sex with your partner, do you have negative emotional reactions such as fear, disgust, shame or guilt?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D13</td>
<td>Does your partner have a problem with erections that affects your sexual activity?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Does your partner have a problem with premature ejaculation that affects your sexual activity?

Compared to orgasms that you have had in the past, how intense are the orgasms you have had in the past six months?

(Tick ONE box only)

Much less intense
Less intense
Same intensity
More intense
Much more intense

How strongly do you agree or disagree with each of the following statements:

A. I feel frustrated with my sex life

B. I feel sexually inferior because of my incontinence and/or prolapse

C. I feel angry because of the impact that incontinence and/or prolapse has on my sex life

How adequate do you think your vaginal tone is for your own satisfaction?

How adequate do you think your vaginal tone is for your partner’s satisfaction?

Overall, how satisfied are you with your sex life?
Appendix C  Prolong POP-Q Examination Sheet

ProLong POP-Q Examination Sheet

Patient Identification

Date of Examination

Consent Form Signed

USS assessment

Blinded to Obstetric History

Cervix present

Bladder empty

Bowel empty

<table>
<thead>
<tr>
<th>Cervix present</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder empty</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Bowel empty</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External</th>
<th>Hymen</th>
<th>Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm</td>
<td>+10</td>
<td>-10</td>
</tr>
<tr>
<td>Aa</td>
<td>+9</td>
<td>-9</td>
</tr>
<tr>
<td>Ba</td>
<td>+8</td>
<td>-8</td>
</tr>
<tr>
<td>C</td>
<td>+7</td>
<td>-7</td>
</tr>
<tr>
<td>D</td>
<td>+6</td>
<td>-6</td>
</tr>
<tr>
<td>Bp</td>
<td>+5</td>
<td>-5</td>
</tr>
<tr>
<td>Ap</td>
<td>+4</td>
<td>-4</td>
</tr>
<tr>
<td>+3</td>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>+2</td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td></td>
<td>S1 Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-2</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-3</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-4</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-5</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-6</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-7</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-8</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-9</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
<tr>
<td>-10</td>
<td></td>
<td>Stage 0 or 1 (depending on TVL)</td>
</tr>
</tbody>
</table>

Genital Hiatus  Perineal Body  Total Vaginal Length

Cm  Cm  Cm

Prolapse Stage (1 to 4):

Anterior (Ba)
Cervix/uterus (C)

Posterior (Bp)
OR Vault/cuff (C)
### Bimanual Examination & Other Findings

**Levator Palpation**

<table>
<thead>
<tr>
<th>Levator Palpation</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Avulsion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Avulsion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix D  Modified Oxford Grading and Proposed Scale for Levator Resting Tone

Modified Oxford Grading
0:  No Contraction
1:  Flicker
2:  Weak
3:  Moderate (with lift)
4:  Good (with lift)
5:  Strong (with lift)

A proposed scale for the grading of levator resting tone
0:  Muscle not palpable
1:  Muscle palpable but very flaccid, wide hiatus, minimal resistance to distension
2:  Hiatus wide but some resistance to distension
3:  Hiatus fairly narrow, fair resistance to palpation but easily distended
4:  Hiatus narrow, muscle can be distended but high resistance to distension, or pain
5:  Hiatus very narrow no distension possible, ‘woody’ feel, possibly with pain: “vaginismus”.
Appendix E  Thesis related publications and presentations


Kamisan Atan I, Lin S, Herbison P, Dietz H P, Wilson P D. Levator avulsion is associated with pelvic organ prolapse 20 - 30 years after the first birth. ICS 2015, Montreal, Canada. 6-9 October 2015. Podium Short Oral Presentation (Neurourology & Urodynamics J. ( to be published)


