Symphysiotomy & Pubiotomy Review- an Imaging Perspective

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Appendix I- Review.

Introduction.

From the outset the SPS team led by Judge Maureen H. Clark felt that it was vital that they themselves endeavour to develop a comprehensive understanding of female pelvic anatomy in both health and disease. Furthermore they were keen that all applicants be afforded a comprehensive clinical case review in line with best practice. For both these reasons it was hoped that diagnostic imaging could be of some value. Only through a balanced understanding of potential anatomic effects of symphysiotomy and pubiotomy on the pelvic structures could one form an opinion on associated morbidity.

Whilst it is for others to decide on the rights and wrongs of the procedures under discussion; it was the responsibility of the radiologist to work with the judge to provide an objective, measurable assessment of the procedure and its effects on the individual patient and their anatomy. This appendix reflects my experience of cases reviewed and their findings. I think it is a unique case series in that much effort was devoted to gathering historical documentary clinical information, oral commentary and clinical assessment which were ultimately reconciled with the imaging. As such it is the most thorough attempt at clinico-pathologic assessment for the symphysiotomy procedure that I am aware of.

In my opinion the judge and her legal counsel on the SPS team developed a particularly keen and insightful knowledge of both the procedure and how patients were affected. The sincerity of advocacy for all applicants posed very challenging questions of the diagnostic imaging and required an application of expertise in general imaging as well as subspecialty interests including musculoskeletal, urologic, gynaecologic and obstetric conditions. The analysis of cases by the SPS team raised original questions and intellectual challenges of the imaging not previously considered by myself or others with an interest in the pelvis in health and disease..

What are some of the questions that were explored?

- Are there radiology findings specific to prior symphysiotomy/pubiotomy operative intervention?
- Are there any patterns of joint disruption that can be solely attributed to such procedures and distinct from multiparity findings?Are there radiology findings specific to ‘pelvic instability’ in this patient cohort?
- What does pelvic instability mean in this cohort?

- Is there a correlation for focal pain on clinical examination?
- Is there a pattern of pelvic ring arthropathy that can be causally linked to the mainly symphysiotomy procedures performed?
- Can some of the patient symptoms be explained by imaging including issues such as dyspareunia?
- Are there imaging findings that demonstrate the prior incisions on MRI?

Pelvis Diagnostic Imaging-Then and Now.

For those not well versed in pelvic diagnostic imaging I present a brief overview. The **plain radiograph or x-ray** is the workhorse modality of past and modern medicine. It is a relatively easy test for patients and widely available nationally. Should one have symptoms in the pelvis in 2016 it remains the first diagnostic test performed and would have been for the general population in the era under review it was by far the most common modality presented for review in the SPS. It is a very high quality test for bone and joint and clearly and objectively defines the width of the pubic symphysis. Furthermore it is sensitive for degenerative changes such as ostephytosis and sclerosis of the bone. Dimensions and alignment can be measured directly and accurately. As well as imaging the pubic symphysis the standard radiograph affords us a view of hips, sacroiliac joints and a limited perspective of the lower lumbar spine Fig.1.

The Computed Tomography-(**CT scan)** is the advanced tomogaphic version of the x-ray. It has been widely available since the late 1970s and is a feature of most modern hospitals today. It gives similar information in relation to the pubic symphysis as the x-ray but also some insights into the soft tissues nearby. 2D & 3D reconstructions of these images gives us unique perspectives to review the bone and joints. (Figs.2,3). This would not have been easily accessible or considered standard in the era under review but has been accessible and widely available in the last 3 decades in Ireland. It is widely applied for pelvic imaging and considered a basic investigation now.

Magnetic Resonance Imaging (MRI) has become increasingly routine and certainly is applied widely in womens health and in particular pelvic health. It does not use radiation and as such it can be safely used assess pregnant women. We use it to assess uterus, ovaries, rectum, bladder as well as all the pelvic joints. For the muscuoskeletal system its strength lies in providing high quality information on muscle, tendons and joints. (Figs.4,5)).It has sensitivity for marrow signal, a sign of bone stress, not obtained easily with x-ray. We found it useful when we wanted to assess the presence or absence of joint fluid. The MRI depicts the close relationship of the pubic symphysis to the urethra and vagina. It can also be used to depict functional anatomy with movement when required and is standard for pelvic floor function assessment. When urinary symptoms or dyspareunia were raised, I specifically assessed this relationship. An MRI can be a difficult procedure for the older patient due to protracted time on a firm table in a claustrophobic space. As such MRI was only recommended when it was likely to provide specific additional information.

Other modalities available to study the joint include ultrasound and nuclear medicine but these not relevant to this discussion.

The pubic symphysis is routinely imaged in radiology practice in 2016 for a variety of reasons in both males and females. The lead indication is probably orthopaedic assessment. It is the focus of imaging in many emergency or unscheduled settings such as trauma and is often the focus of study in the more elective setting of infection, oncology or sports and chronic repetitive injuries. Furthermore,

this joint is commonly visualised coincidentally in the evaluation of other issues, - such as hips or soft tissues of the pelvis. Suffice it to say that imaging of this joint is considered quite routine.

In the patient group under review, there was no contemporaneous imaging available from the time of procedure or in the subsequent early years. It was not and is not routine practice to perform diagnostic imaging after delivery of a child except in exceptional circumstances. I understand that in the 1940s and 1950s it was normal to perform imaging before and after symphysiotomy or pubiotomy. The radiology usually remarked on the increase in true conjugate of the pelvis following the symphysiotomy. However, none of those x-rays or reports survives or was produced for review. Though musculoskeletal symptoms formed the core theme in the majority of applications, it seems that diagnostic imaging was seldom if ever performed throughout the intervening years. All imaging received was from relatively recent times and no more than 2/3 imaging reports from earlier years were available to me. I can only conclude that in most cases, none was performed as there has always been ready access to plain film radiography and reports are typically filed in hospital and primary care records. This was disappointing as we were unable to assess changes over time and were limited in our specificity and ability to discriminate physiologic and aging changes from premature or pathologic changes due to surgical procedures. On a couple of occasions when pubiotomy was claimed, access to radiology for a period of 15 years established that pelvic fractures had long post-dated the symphysiotomy and were likely due to trauma or insufficiency.

The Physiologic Changes of the Pelvis in Pregnancy.

The pubic symphysis is a diathrodial cartilaginous joint. The joint does not have a synovial lining and contains little if any fluid. Furthermore, it is bound by ligaments above and below. The bones have a structure similar to other body parts with marrow, overlying cortex and hyaline cartilage. The joint margins are typically relatively straight and parallel, though the anterior and posterior joint margins can diverge from the midline. There are capsule and ligament and tendon attachments. Immediately posterior to the joint is a small amount of fat, then one encounters the urethra and bladder neck. The uterus and vagina are posterior to this.

The body undergoes many and complex changes and adaptations during pregnancy and in preparation for delivery. There is softening and increased movement of the otherwise firm cartilaginous joints of the pelvis including the sacroiliac joints and pubic symphysis. This will ultimately aid the safe passage of baby. Advanced care of mother and child in recent times has afforded us a new imaging insight into some of these changes. Occasionally we are called upon to apply advanced imaging techniques to the pelvis of pregnant and post-partum women in an effort to solve other problems such as clotting and infection. I illustrate here a case of young women 7-days after a normal spontaneous vaginal delivery (Fig.5). What we see at the pubic symphysis is a significant diastasis, a tear of supporting ligaments, disruption of the cartilage and a fluid filled joint. Further-more, increased fluid signal is noted in the sacroiliac joints and oedema or bruising of erector spinae muscles, iliac muscles and gluteus maximus. This constellation of findings is due to the extra-ordinary forces at play on already flexible structures. This case reflects a spontaneous separation of the pubic symphysis. We know that the majority of changes documented will/may return to normal. However we also know that some women will not return to normal particularly in the setting of multiparity. A persistent diastasis of the joint may be seen. Pelvic floor dysfunction is a well-documented neurologic and muscular condition affecting some women after delivery and would be a routine aspect of pelvic imaging practice today. It is likely, in my opinion, that in the

absence of surgical procedure to the pubic symphysis, a woman suffers significant disruption to varying degrees in pregnancy. I cannot say with confidence that an iatrogenic disruption is necessarily more destructive than a spontaneous disruption in all cases. This debate would be similar to that in planned versus spontaneous episiotomy.

What is the role of imaging in the assessment of the symphysiotomy/pubiotomy patient?

Judge Clark hoped that a direct imaging assessment of the surgical site(s) under discussion would be of additional value in case review. Certainly an imaging assessment would form part of the standard of care of most patients referred with symptoms or signs referable to the pelvis in routine practice. Personally I hoped that direct imaging review and interpretation would potentially prove or disprove that such a procedure had taken place where other evidence was lacking. I hoped that if we could better understand the spectrum of radiologic findings we might be able to better classify the degree of morbidity or symptoms suffered. It was a unique opportunity to better understand the female pelvis in both health and post procedure.

Method.

When a case was presented to me for review it was without any bias and usually I had no knowledge of whether a symphysiotomy or pubiotomy was performed. Imaging was presented in the form of a CD disc from another hospital and rarely in the form of hard-copy film. Imaging was performed in a wide variety of public and independent hospitals and was overall of high quality. CDs were loaded in the standard fashion and viewed using viewer technology, typically embedded in the disc. If the applicant did not present with imaging attempts were made, in so far as possible, to find all previous imaging to limit their need for hospital visits and additional studies. I searched the national archive NIMIS using the patient demographics. This limited it us to imaging performed since the late 2000s. Sometimes, older imaging was retained in hospitals and these hospitals were contacted. Occasionally, where no imaging was available, but it was felt relevant to the case, an imaging study was recommended. Plain radiographs were generally recommended. Though more advanced modalities can give more information I felt MRI could be onerous for the older person and so only recommended MRI and CT in a few cases where there was reason to believe it could specifically benefit the case. In some, but not all cases, I did have the original radiologist report of imaging. Generally the findings were concordant with the original interpretation. On occasion the original reader was contacted to reconcile my interpretation with theirs. Occasionally findings were discussed in consultation with orthopaedic specialist colleagues or in a multidisciplinary forum. In a significant number of cases the radiology report noted that there was a *history* of symphysiotomy or more rarely, pubiotomy but in all such cases this transpired to be an unproven presumption based on a referral letter rather than as a result of an interpretive finding.

Imaging Features Described.

I designed a review format that allowed ease of communication and reproducibility for non-physicians. This was informed by a need to have an objective, scalable and reproducible method to allow review. In addition, it was hoped that the features observed would in some way correlate with the various symptoms and signs that applicants reported e.g. sacroiliac pain was commonly noted so we sought distinctive features in this joint.

Data points included;

- Demographic information
- Modality of study(ies); date;location
- Features of pubiotomy – yes or no
- Pubic symphysis
    - Diastasis present/not; degree of widening. 4mm was deemed to be the mean normal radiolucent space between the pubic bones.
    - Translation. Measurement of and step off superiorly/inferiorly between the bones. More than 1.5mm was thought abnormal.
    - Osteophytosis
    - Ankylosis
    - Bone sclerosis
    - Soft tissue calcification
    - Soft tissue, tendon and capsule/ligament changes were noted if MRI or CT were performed
    - Bone oedema was noted if MRI was performed.
- Sacroiliac joint arthropathy
- Hip arthropathy
- Any other significant findings including scars, metal artefact

Imaging Features Categories.

At the outset I felt it would be a useful undertaking to categorise the imaging findings based on the spectrum of findings on review. It seemed there were imaging features of many joints that were similar to the normal population. Similarly there were findings in some patients that were extra-ordinary to the normal population. We found there were symphysiotomy patients where the joint returned to absolute normality, indistinguishable from the normal population. I am unable to reconcile pelvic joint symptoms in patients where the joint had returned to normal alignment and support. There were those who did not have symphysiotomy where there were significant joint abnormality as a consequence normal pregnancies. Finally there were patients in whom I felt the findings perhaps were more than normal. Clearly there were shades of grey between these categories and all of this was compounded by age and other life changes.

The majority of cases related to symphysiotomy not pubiotomy and thus the information here reflects this group.

In all cases judgement was used to assess the likelihood that there had been a prior symphysiotomy. However this opinion was ultimately reconciled with the history, physical or clinical records by the judge in her final assessment. The open and critical review of my findings by the team was ultimately beneficial to all. The dialogue helped me form a more complete understanding of the procedures and the SPS team brought a very objective assessment of the imaging review.

TYPE I. An imaging feature that is ***highly specific*** for a prior operative intervention and for which there is no reasonable alternate differential for the finding. Such findings ‘rule in’ that such a procedure was performed. I did have to acknowledge that multiparity could potentially cause similar findings and in such cases the ultimate decision was based on reconciling with other information obtained. Included in this group would be

- A healed prior osteotomy/pubiotomy

- Symphysis pubis ankylosis
- Symphysis pubis diastasis over 1cm
- Symphysis pubis translation over 5mm

TYPE II. An imaging feature that in isolation is **not specific** for a prior operative intervention and for which there a reasonable differential for the finding is including physiology of labour and aging. However the finding would not be very prevalent in the age group under review and in the presence of other findings (notes, scars etc.) the finding is potentially supportive of a prior operative intervention whilst again acknowledging the potential for overlap with the normal population.

- Symphysis pubis diastasis > 5mm <1cm
- Symphysis pubis translation/offset >2mm<5mm

Findings of sacroiliitis or pubic symphysis disruption more advanced than for age group or otherwise explained.

TYPE III. A finding that is common in the age group under review and is commonly seen after normal weight bearing and child birth. Such findings are **not** supportive of prior operative intervention. Such findings are not discriminatory of these patients from their normal peers.

- Degenerative change- osteophytes/cysts/capsular ligament thickening.
- Osteitis pubis acute and chronic
- Sacroiliitis

I made some presumptions and associations based on my experience of imaging in womens health E.g. I felt calcifications in the soft tissues in the region of the joint could represent post inflammatory change and could be symptomatic in select cases. In cases of dyspareunia, large posterior osteophytes could lead to local discomfort. It is difficult to reconcile features of osteitis pubis to the procedure. I felt that very large widening of the pubic symphysis could lead to unusual movement and pain. Ultimately I accepted the limits of imaging, including advanced modalities. Though the appearances of pubiotomy were pathognomonic, the features of symphysiotomy were much less so. I could never see the scar or direct evidence of surgery on imaging even with CT and MRI. Nor could I see direct evidence that proved conclusively that arthropathies, urinary symptoms or sexual issues could be absolutely associated with the procedure in many cases.

The diagnosis of '**pelvic instability'** was mentioned many times in applications. It is not an entity that is clearly defined in this context. Though we all accept the 'pelvic ring' theory of pelvic trauma this is largely applied in the setting of high velocity or crush trauma to the pelvis and is somewhat out of context in the setting of a controlled dissection of the joint. Furthermore it usually refers to the acute phase of a trauma and before surgical fixation. I cannot say after review of all the cases I recognise a specific pattern of pelvic instability by imaging in this cohort. I was mindful of this and some of the clinical examinations that purported to demonstrate this instability but ultimately I did not see a pattern or specific features to support this entity. We know there are cases of bladder exstrophy and absent pubic symphysis and some surgeons perform pubis osteotomies and yet neither of these conditions is associated with pelvic instability syndromes.

There were a small subset of patients where directly observable imaging findings were, in my opinion, at significant variance from findings routinely observed *both* in the normal non-symphysiotomy population and indeed in the proven symphysiotomy patients. These were specific

radiologic findings such as soft tissue calcification or bone osteophytosis of such a degree or in a combination with other findings that I felt was at significant variance from that observed in the study series to date.

In the absence of a history or documentation to explain these findings outside of the symphysiotomy recovery context, I felt it was reasonable that this combination of findings could reasonably be ascribed to either extra-ordinary repetitive, chronic movement or inflammation or perhaps a combination of both. I based this on basic principles that we observe in imaging that chronic inflammation and repetitive movement can cause dystrophic calcifications and bone exostoses when healing. When an applicant demonstrated such striking findings, I reserved collective descriptors such as 'grossly abnormal' to describe them to the Scheme team. I further proferred my opinion that such findings could reasonably be considered to reflect a more symptomatic joint over a longer period of time.

Methodological Challenges.

There is very little evidence base/published literature on the subject of symphysiotomy in Ireland or elsewhere. Though still considered a reasonable and legitimate procedure for mother and baby safety in some jurisdictions, there is little in the way of contemporary scientific review and this would be a valuable exercise. The few papers on the subject have methodological weakness in sample size, control groups and the rigour of establishing symphysiotomy.

It is infinitely more difficult to assess clinical conditions when deprived of contemporaneous history, physical examination, documentary and diagnostic evidence. Record keeping and archiving was quite different to that we have come to expect today. Additionally, all joints may suffer deterioration from age and from coexisting conditions such as arthritis. Here, we are trying to make conclusions based on reconciling imaging today with events some time ago. In the setting of pubiotomy the changes of the healing bone remain, as they do for conventional fractures. The finding on imaging is quite specific and characteristic. However cartilage and soft tissue disruption which occurs with symphysiotomy is much more challenging and greatly limits our accuracy.

A note on Non Imaging Findings.

There is no perfect diagnostic test. Our practice in the care of all patients must recognise the patient's individuality and apply the most appropriate tests to the problem under review. Ultimately we proffer our best opinion based on experience, evidence and pattern recognition. All imaging in its final conclusion must be cognisant of non-imaging history and findings and these must be given an appropriate weighting in decision making.

Inter-operator Variance.

It is likely that operative procedures to widen the pelvic outlet were not carried out in a uniform manner nationally. There is nothing unusual in this or in many other surgical procedures. All musculoskeletal surgical procedures can vary in their radiographic appearance reflecting varying techniques. As such, it is expected that those who have undergone such a procedure may vary in their imaging features.

Symphysiotomy/Pubiotomy as a cause of other joint pathologies in the pelvic ring.

This was a question that required some reflection and was raised routinely in applications. In the series of cases I reviewed I did not see a pattern of arthropathy that was peculiar or unique to the symphysiotomy group. In fact, I reviewed cases with proven symphysiotomy where the patients had other pelvic joints that were remarkably good for their age. Furthermore I saw cases where ultimately a symphysiotomy was proven based on case notes but the joint had returned to a completely normal appearance and where it was reasonable to presume that the joint mechanics were those of a normal joint.

I did find significant lower back, sacroiliac and hip arthropathies in some patients but the pattern and degree was similar to that in the normal population, if matched for age and gender. Thus I frequently saw pelvic ring arthropathies in association with pubic symphysis changes but due to their prevalence I was never able to prove a causal relationship. It seemed to me that much of the pathologic findings on imaging presented for review were a source of debate as to whether the findings were causally related to the surgery or related to the aging process. These legitimate queries were raised both by applicants and their teams as well as the SPS team. As a practicing radiologist I felt comfortable in stating that the prevalence of many of the findings was a routine finding in the normal population and thus unlikely to be causally related. This view was shared by orthopaedic specialists involved. However I felt it was only fair to the process to try to scientifically establish this and communicate it in any final report.

With the help of colleagues, we found a similar non-symphysiotomy/pubiotomy cohort of females in the age range of the applicants and we studied their radiology. Unfortunately the scale of the review was limited by time but nevertheless served to inform us better about normal variations in the context of this review **(Appendix III).** Herein lies much of the challenge of understanding the joints of the SPS applicant. In the clinical and radiologic assessment we are met with historic physiologic changes of pregnancy, iatrogenic changes of surgery and these are compounded by overlap with the normal aging process.

Conclusion.

Imaging in medicine is not often 'pathognomonic' for the process under study. Its value in ruling in and ruling out morbidity is only fully realized when weighted and contextualized to the ***history, the clinical notes and physical examination***. I sincerely hope that diagnostic imaging was able to play a constructive role in this review. Personally I felt it brought a level of objectivity to the joint assessment. I think it may have had a discriminatory value in assessing morbidity in select cases. Its role was limited by the lack of contemporaneous imaging and the lack of imaging throughout the intervening years. We were in new ground with very limited knowledge about the sequelae of this procedure and few large scale studies of the normal aging population. I do not think it was ever able to definitively rule in or rule out a prior symphysiotomy though it could do so for pubiotomy. I did ultimately have to form an opinion on the basis of balance of probabilities. I learned that there were women who certainly had symphysiotomy and yet the joint returned to normality by imaging. There were others where it did not and it remained separated for some time. We could not separate this finding from that of the multiparous patient with confidence. I did not prove one is more likely to not return to normal in the setting of symphysiotomy compared to spontaneous diastasis. I never

could find a syndrome of features to establish pelvic instability or particular pattern of arthropathy highly specific to those who had a procedure.

Appendix II Figure References.

Plain Radiograph or X-ray-Fig. 1a

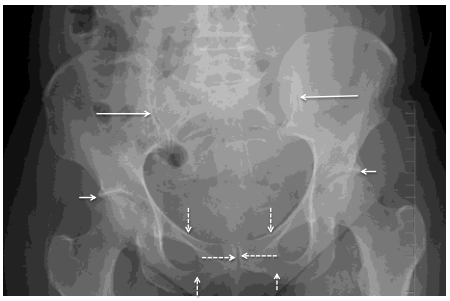


Fig.1a. Legend.

- Long white arrows – sacroiliac joints
- Short white arrows- hip joints
- Long dotted arrow- pubic symphysis
- Short dotted arrows – pubic rami

Fig 1b

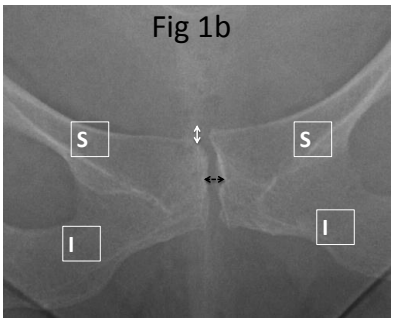


Figure 1b legends.

- S- superior pubic ramus
- I- inferior pubic ramus
- White arrow –translation
- Black arrow – Width /diastasis

Fig 1c.

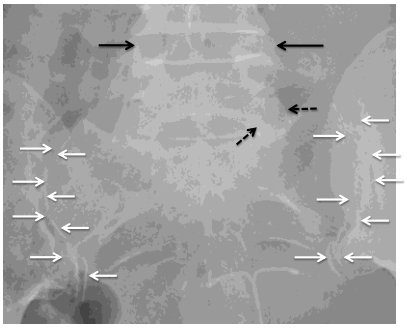


Fig.1c. legends

- Black arrows – lumbar disc space
- Black dotted arrows – lumbar facet joints
- White arrows –sacroiliac joints

Fig. 1d.

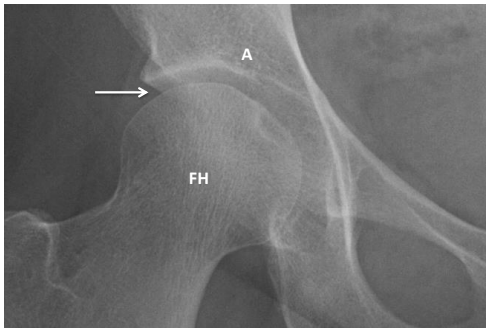


Fig.1d. Legends

- A- Acetabulum
- Long white arrow – hip joint
- FH – femoral head

CT-Two dimensional axial planar image-Fig.2.

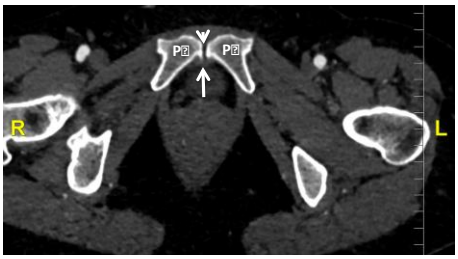


Fig.2. Legends.

- Short white arrow – pubic symphysis
- Long white arrow- joint capsule
- P – Pubic bone
- R- RIGHT hip
- L – LEFT hip

3DCT of pubic symphysis. Fig.3b.

Fig. 3b. Legends.

- S- superior pubic ramus
- I- inferior pubic ramus
- White arrow –translation
- Dotted white arrow – Width /diastasis

MRI Coronal Planar Image- Fig.4b

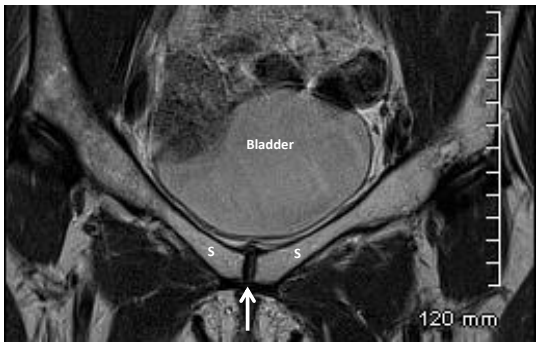


Fig. 4b Legend

- White arrow- symphysis pubis
- S- superior pubic rami

MRI Axial Image- Fig. 4a

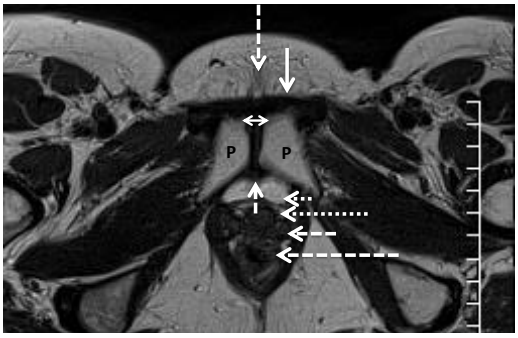


Fig.4a Legends

- Short dotted arrow – posterior pubic ligaments/capsule
- Long dotted arrow – pre-pubic subcutaneous fat
- Short solid arrow – anterior pubic ligaments/capsule
- Double arrow- pubic symphysis
- Long solid arrow – rectum
- Short white dotted arrow- retropubic fat
- Long white dotted arrow – urethra
- Short dashed white arrow- vagina
- Long dashed arrow - rectum

Functional MRI-Fig.4c.

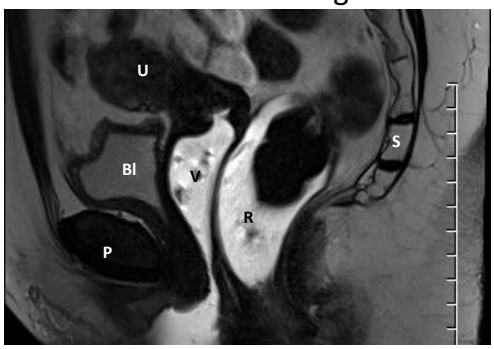


Fig.4c. Legend.

- P- pubic symphysis
- Bl – Bladder
- U – Uterus
- V- vagina
- R- Rectum
- S- sacrum

Axial MRI- Fig.4d.

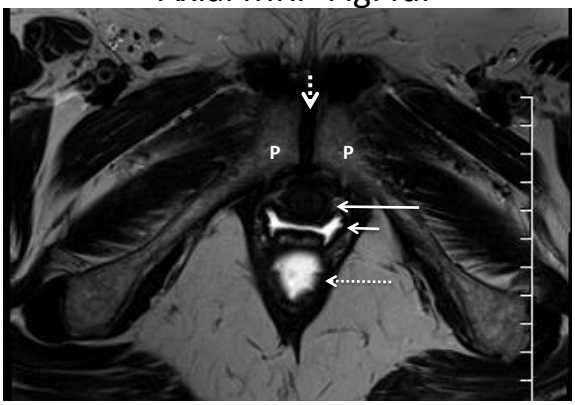


Fig.4d. Legends

- Short dotted white arrow – pubic symphysis
- P – pubic bones
- Long white arrow – urethra/bladder base
- Short white arrow – vagina
- Long dotted white arrow -rectum

Post Partum MRI. Fig.5a

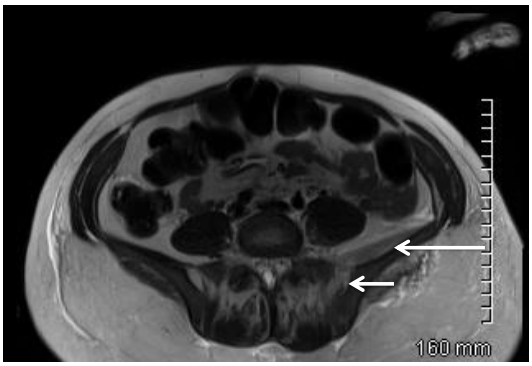


Fig. 5a Legends

- Long white arrow – LEFT iliacus edema
- Short white arrow – widened fluid filled LEFT sacroiliac joint

Post partum MRI. Fig.5b.

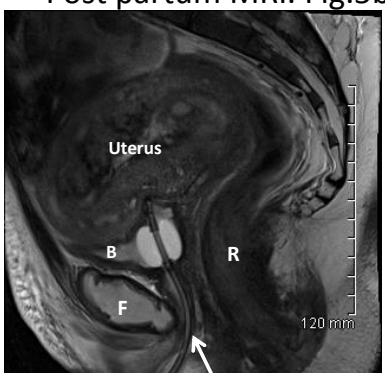


Fig.5b Legends

- F- Fluid filled pubic symphysis joint
- B- bladder
- White arrow – foley catheter in urethra
- R - Rectum

Post Partum MRI- Fig.5c

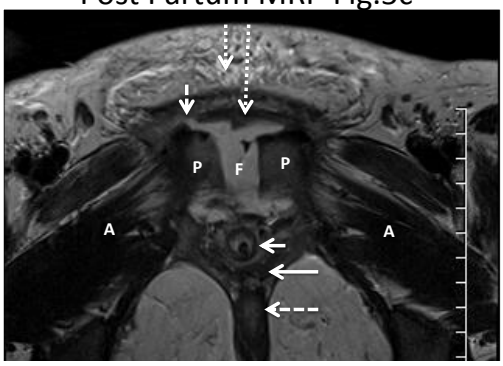


Fig. 5c. Legends.

- Short dotted arrow- pre-pubic fat
- Long dotted arrow- anterior supporting ligaments of pubic symphysis
- Short dashed arrow - tear in anterior supporting structures
- P- pubic bones
- F- fluid filled diastasis with fragments of torn cartilage
- A- Edematous adductor muscles
- Short white arrow – foley in urethra
- Long white arrow- vagina
- Long dashed white arrow -rectum

Post partum MRI. Fig. 5d

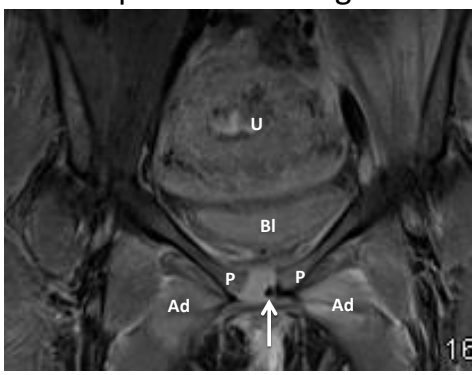


Fig.5d. Legends

- U- post partum uterus
- Bl – bladder
- P- pubic bones
- Arrow- torn symphysis cartilage fragment
- Ad – edematous adductor muscles

Fig. 5e.

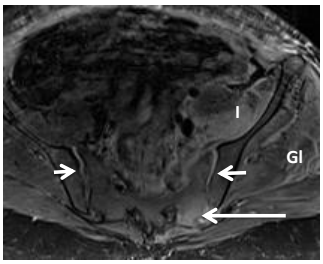


Fig.5e. Legends.

- I – edematous iliacus
- Gl- edematous gluteal musculature
- Short arrows- widened, fluid filled sacroiliac joints
- Long arrow- Edema of LEFT sacral marrow

As stated previously the set up of the Scheme as presented did not allow for a comprehensive scientific review of the conditions under question in advance of awards review. However we felt it would potentially be valuable to summarise retrospectively the data gleaned from the patients studied and to perform a limited review of an age and gender matched cohort. It is acknowledged from the outset that such reviews are limited in their scope and methodology.

APPENDIX III

Pelvis Imaging- An age and gender matched cohort review.

List of contributors: Drs. Heather K Moriarty(lead), David P Mitchell, Brian Gibney, James Ryan, Emma Stanley, Nuala Healy, Aaron Stirling, Alex Murphy, Danielle Byrne, Gavin Sugrue, Michael O'Reilly

Methods: All consecutive radiographs of female patients aged between 60 – 80 (at the time the radiograph was performed) taken in November 2015, January, March and May 2016 and 50 randomly selected radiographs performed per month in the remaining months from 1 September 2015 and 31 July 2016 were reviewed. Radiographs were performed at a single center between. Reviewers were all specialist registrars or radiology fellows.

The following search selection filter was created on the NIMIS system:

"Body Region – Pelvis

Modality – CR

Procedure Type - XR Pelvimetry

- XR Pelvis
- XR Pelvis And Hip LT
- XR Pelvis And Hip RT
- XR Pelvis Judet Both
- XR Pelvis Judet Lt
- XR Pelvis Judet Rt
- XR Pelvis Portable
- XR Pelvis Weightbearing

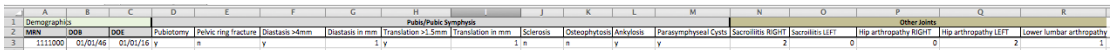
Work Group= - MMUH – Mater Radiology"

Female patients only between 60 – 80 years of age (at the time the radiograph was performed) were selected.

The degree of cranio-caudal asymmetry at the pubic symphysis was recorded as 'translation' and recorded in millimetres. Pubic diastasis was measured at the narrowest point.

The following parameters were recorded: MRN, DOB, DOE, Pubiotomy, Pelvic ring fracture, Diastasis >4mm, Diastasis in mm, Translation >1.5mm, Translation in mm, Sclerosis, Osteophytosis, Ankylosis, Parasymphyseal Cysts, Symphyeal arthropathy (any), Sacroiliac arthropathy RIGHT, Sacroiliac arthropathy LEFT, Hip arthropathy RIGHT , Hip arthropathy LEFT, Lower lumbar arthropathy. If there was a hip prosthesis in situ the side and type was recorded. Acute femoral neck fractures were recorded.

Fig 1: Example of data collected.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Demographics			Pubis/Pubic Symphysis										Other Joints				
2	MRN	DOB	DOE	Pubiotomy	Pelvic ring fracture	Diastasis >4mm	Diastasis in mm	Translation >1.5mm	Translation in mm	Sclerosis	Osteophytosis	Ankylosis	Parasymphyseal Cysts	Sacroiliitis RIGHT	Sacroiliitis LEFT	Hip arthropathy RIGHT	Hip arthropathy LEFT	Lower lumbar arthropathy
3	1111000	01/01/46	01/01/16	y	n	y	1	y	1	n	n	y	y	2	0	0	2	1

Osteoarthritis of the hip was graded using conventional radiograph grading. Ref 1, Addendum 1

Degenerative change at the sacroiliac joint was graded 1 - 4. Our grading system (addendum 2) is based on the grading of osteoarthritis of the hip and the Kellgren and Lawrence system classification of the severity of knee osteoarthritis. Ref 2, addendum 3.

Findings:

Demographics

562 pelvic radiographs reviewed.
Date of birth range October 1935 – April 1956. Median 16th October 1945
Age range 60 – 80 years. Median 71 years

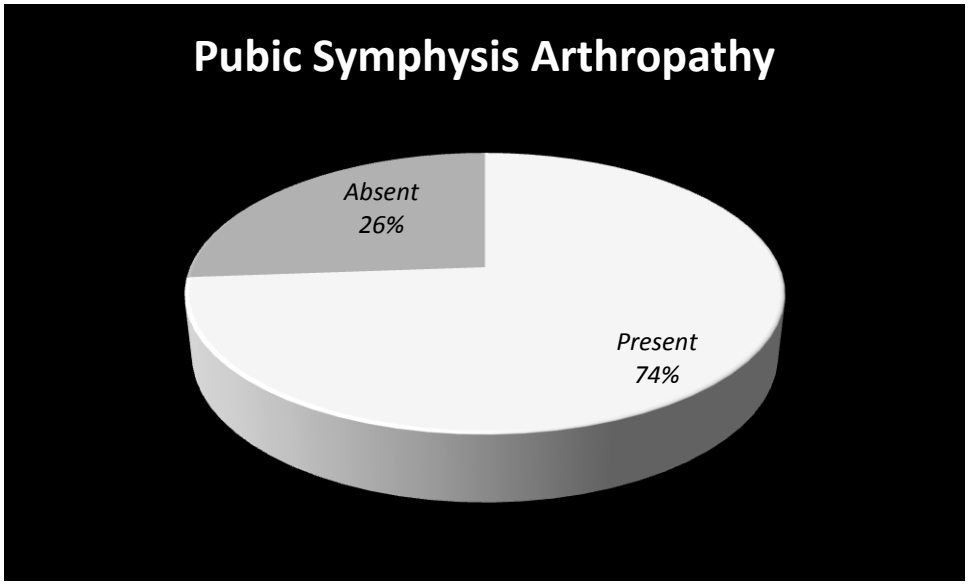
Pubic symphysis:

Pubiotomy : No 562. Yes 0 . Unrecorded 0.
Pelvic ring fracture: No 541. Yes 21 (3.6%). Unrecorded 0.

Pubic symphysis arthropathy:

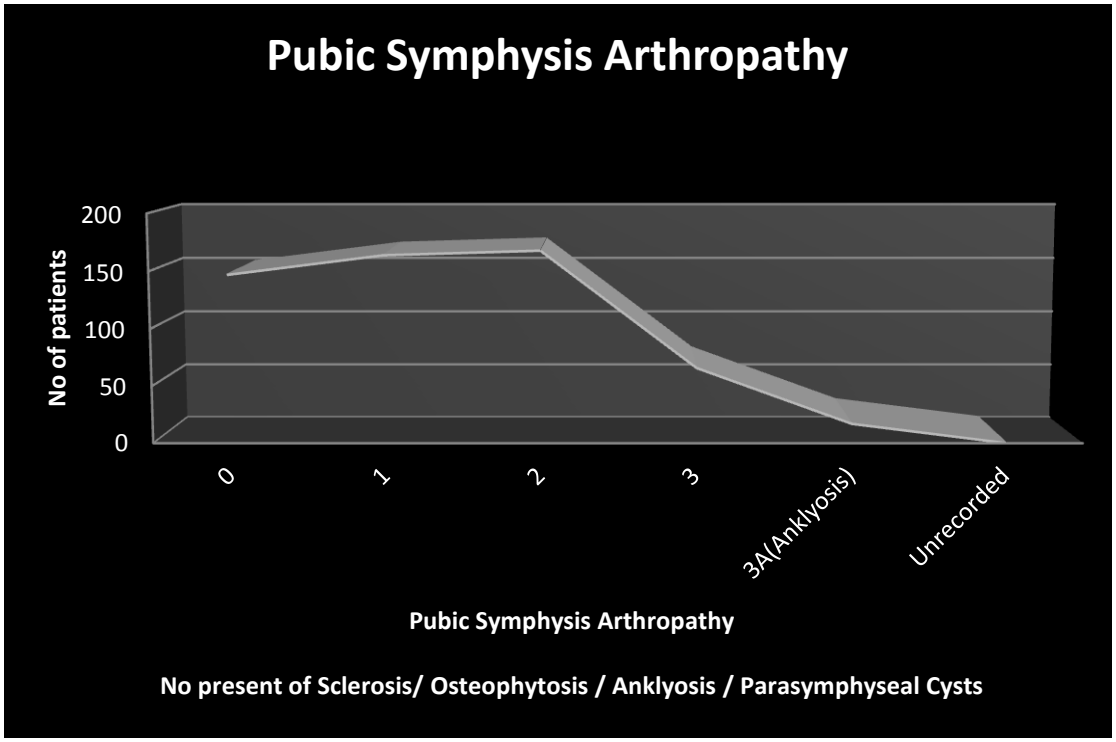
Sclerosis: No 244. Yes 318. Unrecorded 0.
Osteophytosis: No 258. Yes 304. Unrecorded 0.
Anklyosis: No 545. Yes 17 (3.02%). Unrecorded 0.
Parasymphyseal Cysts: No 444. Yes 118. Unrecorded 0.

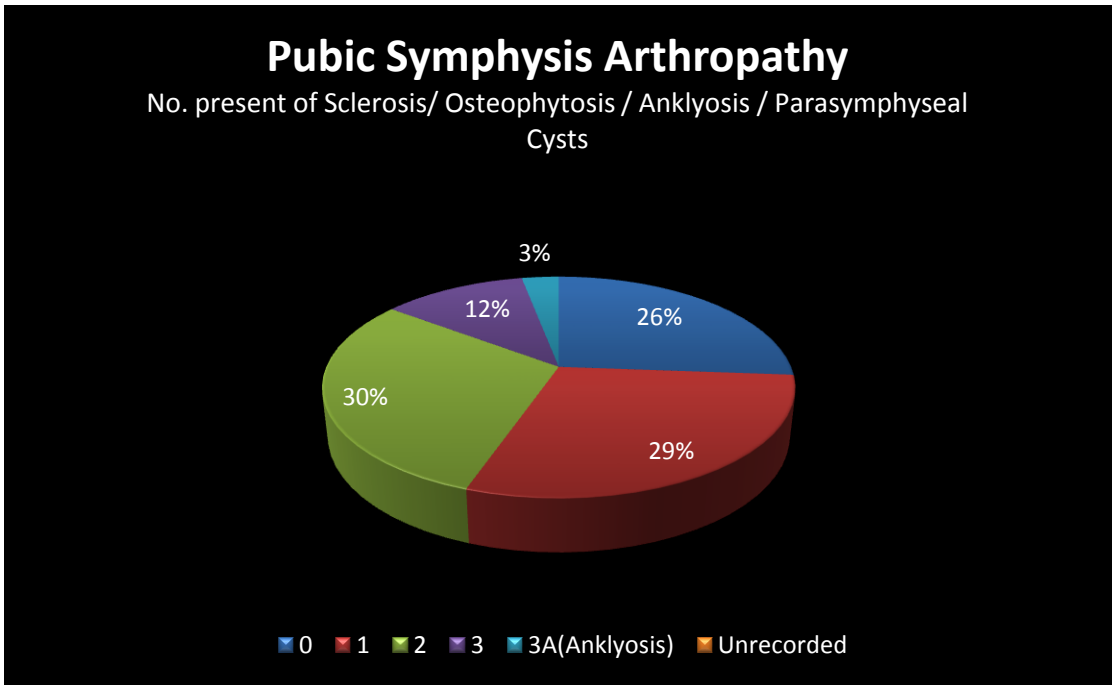
415 of 562 had (ANY) evidence of pubic symphysis arthropathy (73.84%)
147 had NO evidence of pubic symphysis arthropathy (26.21 %)



All 17 patients with ankylosis had at least 2 of Sclerosis/ Osteophytosis / Anklyosis / Parasymphyseal Cysts.
66 patients had all three of Sclerosis/ Osteophytosis / Parasymphyseal Cysts without Ankylosis
138 patients had sclerosis and osteophytosis but no other evidence of pubic symphysis arthropathy

21 patients had Parasymphyseal Cysts and sclerosis but no other evidence of pubic symphysis arthropathy
9 patients had Parasymphyseal Cysts and osteophytosis but no other evidence of pubic symphysis arthropathy
76 patients had sclerosis but no other evidence of pubic symphysis arthropathy
80 patients had osteophytosis but no other evidence of pubic symphysis arthropathy
8 patients had Parasymphyseal Cysts but no other evidence of pubic symphysis arthropathy





Pubic Symphysis Arthropathy

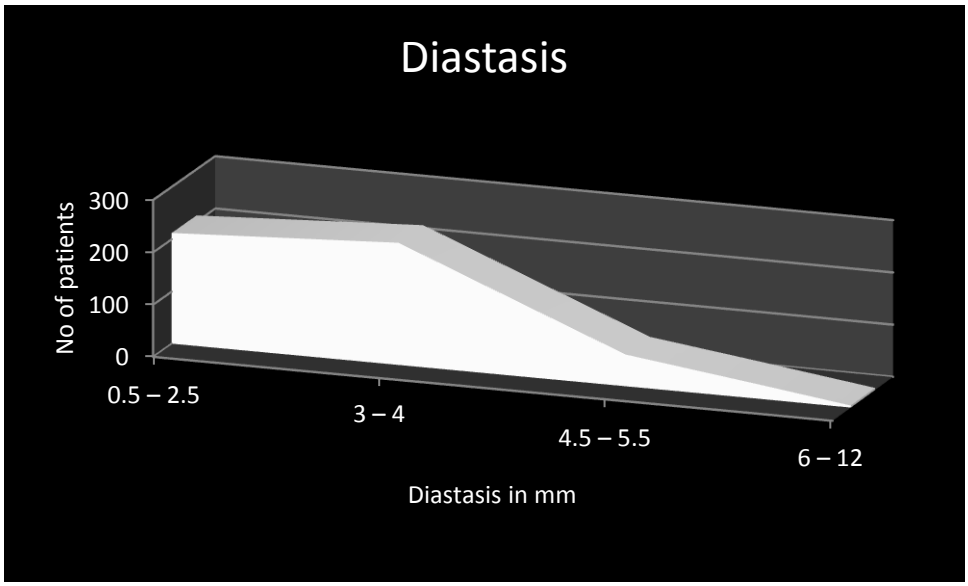
	0	*1*	*2*	*3*	*3A(Anklyosis)*	*Unrecorded*
No of patients	147	164	168	66	17	0

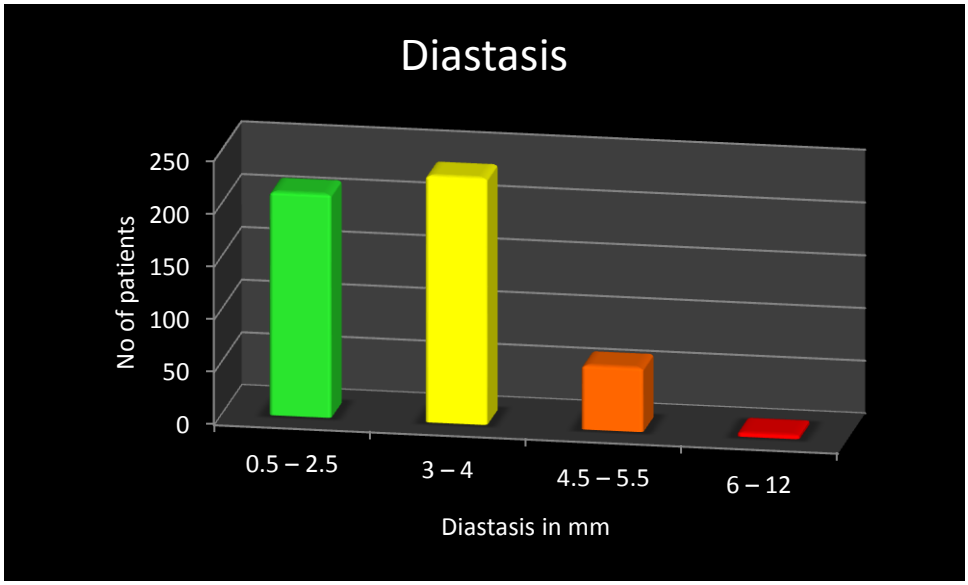
No. present of Sclerosis/ Osteophytosis / Anklyosis / Parasymphyseal Cysts

Diastasis of pubic symphysis

Diastasis > 4mm: No 468 (83.27) %. Yes 94 (16.72%). Unrecorded 0.
Mean distance between pubic bones measured at the narrowest point was 2.9255 mm
16 had diastasis greater than 5mm (2.84%)
No-one had diastasis of >10mm

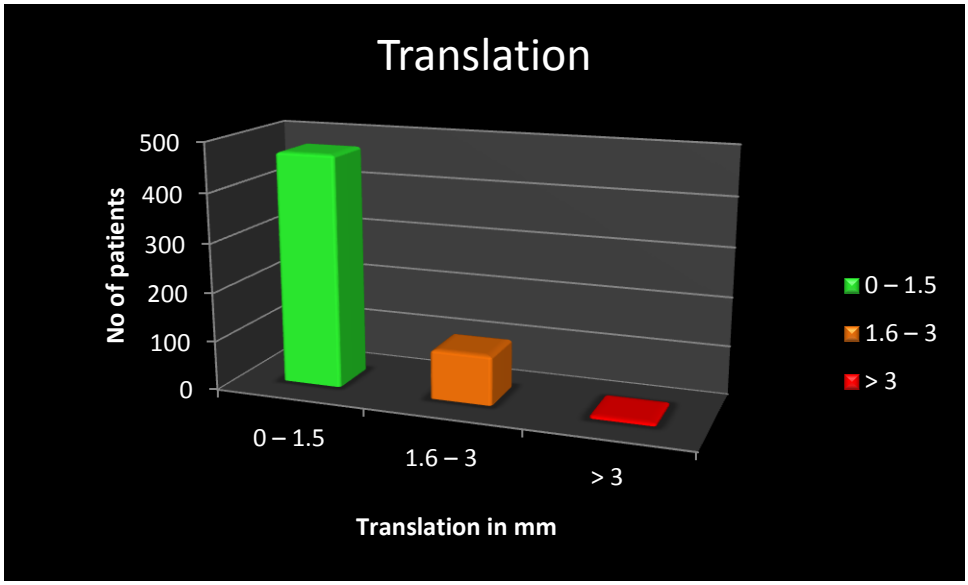
59 had diastasis between 4.1and 5 mm (10.5%)





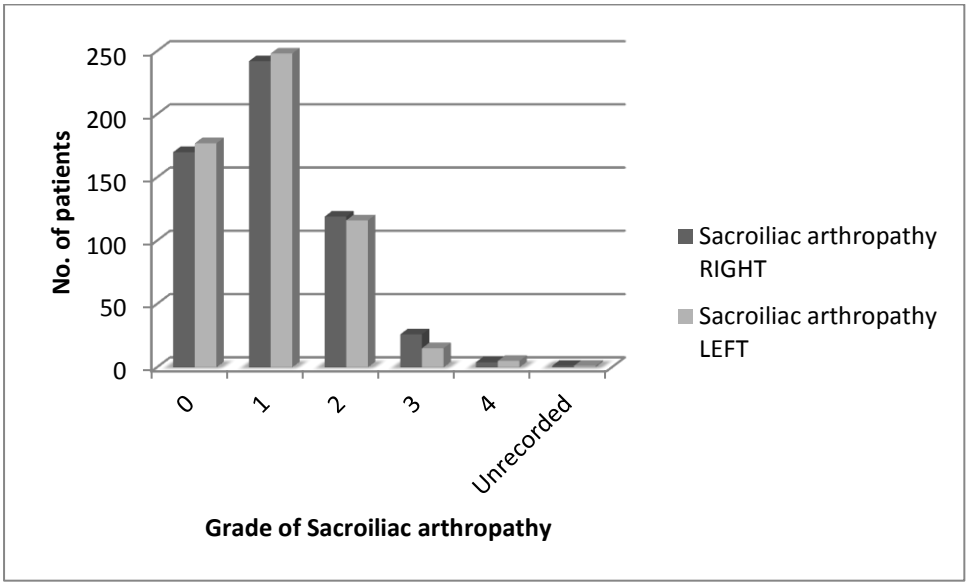
Pubic bone translation

Translation > 1.5mm: No 473 (84.16%). Yes 89 (15.83%). Unrecorded 0.
6 had translation greater than 3mm (1.06%).
101 had translation between 1.6 and 3mm (17.97%).
No-one had translation of more than 5mm



SACROILIAC JOINTS

Grade	*0*	*1*	*2*	*3*	*4*	*Unrecorded*
Sacroiliac arthropathy RIGHT	170	242	119	26	4	1
Sacroiliac arthropathy LEFT	177	248	116	15	5	1

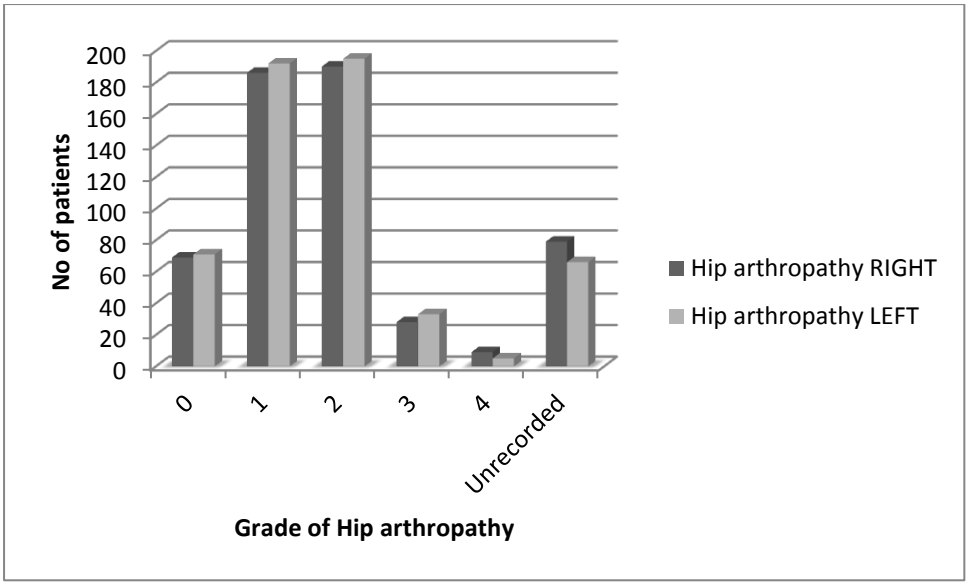


391 had (some) evidence of sacroiliac arthropathy on the right (69.69 %)
170 had NO evidence of sacroiliac arthropathy on the right (30.30 %)
30 had grade 3-4 arthropathy on the right (5.34%)

384 had (some) evidence of sacroiliac arthropathy on the left (68.44%)
177 had NO evidence of sacroiliac arthropathy on the left (31.55 %)
20 had grade 3-4 sacroiliac arthropathy on the left (3.56%)

Hip arthropathy

Grade	*0*	*1*	*2*	*3*	*4*	*Unrecorded*
Hip arthropathy RIGHT	69	186	190	28	9	79
Hip arthropathy LEFT	71	192	195	33	5	66



414 of 483 had (some) evidence of hip arthropathy on the right (85.71 %)
69 of 483 had NO evidence of hip arthropathy on the right (14.28 %)
37 of 483 had grade 3-4 hip arthropathy on the right (7.66 %)
425 of 496 had (some) evidence of hip arthropathy on the left (85.68 %)
71 of 496 had NO evidence of hip arthropathy on the left (14.31 %)
38 of 496 had grade 3-4 hip arthropathy on the left (7.66 %)
Two patients had acute femoral fractures, one of which the degree of arthropathy was unrecorded, the other had a grade 2 arthropathy recorded in the hip which was acutely fractured.
Hip arthropathy RIGHT: Of the 79 unrecorded, 1 had an acute fracture which precluded accurate assessment of the arthropathy grade. 6 patients had DHS or IM nail recorded, but the grade of arthropathy was not recorded. 17 had hemiarthroplasties which precluded accurate assessment of the arthropathy grade. 54 had THR which precluded accurate assessment of the arthropathy grade.
Hip arthropathy LEFT : Of the 66 unrecorded , 8 patients had DHS or IM nail recorded, but the grade of arthropathy was not recorded. 17 had hemiarthroplasties which precluded accurate assessment of the arthropathy grade. 40 had THR that precluded accurate assessment of the arthropathy grade. 16 patients had the reason for the THR recorded, of these 15 were for advanced osteoarthropathy, 1 was due to acute fracture.
Discussion: THR which usually infers that there has been severe arthropathy in that hip

Lumbar arthropathy:

Lumbar arthropathy: No 93. Yes 463. Unrecorded 6 (2 of which no reason was recorded, 4 of which could not assess – insufficiently imaged).
463 of 556 had (some) evidence of Lumbar arthropathy (83.27 %)
93 of 556 had NO evidence of Lumbar arthropathy (16.72%)

Appendix IV

Dr. Heather Moriarty.
It was considered that there would be merit in a review of the patient sub-group who were deemed to have likely undergone a symphysiotomy and who had imaging studies.

Analysis of imaging features in the symphysiotomy patient cohort.

Symphysiotomy patient group N=126

Methods: See Appendix III. The recorded imaging features / data points were entered into an excel spreadsheet and analyzed, results recorded below.

Data points collected: See Appendix III.

This cohort included 126 female patients ranging in age from 50 – 98 years.

The majority of patients had x-ray (XR) pelvis performed n= 105 (83.3%). Plain radiographs were typically dedicated standard pelvis and hip views. A further 21 patients (16.6%) had dual imaging of their pelvis in the form of MRI (n=10) or CT (n-11). Eight patients had a MRI of pelvis alone followed by 4 patients having a CT alone. Nine patients (7.1%) had no imaging available to review at the time of this analysis. The image quality was good for the majority of studies presented and they were comparable.

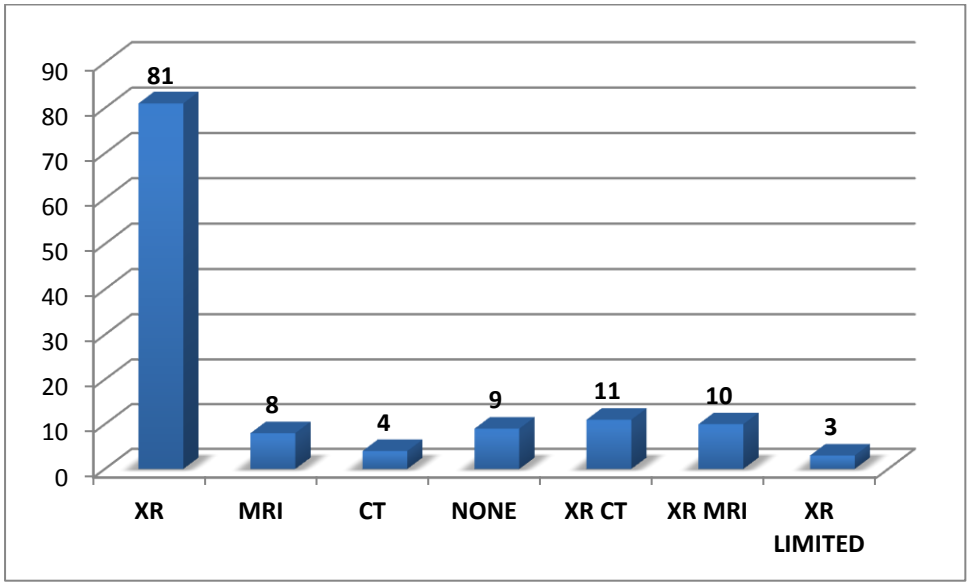


Fig 1: Format of imaging used to assess boney pelvic anatomy

Dates of imaging ranged from 1999 to the most recent dated in May 2016. The majority of images analysed were performed in 2015 (n=48). 21 patients had imaging performed in 2014 followed by 10 and 12 in 2013 and 2014 respectively. Fewer numbers were obtained or submitted for earlier years as depicted by the bar chart below.

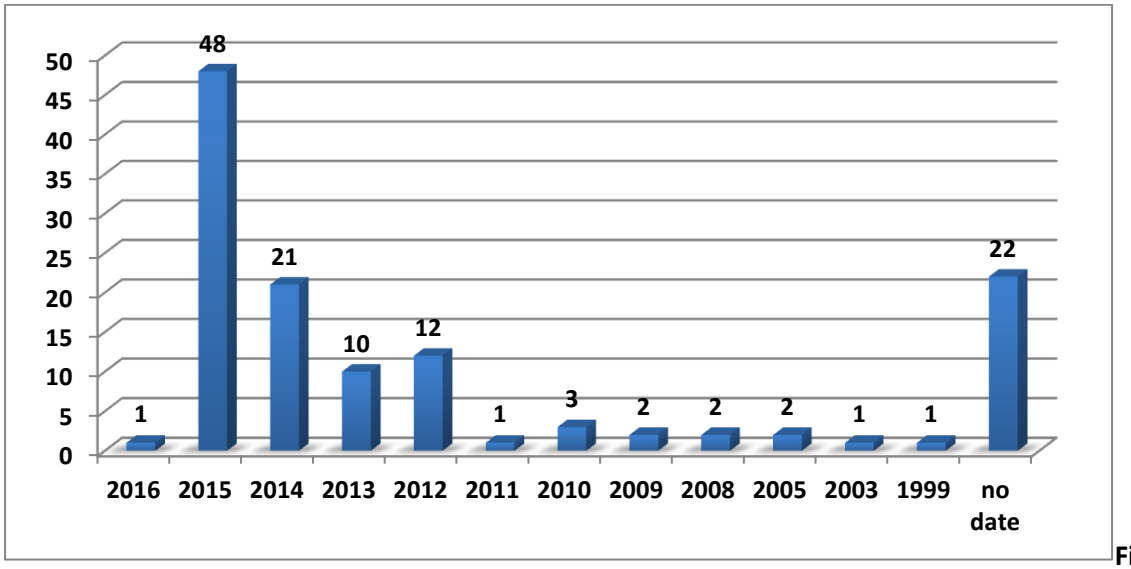


Fig 2: Annual number of images performed during the period of analysis of this patient cohort.

Patients had imaging performed in a wide number of institutions throughout the country. Increased proportion of patients had investigating radiology performed in the Bons Dublin (n=10), Euormed (n=10), Our Ladies hospital of Lourdes (n=9), Mater private hospital (n=7) and Louth County Hospital and Bons Glasnevin (n=6). The industry of the Scheme team and applicants in seeking out and providing imaging for review is self-evident in the breadth of hospitals represented.

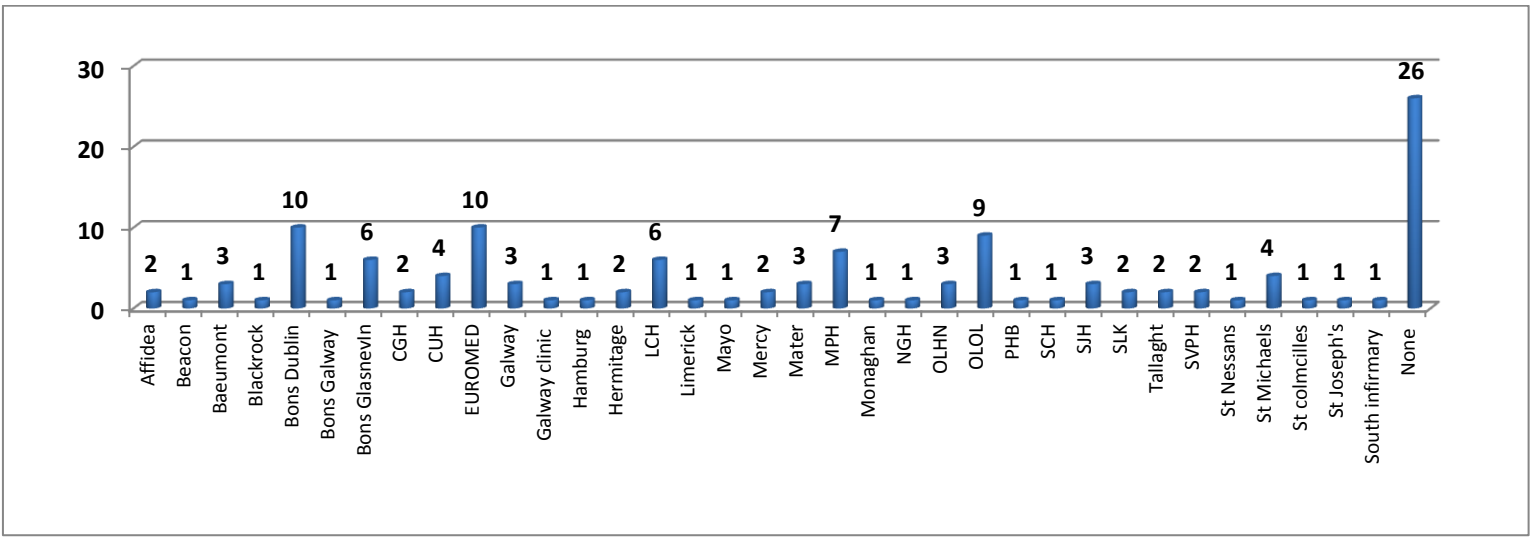


Fig 3: Institutions where patient imaging had been performed during the patient analysis

Diastasis was considered present when the minimum transverse joint space at the pubic symphysis was 4 mm or greater. Pubic diastasis was measured at the narrowest point. On review of the imaging 83 patients (65.8%) had evidence of diastasis. One patient had possible signs of diastasis, in 11 patients the presence or absence of diastasis was not recorded, nine of these patients because no imaging was available. Thirty-one patients (24.65%) of patients had no evidence of diastasis.

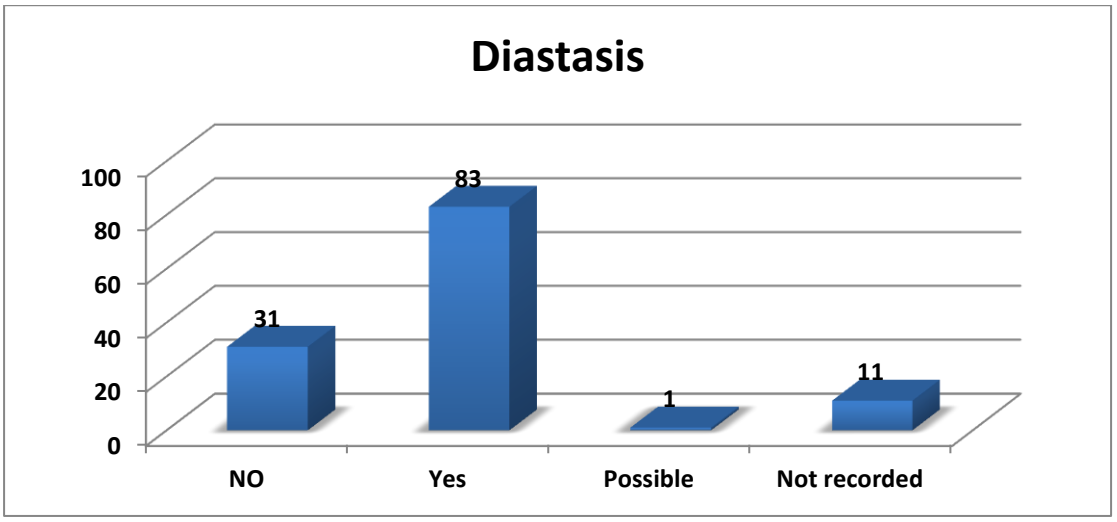


Fig 5: The presence of diastasis within the patient cohort (n=126)

In those patients with diastasis of >4 mm, the actual millimeters of diathesis was recorded. Diastasis ranged from 4.3mm to 39mm. The mean diathesis in millimeters in this patient group was 13.86 mm. A large proportion of patients had diastasis measuring between 4mm - 8mm (n=24, 28.5%). Fewer patients had greater than 20mm of diastasis as seen in the graph below. Two patients had diastasis greater than 32mm.

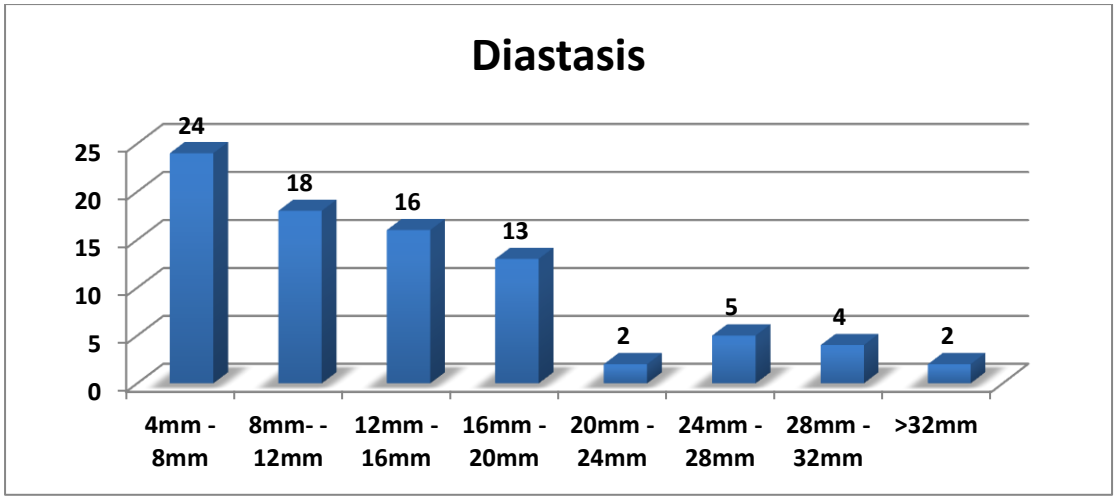


Fig 6: Length of diastasis in patients with diastasis greater than 4mm on imaging (n=84).

The degree of cranio-caudal asymmetry at the pubic symphysis was recorded as 'translation' . This was documented in milimeters. It was considered significant if the distance was greater than 1.5 millimeters (mm). Within this group 46 patients (36.5%) were found to have evidence of translation on their imaging. The majority of patients (n=67) had no evidence of translation >1.5mm.

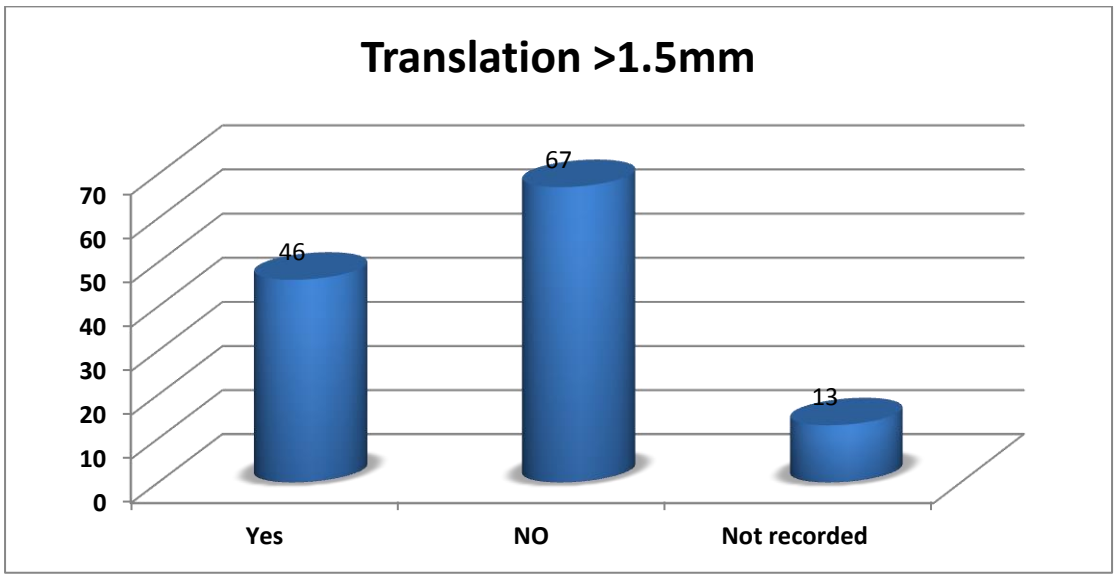


Fig 7: The presence of translation within the cohort of patients (n=126).

The actual millimeters of translation was recorded in all 46 patients in whom translation was greater than 1.5mm. The average length of translation in this group was 3.87mm (range 2mm to 14mm). Twenty patients (43.4%) had translation lengths between 1.5 – 3mm. Nine and 11 patients had

translation lengths between 3 – 4.5mm and 4.5 – 6mm respectively. Two patients had translation lengths greater than 9mm.

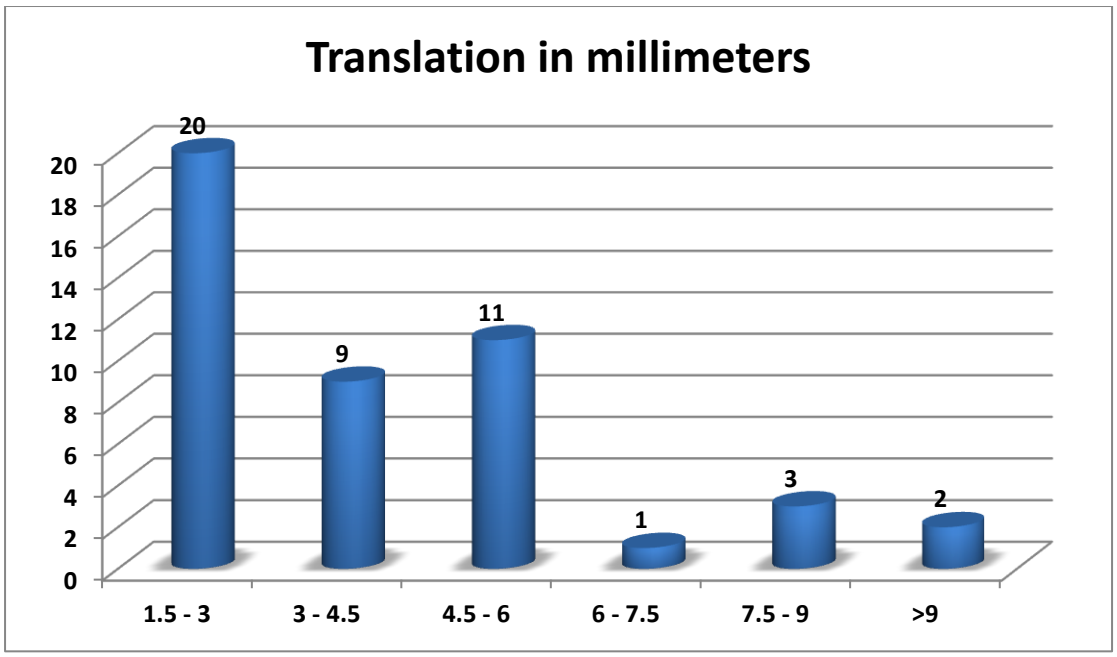


Fig 8: Translation measurement in patients with translation greater than 1.5mm (n=46).

All imaging was examined for the presence of bone fragmentation at the pubic symphysis. The majority of patients (96.58%) did not have any evidence of bone fragments on available imaging.

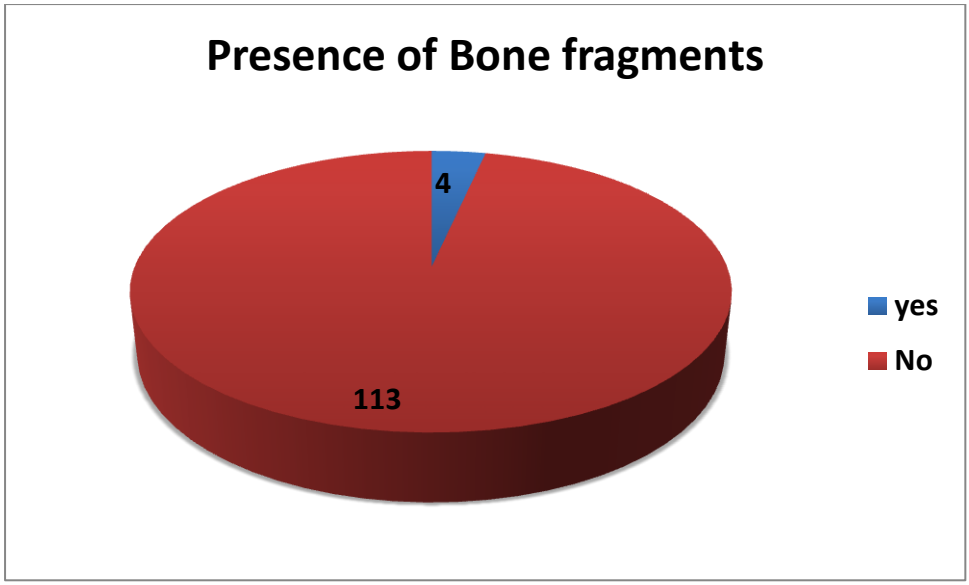


Figure 9: Bone fragments at the pubic symphysis within the patient cohort (n=117).

The incidence of pubic symphysis arthropathy was recorded. This was evaluated by analyzing imaging for the presence of any of; sclerosis, osteophytosis, parasymphyseal cysts or anklyosis. Sixty-eight patients (61.8%) of patients who had imaging available at time of analysis (n=110) had radiological evidence of pubis arthropathy on imaging. In 16 patients this was not recorded, nine of these patients had no imaging available.

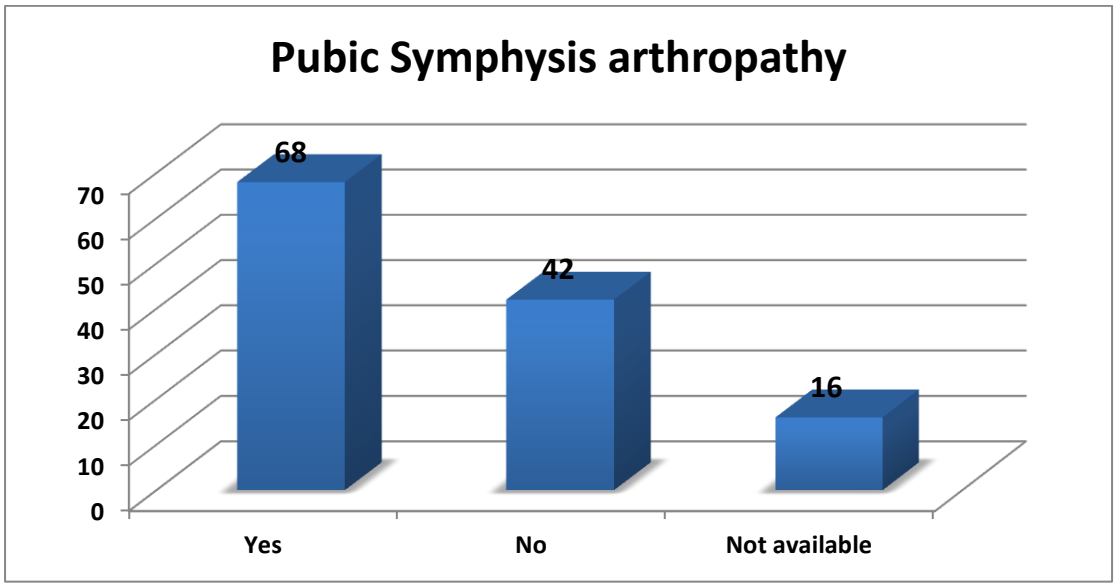


Fig 10: Patients with features on imaging suggestive of pubic symphysis arthropathy.

Pubic symphysis arthropathy was also analyzed by specific imaging feature of sclerosis, osteophytosis, parasymphyseal cysts or anklyosis (highlighted in the graph below). Patients with evidence of pubis arthropathy predominantly had sclerosis and osteophytosis, (38.2% and 83.8% respectively). A minority of patients had parasymphyseal cysts (16.1%), only one patient had evidence of anklyosis on imaging.

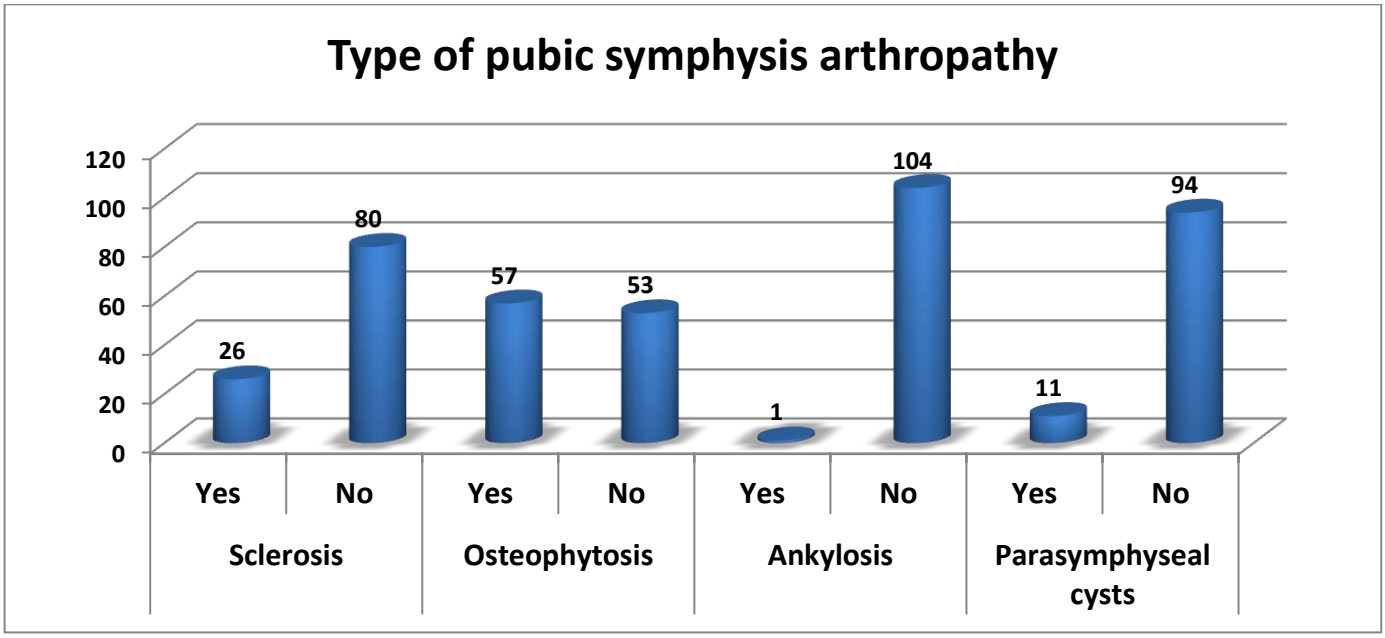


Fig 11: Pubic symphysis arthropathy by imaging feature (n= 68)

Of the 18 patients who had MR imaging (8 of whom MR was the only imaging available, 10 of whom also had plain radiographs in addition), 9 patients had evidence of capsular hypertrophy (50%) and 2 patients were noted to have oedema (11.11%).

The presence of sacroiliac (SI) disease was also examined within the patient group. If present, this was either recorded as present or absent, or it was graded as mild, moderate or severe, based on radiological evaluation. In total 114 patients radiographs were examined (9 no imaging available and 2 not commented upon). Fifty-two and 51 patients (44.8%) had no evidence of sacroiliac arthropathy on radiological examination at time of analysis. Twenty-seven patients (23.7%) had documented presence of SI disease on either right or left side without mention of severity. Furthermore 21 and 23 patients had moderate evidence of SI joint arthropathy on the right and left side respectively. Twelve patients had documented mild SI joint arthropathy on the right and left side (10.5%). Two patients had radiological features of severe SI arthropathy on the right side with one patient having severe disease on the left side (1.7% and 0.87% respectively).

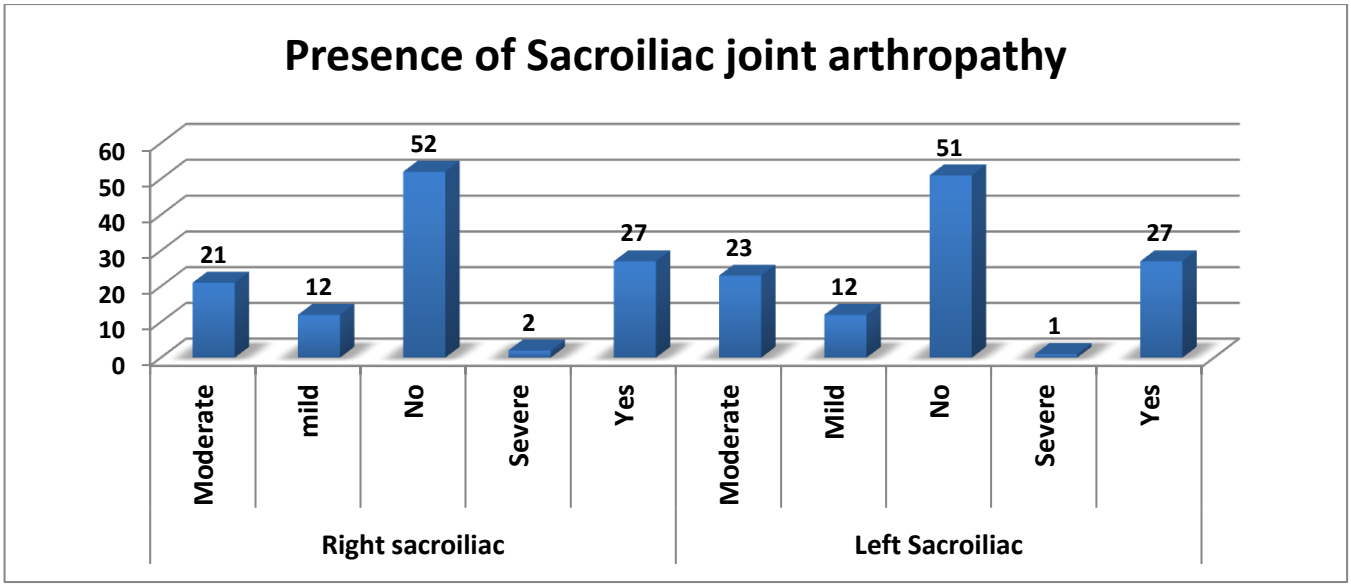


Fig 12: The presence of documented sacroiliac (SI) joint arthropathy with the patient cohort (n=114).

Patients were analysed for the presence of hip arthropathy. One hundred and ten patients were included in this analysis (9 no images available and in 7 there was no comment on hip arthropathy). Approximately half of the patient cohort had evidence of hip arthropathy. On the right 28 patients (25.4%) had evidence of mild arthropathy with five patients having features of moderate arthropathy and two with signs of severe arthropathy. Fifty-four patients (49%) of patients had no radiological features of right-sided hip arthropathy. Six patients (5.45%) had previous right sided total hip replacements performed. Of note indications for total hip replacement includes severe arthropathy amongst others.

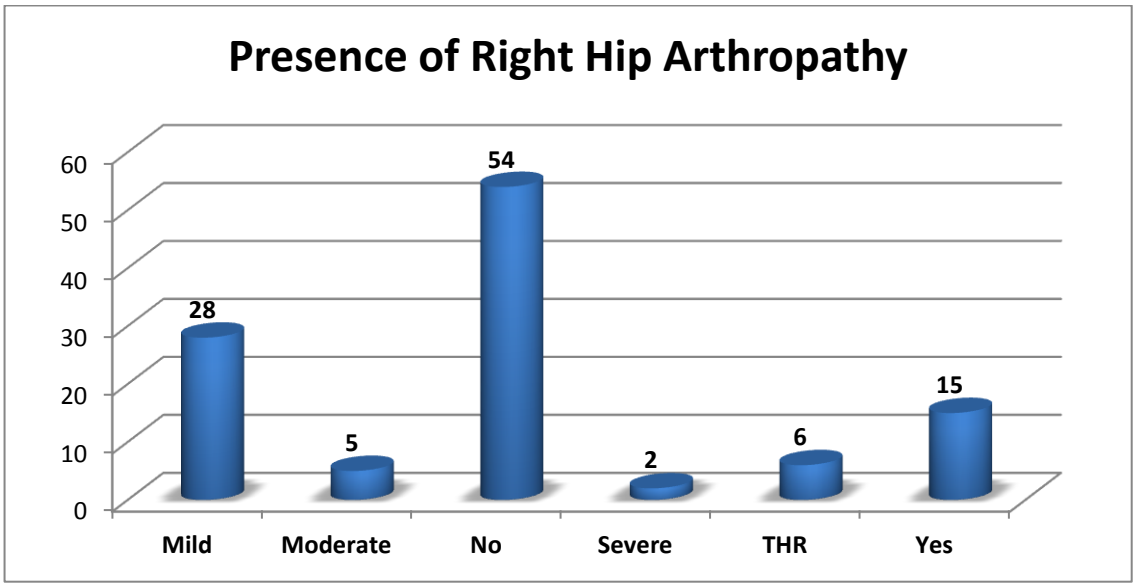


Fig 13: The presence of right sided hip arthropathy (n=110).

51 patients (46.3%) had no radiological evidence of left sided hip arthropathy. Similar to numbers of right sided hip arthropathy, 31 patients (28.1%) had features suggestive of mild hip arthropathy and 4 patients had moderate arthropathy of the joint. One patient had finding of severe hip arthropathy. Nine patients (8.1%) in this patient group had previous total hip replacement (THR) of the joint.

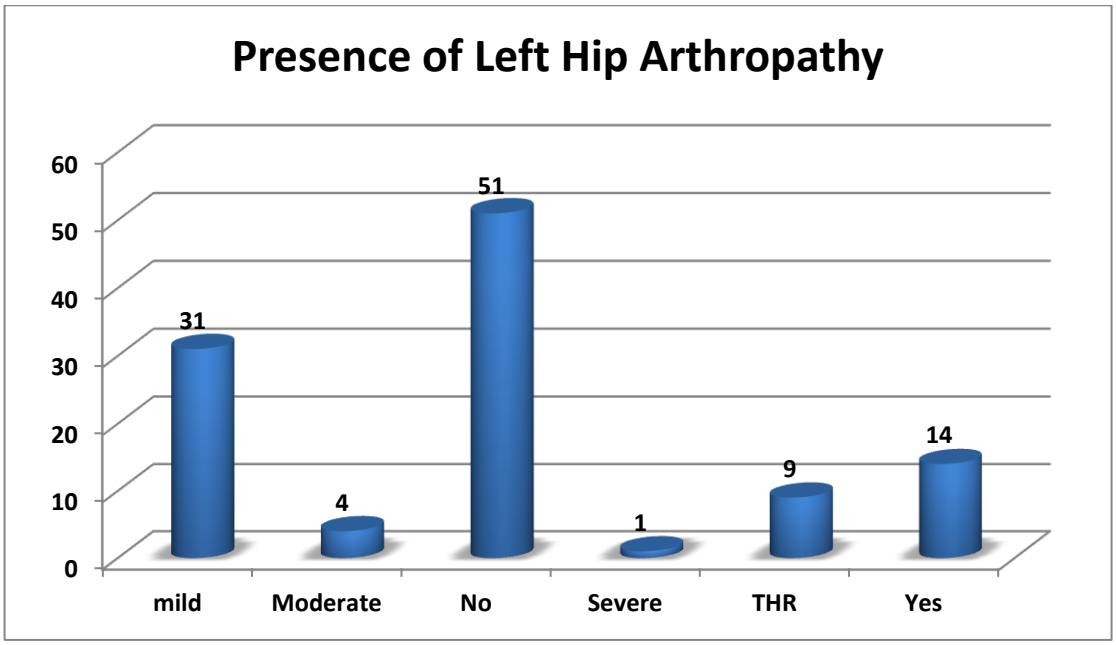


Fig 14: The presence of left sided hip arthropathy (n=110).

Evidence of the presence lumbar arthropathy was documented in 77 patients. 38 patients (49.35%) had radiological findings of lumbar arthropathy with six patients having mild arthropathy and one patient having moderate radiological signs of lumbar arthropathy. Thirty-two patients (41.5%) had no features of lumbar disease.

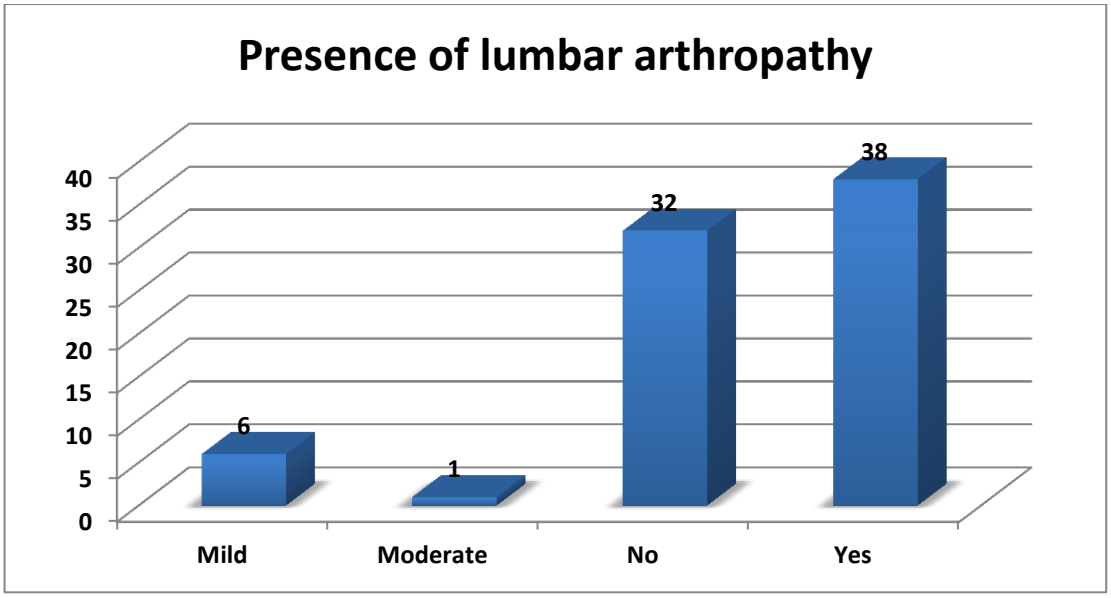


Fig 15: Presence of documented lumbar arthropathy within the patient group (n=77).

It is noteworthy how significant patient numbers who were ultimately considered to have undergone the procedure did not demonstrate significant associated joint arthropathy.

Pubiotomy

In one case with proven pubiotomy the imaging was concordant and confirmed the procedure and it was bilateral. However the associated joint changes were relatively minimal and again no specific pattern that was distinctive from a non-symphysiotomy/pubiotomy cohort or indeed significantly different from the proven symphysiotomy cohort.

Presence	Diastasis	Translation	Sclerosis	Osteophytosis	Ank	Cyst
Yes	**N**	**N**	**Y**	**N**	**N**	**Y**

Presence	SI Arthropthy	Hip Arthropathy
Yes	**N**	**N**

Comparative Analysis: Symphysiotomy / Control groups.

On comparative analysis of the symphysiotomy versus control groups, there were appreciable differences in the number of patients per hundred with diastasis > 4mm and translation > 1.5 mm. The percentage of patients with diastasis > 4mm was 65.8% in the symphysiotomy group, versus 16.72% in the control group. This may be related to the procedure or multiparity though one could make the assumption that the control group had similar parity. We did not have details on the parity of the control group.

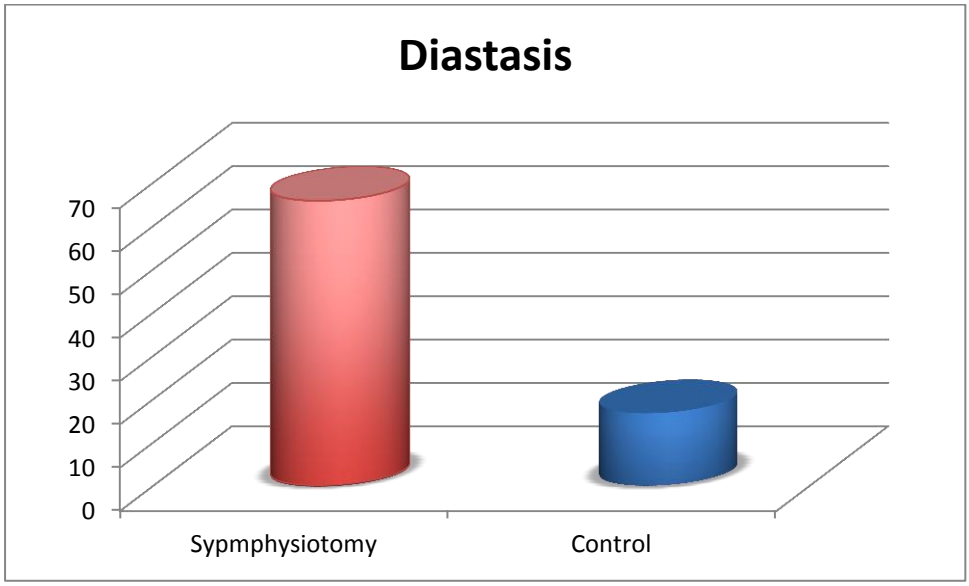


Fig 16: Percentage of patients with diastasis >4mm in the symphysiotomy versus control group.

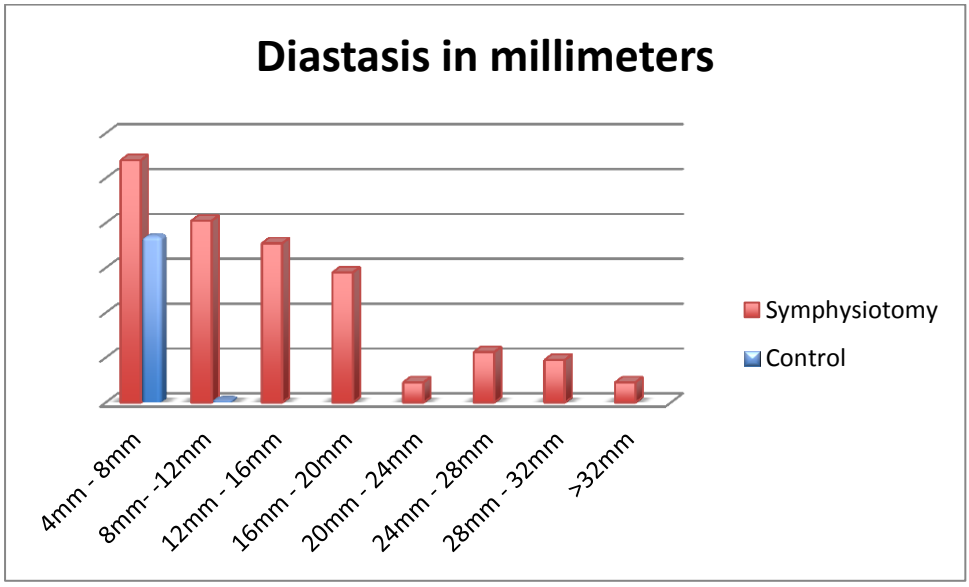


Fig 17: Proportional representation of the length of diastasis, in those patients with diastasis >4mm in the symphysiotomy versus control group. There is a greater prevalence of small diastasis in the symphysiotomy group than normal cohorts but it appears the larger diastasis is largely the preserve of the post procedure group.

Translation was present in 36.5% of the symphysiotomy group, 15.83% in the control group.

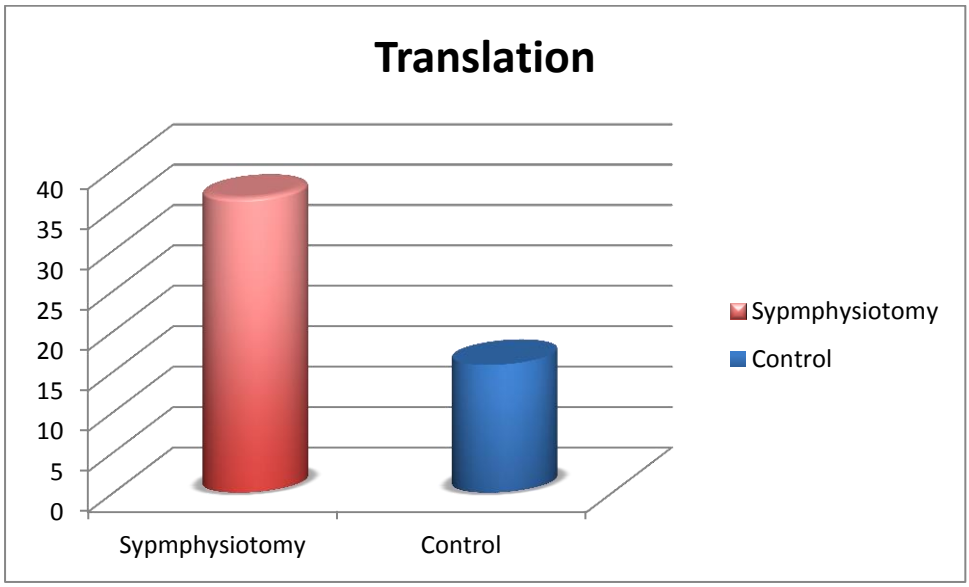


Fig 18: Percentage of patients with translation >1.5mm in the symphysiotomy versus control group. We did consider if translation could be a sign of prior symphysiotomy. Clearly it's not absolute. However one theorises that with a divided pubis and rehabilitative walking it may not completely align in the cranio-caudal direction.

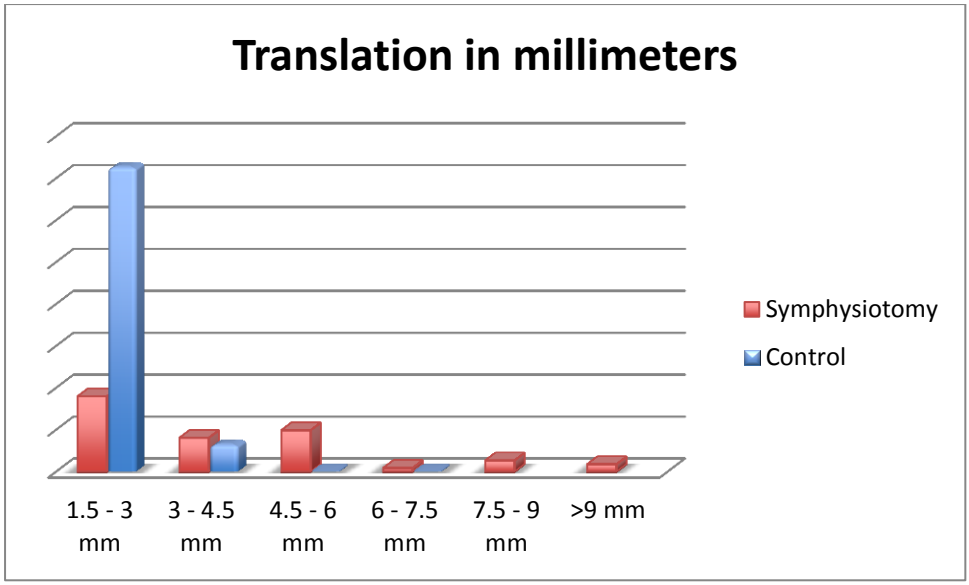


Fig 19: Proportional representation of the length of translation, in those patients with translation >1.5 mm in the symphysiotomy versus control group.

Comparative analysis was performed for the proportion of patients with pubic symphysis, sacroiliac and lumbar arthropathy. Pubic symphysis arthropathy was present in 61.8% of the symphysiotomy group and 73.84 % of the control group.

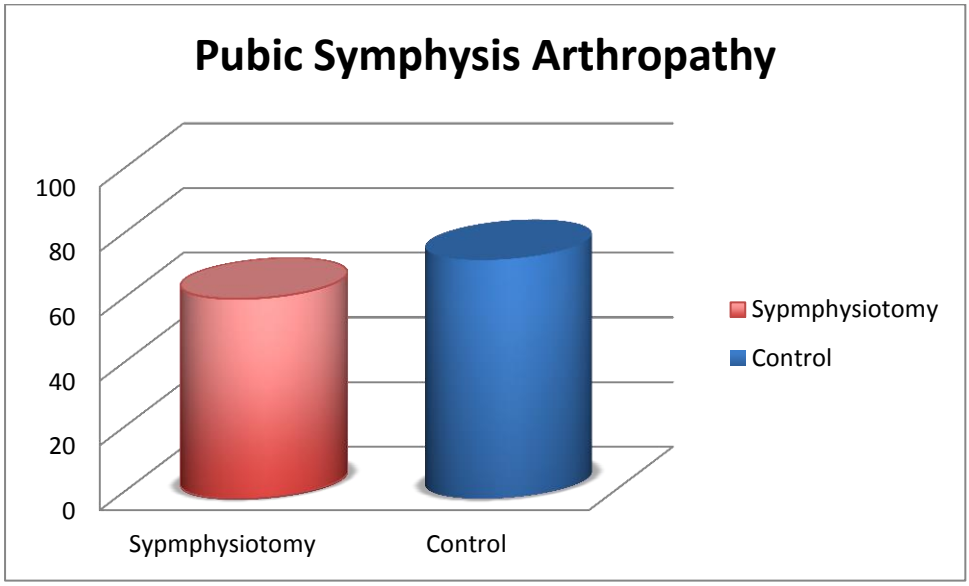


Fig 20: Percentage of patients with pubic symphysis arthropathy in the symphysiotomy versus control group.

Discussion:

Presence of sacroiliac arthropathy was recorded as 55.2% in the symphysiotomy group versus 69% in the control group. Lumbar arthropathy was documented as 58.5% in the symphysiotomy group and 85% in the control group. Hip arthropathy was recorded in 47.65% of the symphysiotomy group, versus 85.7% in the control group. There would be some error related to interobserver variation and it is recognised that strict categorisation of arthropathy is somewhat qualitative and subjective. There are further challenges in assessing normality in distinguishing that which is normal for age and that which is truly normal joint. This reflected my impression on review of the imaging where I noted there were significant case numbers where the arthropathy was remarkably unremarkable even for age. This may be important as it may imply that a true causative relationship between the procedure and subsequent arthropathy cannot be established based on imaging. This is at variance with other literature on the subject.

OVERALL CONCLUSION.

It is important to note at the outset that imaging review performed was primarily to add objective imaging diagnostics to compliment the other aspects of individual patient applications and not as part of a scientific study. There is therefore some methodological weakness in data review design though I do still feel that there is value in the findings both for applicants and for our better understanding of the conditions under review. I think there is much scope for further inferences and and opinions to be raised and debated but they are beyond the remit of this review. Others may draw other conclusions from the findings presented but the main ones that I feel pertinent to the discussion are outlined in Appendix I.

I would like to acknowledge the help of my registrar colleagues noted above and in particular the lead role of Dr. H Moriarty who aided me in the final data analysis.

Addendums

1. Osteoarthritis of the hip grading - conventional radiograph grading.[1]

- Grade 0: normal
- Grade 1: possible joint space narrowing and subtle osteophytes
- Grade 2: definite joint space narrowing, defined osteophytes and some
- Sclerosis, especially in acetabular region
- Grade 3: marked joint space narrowing, small osteophytes, some
- Sclerosis and cyst formation and deformity of femoral head and
- acetabulum
- Grade 4: gross loss of joint space with above features plus large
- osteophytes and increased deformity of the femoral head and acetabulum

2. Osteoarthritis of the sacroiliac joint. (Lawler et al)

- Grade 0: no radiographic features of OA
- Grade 1: possible joint space narrowing and subtle / mild osteophytosis
- Grade 2: definite osteophytes and probable joint space narrowing
- Grade 3: multiple osteophytes, clear joint space narrowing, sclerosis and cysts
- Grade 4: large osteophytes, marked joint space narrowing or ankylosis, severe sclerosis

3. Kellgren and Lawrence system classification of the severity of knee osteoarthritis

- Grade 0: no radiographic features of OA are present
- Grade 1: doubtful joint space narrowing (JSN) and possible osteophytic lipping
- Grade 2: definite osteophytes and possible JSN on anteroposterior weight-bearing radiograph
- Grade 3: multiple osteophytes, definite JSN, sclerosis, possible bony deformity
- Grade 4: large osteophytes, marked JSN, severe sclerosis and definite bony deformity

References

1. http://rheumatology.oxfordjournals.org/content/44/suppl_4/iv43.full.pdf
2. Kellgren and Lawrence system classification of the severity of knee osteoarthritis