1. Introduction

1.1 Importance of clinical anatomy for clinical procedures

The safe and successful performance of office procedures, surgical procedures, emergency procedures and radiological imaging procedures demand a working and yet specific knowledge of anatomy[1].

Clinical anatomy forms the basis of medical practice and is usually defined as anatomy applied to patient care[2]. This is certainly true for developing countries where high technology is often lacking. General practitioners are therefore often dependent on their anatomical knowledge for the performance of clinical procedures. Despite the information revolution from medical research and the rapidly expanding diagnostic and therapeutic possibilities in medical technology, effective performance of procedures in family practice still rests on a solid anatomical basis. This includes the performance of all clinical procedures, which depend heavily on a sound knowledge of human anatomy[3, 4].

Coupland *et al* [5] points out by referring to an address by Dr D Hines to the Royal College of Surgeons of England titled "Anatomy in general medical practice", that general practitioners need and make use of anatomical knowledge in everyday practice. Referring to 7500 consecutive consultations, Hines found a specific need for anatomical knowledge in 814 cases. This was phrased as conscious use of anatomy, which does not involve subconscious use.

In a recent survey[6] done in the USA to determine deficient areas of anatomical knowledge in students starting with their residency in Family Medicine, clinical application of anatomy was pointed out to be the most deficient area in anatomical knowledge. This means simply a desire that students be able to apply their anatomical knowledge to real problems in the clinical setting.

Clinical procedures that fail to achieve their objective or that result in complications, can often be linked to a lack of understanding or misunderstanding of anatomy[7]. Dando[8] confirms this by referring to injury to nerves and arteries and other injuries in anatomically complicated areas associated with minor surgical procedures. In particular he refers to the:

i) Mandibular branch of the facial nerve on the lateral aspect of the jaw, when division of the nerve leads to paralysis of the lip and angle of the mouth.
ii) Common fibular nerve on the lateral side of the popliteal fossa and in close relation to the neck of the fibula. Division of this nerve leads to weakness of dorsiflexion and eversion of the foot.
iii) The spinal accessory nerve in the posterior triangle of the neck. Injury to this nerve leads to a shoulder drop.

These examples refer to superficial nerves that are at risk during minor surgical

procedures like removal of skin lesions and do not even dwell on more complicated anatomical regions associated with complications for example found during the insertion of a central venous catheter or the removal of the appendix.

Beahrs *et al* [9] states that it is a fact that a large percentage of medicolegal cases are based upon an inadequate knowledge of anatomy. For example inserting a needle into the chest to withdraw fluid from the pericardial cavity can cause complications if a coronary vessel is pierced, a thoracocentesis from a lateral or posterior approach may result in a liver or a spleen injury if the needle is inserted too deeply and a simple intramuscular injection can cause an axillary or sciatic nerve palsy if the nerve is struck[10]. Damage to nerves can result in loss of function. The facial nerve is at risk when operating deep in the facial area and damage will cause a serious loss of expression.

Ger[11] rightly points out that doctors who are deficient in anatomy are responsible for prolonging the operation and the anesthesia. This may be accompanied by complications of various degrees. Beahrs *et al* [9] points out that prolongation of a procedure due to lack of anatomical knowledge leads to increased morbidity and mortality. With expert knowledge of the relevant anatomy, a procedure can be carried out safely.
Complications may be even worse for the so-called minor procedures, which are carried out in the ward, often without supervision and a proper understanding of the anatomical implications[41].

The importance of a sound understanding of the anatomy underlying clinical procedures is therefore primarily to the benefit of patients. Ger[11] points out that both the American and British training programs in clinical anatomy have declined from the high standards which they once maintained. This may have implications on patient care. It is therefore timely to foster new interest and emphasis on clinical anatomy, the foundation stone for the safe and successful performance of clinical procedures.

Grossman[12] also points out how anatomy was marginalized over the last few decades to a point where students have limited opportunity actually to dissect and therefore have a first-hand experience of three dimensional relationships of anatomical structures.

Anatomy teaching has now often declined to group observation of prosections, aided by computer technology. It is argued that those specializing in the surgical disciplines will do in-depth postgraduate anatomy once in their residency and therefore do not need it during their undergraduate training. Ger[11] points out that this is seldom the case.

Surgical residents in this state of anatomical education often end with great gaps in anatomical knowledge, especially outside their field of expertise.
In developing countries, general practitioners often perform surgical procedures that are usually performed by surgeons in developed countries. They therefore usually have to perform a very wide range of procedures compared to their colleagues in developed countries[13].

A sound anatomical basis of not only one region, but a working knowledge of diverse

anatomical regions is therefore important to secure safe and successful performance of all clinical procedures.

Due to the decreasing amount of time spent by students studying anatomy, it has been shown that the retention of anatomical knowledge is less than desirable[14].
Rennie[15] argues that this may in part be due to anatomical teaching in the early years of medical education, before students have a clinical framework to incorporate anatomical knowledge. There is therefore a need to move anatomical teaching to later years in medical undergraduate and definitely to boost its presence in postgraduate training.

It is widely accepted that retention of anatomical knowledge is increased by correlating anatomical knowledge to the clinical world for example the performance of practical procedures[16].
This is reinforced by Rennie[15] when arguing that students need to incorporate new anatomical facts into a clinical framework. A problem solving approach is necessary.

Crisp[17] states that the hallmark of the medical practitioner is the fact that he invades the human body in the sole interest of his patient. This invasion may be investigative and diagnostic by means of physical examination or accessing body cavities. It may also be therapeutic, either by means of needles, knives or radiological means. Competency and confidence to perform these is derived from a sound anatomical dissection of the human body. Crisp[17] goes on to point out that anatomical dissection heavily contributes to the safe and successful performance of various practical skills and clinical procedures.

Many surgical procedures that were previously performed in an operating theatre are now done in the office. The concept of office procedures has gained increasing popularity. Needles and catheters are nowadays passed into various anatomical regions that were less well known before advances of radiological imaging, emergency medicine and minimal invasive surgery. Ger[11] states that relevant anatomy applied to clinical procedures is therefore important to identify. This does not mean trivial anatomy with no practical application. Anatomy should move into the clinical sphere. This means that the anatomy necessary and relevant for specific procedures needs to be studied in depth. Vague or too detailed gross anatomy of the region in which the procedure is performed is not helpful. Relevant anatomy needs to be identified from a clinical perspective, and therefore does indeed mean the development of a new academic discipline.

Phillips[18] points to the importance of identifying those features of anatomical relationships that are of special interest to clinicians, such as the relationship of the subclavian artery and vein inferior to the clavicle as applied to central venous catheterization. The anatomy of practical procedures often becomes a very focused and intense regional endeavor, because it deals with structures or portions thereof that are immediately and directly related to the needle, tube or knife.

In his landmark book, "A colour atlas of Applied Anatomy", McMinn *et al* [19] rightly remarks that the anatomy of "how to get at things" is of great importance. Bridging the "awkward gap" as McMinn states it between academic anatomy and clinical practice is

vitally important. With new advances in medical technology like minimal invasive surgery, a sound anatomical knowledge will become even more important. McMinn *et al* [19] refers to various anatomical hazards, safeguards and surgical approaches for various clinical procedures.

Hamilton *et al* [14] rightly states that a sound understanding of human anatomy is vital for the field of emergency medicine with its strong procedural orientation. An understanding of "what's there ?" is crucial for making correct decisions. There is a need for focused clinical anatomy training regarding the performance of procedures. Hamilton *et al* [14] points out that the average score of a clinically oriented anatomy exam for emergency residents was 40%. First year medical students scored 78% on the same exam. The need for clinical anatomy refresher courses is evident. In such a course, basic anatomy should strongly be integrated with clinical correlations with hands-on dissection elements. Hamilton *et al* [14] states the need to better research the integration between basic anatomy and clinical practice. The aim of this study is to advance "one small step" along this road.

Clinical anatomy is an important component in the area of clinical knowledge and judgement[20]. Competent general practitioners must be able to distinguish between normal and abnormal structures and know about normal relationships of structures.
Focus on this component (clinical anatomy) of the knowledge domain is necessary for competency with clinical procedures. Clinical anatomy is not the only component of knowledge that should be mastered by the competent family physician, but certainly an important one. The knowledge domain of clinical anatomy cannot be separated from motor and technical skills to perform a safe and successful procedure[21]. Clinical anatomy can therefore never be isolated from skills and attitudes.
Valuable lessons on how to integrate anatomy with surgical procedures can be learned from Peuker *et al* [22] who developed clinical anatomy refresher courses on surgical approaches for various surgical procedures. An innovative method of teaching procedural anatomy has been introduced by Hubbell *et al* [23] in which regional anatomy is taught both before and during a surgical procedure in the operating room. In this way an immediate relevance is brought into the learning process.

Barrows *et al* [24] noted the following in 1969 regarding students and residents of the McMasters University in Canada: " I discovered that medical students and residents, for the most part, did not seem to think at all. Some gathered data ritualistically and then tried to add it up afterwards, while others came up with as diagnosis based on some symptom or sign, never considering possible alternatives." The outcome of their curriculum did not match their expectations. Consequently the curriculum was changed to a problem-oriented one, a now very common type of medical curriculum worldwide. The basic philosophy of this approach lies in the fact that both knowledge and skills are trained and learned in an environment similar or identical to that of the final working environment of the student. When applying this principle to anatomy, it means that anatomy which involves the knowledge, attitudes and skills domain, should be taught in a clinical environment as well, or at least in a clinical reasoning framework. The means to do this is to elevate anatomy teaching into the real clinical world, or at least a virtual clinical world which can be based on various technological modalities ranging from

paper based clinical cases to state of the art multimedia environments.

1.2 Clinical competence

Clinical procedures are an important part of the daily work of general practitioners[25]. The competency general practitioners display in procedural skills may be considered a very relevant aspect of their overall clinical competence[20]. Competence is defined as what a doctor is capable of doing and differs from performance, which reflects on the actual day-to-day practice. Competence however predicts performance[26].

In family practice, the competence of a physician can be categorized into three areas: a) Attitudes and interpersonal skills which involves the behavior and ethics of the profession that are necessary for communicating and working with patients; b) Intellectual faculties and abilities such as cognitive knowledge, ability to organize and to synthesize; and c) Motor and technical skills which include the manual skills required to conduct a physical examination and to perform necessary procedures[27]. Competency is therefore an issue of professional responsibility. Failure to exercise the skill a doctor claim to have is in breach of his/her duty of care and is therefore negligent[8].

There is a need to focus on the competency to perform clinical procedures, especially the underlying anatomical knowledge framework necessary to perform a safe and successful procedure. The performance of any clinical procedure needs a certain level of competency[28]. Competency exists when a practitioner has sufficient knowledge and manual skill, such that a procedure can be performed to obtain the intended outcomes and without harm to the patient. Competency is especially important when the procedure has the potential to harm or cause patient discomfort[20]. An important part of this competency is the knowledge base necessary to perform a safe and successful procedure. Recognition of the anatomy relevant to the specific procedure is an important part of this knowledge base.

There are basically three general areas of knowledge in the development of competency for performing clinical procedures. They are:1) Clinical knowledge and judgement, 2) Knowledge of the equipment, instruments and supplies, and 3) Knowledge of the procedure. These elements are in fact closely interrelated[20].

The Royal College of General Practitioners[29] states that it is essential only to undertake those procedures, which a doctor feels competent to perform. This includes an adequate competency level of the relevant anatomy.

Wigton[30] states that the most important elements of procedural competency are the cognitive aspects. Anatomy plays an important part in this domain: This includes knowing the indications and contra-indications, knowing the anatomical pitfalls and possible complications, identifying them and managing them. Kneebone[31] points out that confidence in performing a procedure comes from a knowledge base, which knows what to expect. This underscores the notion that a sound clinical anatomy knowledge base is essential to perform a procedure.

1.3 Procedures

Clinical procedures form an important part of competency in general practice[25]. Literature from developed countries generally appears to agree on which procedures should be performed in general practice [32,25,33,34,35]. These include a variety of minor operations such as excision of cysts and skin lesions, suturing uncomplicated lacerations, injection or incision of hemorrhoids, resection of ingrown toenails, injection of joints, bursae and tendons, emergency procedures such as advanced cardiac life support, arterial puncture for blood gases, chest tube placement, electrocardioversion and diagnostic tests like flexible sigmoidoscopy, laryngoscopy, lumbar puncture and chest radiology.

General practitioners usually have long-standing relationships with their patients. Especially concering office procedures, patients will want to come to the family physician, which is both convenient and reassuring. General practitioners therefore have a duty to perform clinical procedures competently[36].

The following list is provided for general practitioners in the UK by the National Health Services (NHS)[37]: *Injections*: intra-articular, peri-articular, varicose veins, haemorrhoids; *Aspirations*: joints, cysts, bursae, hydrocoele; *Incisions*: abscesses, cysts and thrombosed piles; *Excisions*: sebaceous cysts, lipoma, skin lesions for histology, intradermal nevi, papilloma, dermatofibroma, warts, removal of ingrown toenails; *Curettage, cautery and cryocautery*: warts, verrucae and other skin lesion; *Other*: removal of foreign bodies and nasal cautery. The Society of teachers of emergency medicine identified 26 important procedures in emergency medicine[38]. A minimal set of 39 procedures has been defined by the American Board of Family Practice[39]. Wigton[30] has published widely on procedural skills in the field of internal medicine. His comments and suggestions are very helpful in the field of family medicine as well. Certainly procedural competency is of the utmost importance in the invasive procedures that general practitioners are expected to perform in South Africa, yet the research in this field is strikingly lacking for developing countries.

It is clear that various clinical procedures are done in family practice. These procedures can be divided into office procedures[27], surgical procedures [33,40], emergency procedures[28] and radiological imaging procedures. In a South African context, various clinical procedures are performed by general practitioners. There is however not much data available on which procedures are done by general practitioners and would therefore be included in family practice residency programs. One would assume that this will reflect in the residency programs of academic institutions were general practitioners are trained.

Patient safety and quality of diagnostic and therapeutic information depend on the skill with which practitioners perform procedures. It is often assumed that residents in Family Practice receive adequate procedural training, but this is not always the case. Many learn to perform procedures only after their training. General practitioners need however to be fully competent in every procedure they perform. Wigton[30] points out that average resident knowledge traditionally reflect excellence in one area, which compensates for

weakness in another. This is not the case for procedural competency where proficiency in one procedure does not compensate for deficiency in another. Patients expect absolute competence. Our challenge is to ensure that general practitioners acquire competency in the procedures they will need in practice, not only regarding technical ability but also cognitive skills regarding the performance of the procedure.

There is a need to identify the problem procedures and address the cognitive skills domain of clinical anatomy necessary to perform a safe and successful procedure.

Concerns like patient safety and potential liability exposure have increased interest in procedural skills of medical practitioners. Training of procedural skills did not always receive great attention in the literature in the past [41]. Certainly for general practitioners in South Africa, training in procedures is not aggressively monitored, partly because of the conception of regional variations in the procedures performed and consequently the lack of consensus about which procedures are necessary to be mastered. Little information is available on which procedures are performed by general practitioners and whether these procedures match those they possibly learned during residency.

There is a need to identify the procedures that are required in developing countries as well.

The need for procedural training is not confined to postgraduate medical education. The General Medical Council in the UK[42] states that the acquisition of a range of practical skills, which every graduate must have in preparation for house officer responsibilities, is essential to a core undergraduate curriculum. Clinical anatomy has a definite responsibility in this field. This notion is underscored by the Association of American Medical Colleges[43], by stating that before graduation a student should have demonstrated to the satisfaction of the faculty the ability to perform routine technical procedures including the following *minimum*: venipuncture, inserting an intravenous catheter, arterial puncture, thoracocentesis, lumbar puncture, inserting a nasogastric tube, inserting a Foley's catheter and suturing lacerations.

1.4 South African context

Different family practice situations exist in South Africa. They can be differentiated as follows:

a) General practitioners working in hospital practice in urban and rural hospitals.
b) Genral practitioners working in private practice situations in urban and rural practices.

In South Africa the term general practitioner is usually used for referring to a practitioner without a postgraduate masters degree including a Masters in Family Medicine. If a practitioner would obtain a Masters degree in Family Medicine which is called differently depending on the institution where it was obtained, he/she would be referred to as a family physician. The scope of this study is however broader and includes both general

practitioner and family physician working in hospital practice. Private practice situations (where general practitioners or general practitioners run there own practice) were not included in this study.

It is generally accepted that rural general practitioners will have to perform more procedures than their urban counterparts [44,45,46,47]. These studies have all been conducted in developed countries. No study has however been done to compare and correlate the performance of procedures in different South African hospital practices. We do not really know what procedures general practitioners are doing in their practices and we certainly do not know what the influence of clinical anatomy on the performance of these procedures are.

A minimal set of 39 procedural skills (both inpatient and outpatient) has been defined by the American Board of Family Practice[39]. This may have some relevancy in South Africa, but procedures performed in developing countries may be very different. Although various studies determined the type of procedures done in family practice [27,28,34,48], none of them were done in developing countries especially not in South Africa.
A variety of clinical procedures being both diagnostic and therapeutic are performed by general practitioners in developing countries like South Africa. Arterial and venous access, fluid drainage from body cavities, nerve blocks, not to mention the almost infinitely variable manifestations of trauma are but a few of the examples in South African family practice.

Research in clinical procedures in family practice is of particular importance for several reasons.

- Firstly, general practitioners in rural areas need to perform several different clinical procedures, since other specialists are not always readily available for referral and the nearest hospital may be many kilometers away.
- Secondly, although many procedures can be safely performed, even relatively common procedures can be associated with significant morbidity if not performed correctly. Training and supervision in such procedures are important as part of the residency program of general practitioners.
- Thirdly, governments, insurance companies and patients increasingly demand procedures to be done on an outpatient basis to reduce health care costs and to avoid the inconvenient stay in hospital and often long waiting periods to see a specialist[27]. One British study estimated savings of £15000 to a local health authority in one year if one general practitioner performed four procedures weekly[32]. Performing procedures in family practice has been shown to be cost effective, convenient for patients and professionally satisfying for general practitioners[49].

General practitioners in developing countries have to rely heavily on their anatomical knowledge in performing clinical procedures. Medical schools in developing countries therefore have a responsibility in teaching their students clinical anatomy to ensure that their qualified physicians that can best provide their patients with proper performance of diagnostic and therapeutic procedures.

Developing countries are often deprived of high technology for the performance of clinical procedures. Patients in this environment still need good quality care, although the infrastructure is less developed.

Doctors in family practice should therefore have an appropriate and sound knowledge of clinical anatomy. Improvement of the status of knowledge of clinical anatomy will therefore be of tremendous importance in improving patient care in developing countries. No study has been undertaken in the past to evaluate and improve on clinical anatomy as the basis for performance of clinical procedures in developing countries.

Training programs in developing countries have unique challenges. This is also true for clinical anatomy training programs:

- General practitioners in hospital practices often lack the infrastructure and manpower to attend continued medical education programs located at tertiary learning centers[50].
- Training programs for procedural competency regarding the knowledge base and skills are often based on data from developed countries and do not address the specific needs for developing countries where a higher level of competency is often required to perform a wider range of clinical procedures.
- Successful training programs often have more emphasis on self-directed learning within the available infrastructure of the family physician. Various modalities of telematic education deliveries need to be explored[13]. Online courses are perhaps not ideal due to problems to access the internet via small capacity modems. A training program on a CD-ROM platform may therefore be a better choice needing only a personal computer. Such training programs make a whole range of media available in an interactive way to facilitate self-directed learning[13].

1.5 Assessment of clinical competency

Assessment of the competency of general practitioners to perform clinical procedures is important to evaluate the outcome of quality patient care. Competency can be assessed in basically three different ways or combinations of them. A performance based test, a written knowledge test of skills or a self- assessment questionnaire. Performance based testing (multiple station evaluation) is obviously the best method to assess proficiency in hands-on procedures[51]. In this study Jansen *et al* [51] assessed competency of technical skills of general practitioners with all three methods. They showed that the score on the self-assessment questionnaire showed a rather low correlation with the performance-based test. They also showed that, although performance-based testing is obviously the best method to assess proficiency in hands-on procedures, a written test can serve as a reasonable alternative, particularly for screening and research purposes. A written test on the knowledge framework of clinical procedures could therefore correlate well with a performance-based test. This notion is underscored by Wigton[30] stressing the importance of the clinical knowledge background in the performance of clinical procedures. This could however be quite different among general practitioners working in variable practice situations in developing countries. No study report on the assessment of clinical anatomy

as part of the competency of general practitioners to perform clinical procedures.

Page *et al* [52] described the so-called "key features approach" to assess basic sciences within a clinical context. Key features of clinical anatomy are according to this approach assessed within a clinical context. A Key feature applied to clinical anatomy competency with regard to procedures, can be defined as follows:

i) A crucial step in the procedure where it is more likely to make errors during the performance of the procedure. This means clinical anatomy features which are crucial to prevent difficulties and complications.
ii) A difficult concept to identify during the performance of the procedure.
iii) Key anatomical features imply that there are clinical anatomy points during the performance of the procedure that are not of equal importance when compared to the critical key features.

Introduction

It is believed that these features are discriminating measures of competence[52].

During the key features assessment approach a rich stimulus format is provided which represents the clinical context. This means an outline of a clinical case or clinical scenario from which the key feature is to be asked. The stimulus format is followed by the response format (question) in which the key feature is assessed. This assessment can be done by various assessment modalities including multiple-choice questions, essay type questions or identification on images. The stimulus format of the test, dictates the validity of the test rather than the response format[53]. This is the case when problem solving is measured, i.e. when clinical anatomy concepts are tested within the procedural scenario.

Van der Vleuten[53] describes the concept of utility of assessment methods. He defines the utility of an assessment method as follows:
U(utility) = Reliability + Validity + Educational impact + Acceptability + Cost.

These concepts are briefly discussed here and as they relate specifically to the key features approach of assessment.

Reliability

Reliability refers to the consistency and accuracy with which a test measures what it is supposed to measure. To achieve this wide sampling of content across the area is needed. This is imperative to allow for stable and reproducible scores.

Validity

It is important to make sure that an assessment actually assesses what is intended to be evaluated. This concept is referred to as the validity of an assessment method. Assessment can be performed on various levels as described by Miller's assessment pyramid[54] (Fig 1). According to this model an assessment method can assess

knowledge (level 1), application of knowledge (level 2), simulation of the applied knowledge like in the case of a procedure (level 3) or the actual performance of a procedure in the real setting (level 4).

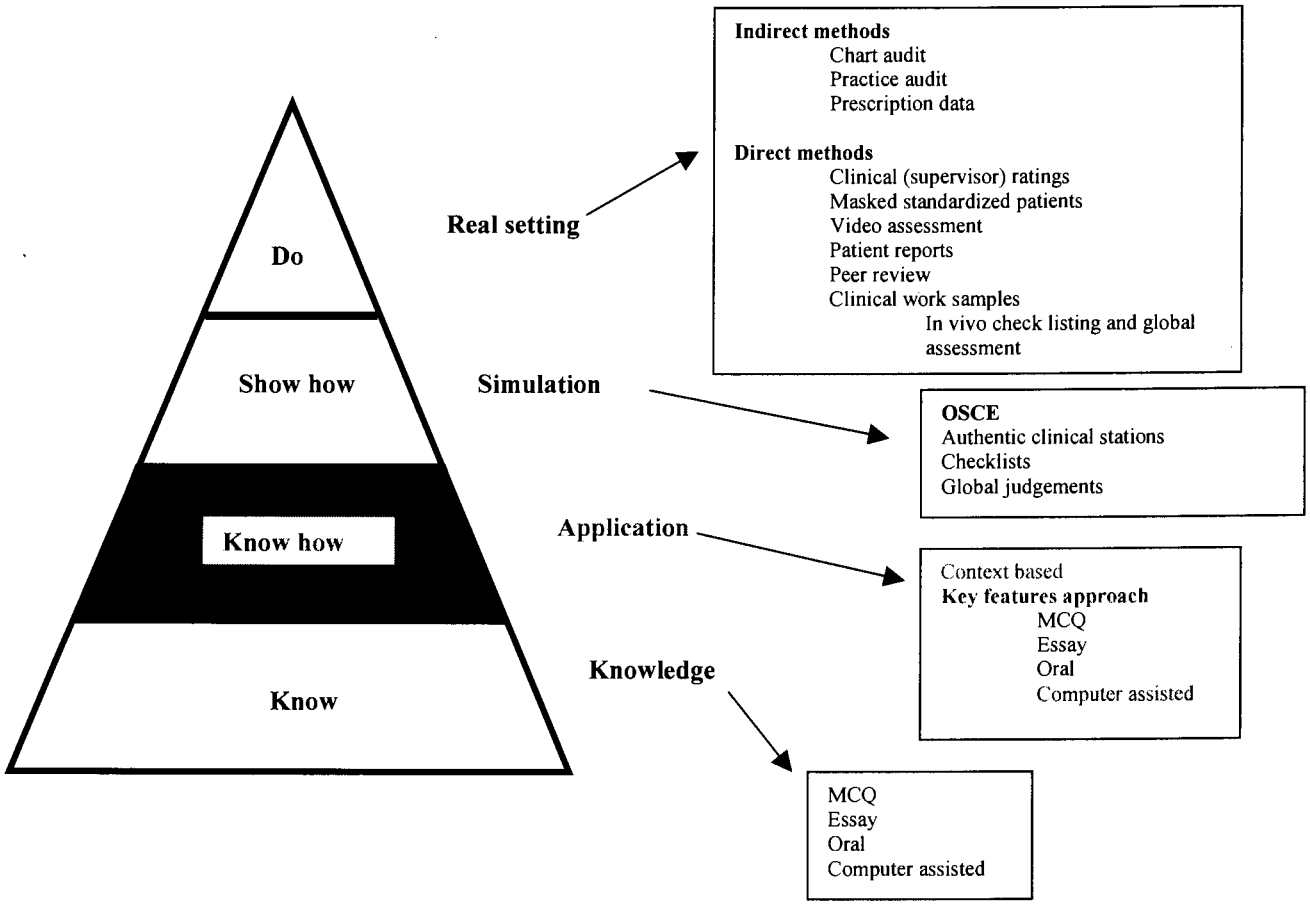

Fig 1. Miller's[54] assessment pyramid correlated with assessment methods as described by Van der Vleuten[53]

Educational impact

Any assessment action has a natural educational reaction. By testing knowledge on the first level of Miller's pyramid by multiple-choice questions for example, students adapt a learning style of recognizing facts. This may be valuable for recognizing facts in the knowledge domain, but is detrimental for assessing actual procedural competency.

In clinical anatomy assessment we need to make sure that assessment occurs on the application of knowledge and performance levels. Clinical anatomy needs to be assessed within a clinical framework. By doing this students will adapt a learning style which always asks the question of relevancy.

Acceptability

Assessment programs need to be acceptable for faculty. Performance based assessment of procedural skills by means of an objective structural clinical exam (OSCE) may prove to be valid, reliable and have a desired educational impact, but may be unacceptable to the faculty who conduct the exam with regards to logistical constraints that may exist. This is often the case in developing countries. OSCE's are logistically complex and time consuming. Harden *et al* [55] introduced the OSCE about 25 years ago. This assessment method involves examinees rotating around a circuit of stations at which they are required to perform a variety of tasks. Tasks may include taking a brief history, performing some portion of a physical examination, demonstrating procedural skills on a cadaver, counseling a patient, and so on. Performance is rated on checklists to the content of each station. To reach adequate reliability long tests are necessary which must include large numbers of stations to obtain a stable reproducible assessment[56]. Van der Vleuten *et al* [57] has shown that a knowledge test of skills correlates well with an OSCE but at relatively lower cost and easier logistics.

Cost

Good assessment programs are costly but are an invaluable investment in teaching and learning. A well-structured assessment of the application of knowledge and elements of simulation may be more cost effective than a performance based exam like an OSCE.

The following table illustrates the utility of both the key features assessment format, testing on the "know how" level of Miller's pyramid and the OSCE testing on the performance levels of Miller's assessment pyramid (Table 1).

	Key features approach	**OSCE**
Reliability	Fine with good sampling	Fine with good sampling
Validity	Level 2 of Miller's pyramid	Level 3 or 4 of Miller's pyramid
Educational impact	Good in problem solving skills and cognitive framework assessment	Good in performance skills
Acceptability	Good	Staff intensive, time intensive
Cost	Reasonable	May be very high

Table 1. Utility of both the key features approach and OSCE.

The key features assessment format allows to move from the test your knowledge domain of the assessment pyramid as described by Miller, to the "know how to do/use" domain. When emphasizing clinical reasoning skills we need to climb the pyramid to higher levels of assessment[53]. This has particular relevance to clinical anatomy.

Computer technology provides an ideal platform to perform key feature assessment. A rich stimulus format can be created by various media including images, audio, video and text in an interactive manner. The response format can then assess the key anatomical features within the clinical context created in the stimulus format.

Proper development of the stimulus format is therefore extremely important since it dictates the validity of the test[53]. When translating this model to training procedural skills and specifically the knowledge domain of clinical anatomy, the following is important:

- The clinical procedure provides a rich clinical context (stimulus format).
- Key anatomical features need to be identified, which are crucial to ensure the safe and successful performance of the procedure.
- These key anatomical features are found in both the anatomical pitfalls and complications of the clinical procedure.
- As soon as the key anatomical features are identified, a question format can be created to assess the anatomical knowledge base within the clinical context of the procedure.

The key anatomical features, once identified, can also be used to assess on higher levels of Miller's assessment pyramid, i.e. the levels of simulation and actual performance of the procedure. This can be done by checklisting the key anatomical features as the

procedure is performed in for example an OSCE [59]. Assessment of knowledge can therefore occur within a performance based assessment environment, whether real or simulated[58].

Reznick *et al* [59] has developed the Objective Structured Assessment of Technical Skill (OSATS) for assessing surgical trainees. During this assessment surgeons carry out the procedure on a model or cadaver. Every station has a specialist examiner using task specific checklists and global rating scales. Clinical anatomy can be assessed by key anatomical features in the checklist. To run an OSATS exam is very expensive and it seems that when assessing clinical anatomy competency, the key feature approach as described by Page *et al* [52] with key elements of simulation may be adequate.

Chapman *et al* [60] has described a unique approach using computer based multimedia to assess the performance of procedures. To perform a thoracotomy a student would use the mouse and a menu set to indicate each procedural action with corresponding instruments and materials needed. Placement, orientation and extent of each action is also indicated by the examinee. A still frame or motion video then displays the procedural action as the sequence was entered. A score is then derived from the electronically generated data.

Areas of cognitive orientation like anatomy need to be assessed in a clinically rich environment. This can be done in a virtual, simulated or real clinical environment. Hager *et al* [58] develops further on this notion when he argues that it is important to advance from traditional methods of testing knowledge which tend to focus on recall and understanding and assess knowledge in the clinical situation where emphasis is laid on synthesis and application. Assessing basic anatomical knowledge in a clinical situation requires comprehension, application, analysis, synthesis and evaluation.

To evaluate the effectiveness of a training program, objective data from structured observations or performance assessment examinations need to be obtained. Self-assessment of clinical competence does not necessarily reflect true ability[25].

2. Aims and Objectives

2.1 To develop a survey to determine the following objectives:

2.1.1 To determine which clinical procedures are performed in both urban and rural hospital practices in South Africa.
2.1.2 To determine the frequency of performance of the procedures determined.
2.1.3 To determine the importance rating of clinical procedures by general practitioners in their practice situation.
2.1.4 To determine the comfortability of general practitioners in performing the procedures.
2.1.5 To determine the difficulties associated with the procedures.
2.1.6 To determine the anatomically related complications encountered whilst performing the procedures.
2.1.7 To evaluate the assessment of doctors on the role of clinical anatomy competency in reducing difficulties and complications.
2.1.8 To evaluate the assessment of doctors on the role of clinical anatomy in improving confidence in the performance of clinical procedures.

2.2 To conduct the developed survey.

2.3 To select a total of **15 problem procedures** from the list determined proportional in every category (emergency procedures, surgical procedures, office procedures and imaging procedures),

- which are often performed (incidence more than 50%),
- essential,
- which more practitioners are uncomfortable with rather than comfortable,
- with which doctors experience difficulties and complications,
- where most practitioners thought that improvement of critical anatomy knowledge necessary to perform the procedure will reduce difficulties and complications and
- where most practitioners thought that improvement of anatomy knowledge necessary for the procedure will increase confidence in performing the procedure.

2.4 To compare the clinical procedures as well as **competency levels** in the different hospital practice settings in South Africa (urban and rural).

2.5 To determine the **knowledge domain** relevant to the clinical anatomy necessary to perform the procedures selected in 2.3 regarding the following aspects:

- Indications,
- Contraindications/ Precautions,
- Step-by-step procedure,

- Materials,
- Anatomical pitfalls and
- Anatomically relevant complications.
- References

2.6 To develop a **clinical anatomy-training program** for the procedures selected in 2.3, within a continued medical education environment.

3. Materials and Methods

3.1 Development of a survey-questionnaire

Objectives 2.1.1 - 2.1.8 were determined by a survey that was conducted as stated in 2.2 by means of a questionnaire.

A list of 57 procedures relevant to family practice in South Africa was determined by consulting various resources. An extensive literature survey was performed to determine what procedures are regarded as important for general practitioners in various practice situations all over the world. These included the standard procedures that are identified by family practice bodies like the American Board of Family Practice in the United States of America[39] and the National Health Service (NHS) in the United Kingdom [37].
After determining the list of procedures from the literature, they were discussed with experts in the field of Family Practice in South Africa and modified appropriately.

From the literature, clinical procedures in Family Practice can be divided in emergency procedures, surgical procedures, office procedures and imaging procedures [25,32,33,34,35].
Most procedures were chosen because of their relative importance. Procedures where a sound understanding of anatomy is crucial were included as well as those procedures determined by the American Association of Clinical Anatomists[1].

The questionnaire was reviewed at several stages.

Table 2 provides the list of procedures determined.

Statements or questions were developed to reflect the specific aims and objectives and determine the response(s) of the general practitioners. This is summarized in Table 3.

Table 2. List of procedures

Emergency procedures	
1	Oro/nasotracheal intubation
2	Cricothyroidotomy
3	Vascular access: Peripheral arm veins
4	Vascular access: Femoral vein
5	Vascular access: Great saphenous vein
6	Subclavian vein catheterization
7	Internal jugular vein catheterization
8	Pretibial intraosseous puncture/ infusion
9	Intercostal drain insertion
10	Lumbar puncture
11	Arterial blood puncture for blood sampling
12	Pericardiocentesis
13	Umbilical line placement
14	Suprapubic catheterization and puncture
15	Eye injury examination
Surgical procedures	
16	Reduction of uncomplicated forearm fractures
17	Sigmoidoscopy and proctoscopy
18	Dilatation and curettage
19	Episiotomy
20	Normal vaginal delivery
21	Caesarian section
22	Sterilization
23	Ectopic pregnancy surgery
24	Circumcision
25	Excision of external trombosed hemorrhoids, Injection or ligation of internal hemorrhoids
26	Appendectomy
27	Tonsillectomy and adenoidectomy
28	Wrist block and digital nerve block
29	Pudendal nerve block
30	Brachial plexus block
Office procedures	
31	Injection of shoulder joint
32	Colposcopy
33	Paronychia incision and drainage
34	Upper gastrointestinal endoscopy
35	Knee joint aspiration
36	Liver biopsy
37	Indirect laryngoscopy
38	Epistaxis and nasal packing
39	Bone marrow aspiration
40	Aspiration of pleural effusion
41	Reduction of shoulder dislocation
42	Reduction of elbow dislocation
43	Reduction of interphalangeal joint dislocation

44	Reduction of hip dislocation
45	Nasopharyngoscopy
46	Slit lamp examination
47	Rectal examination
48	Vaginal examination
Imaging procedures	
49	Musculoskeletal ultrasound
50	Abdominal CT scan
51	Brain CT scan
52	Chest X-Ray
53	Abdominal X-Ray
54	Pelvic X-Ray
55	Neck X-Ray
56	Obstetric ultrasound
57	Abdominal ultrasound

Table 3. Questionnaire development of aims and objectives, statements orquestions and responses for every procedure

Aim	*Statement/ Question*	*Response*
2.1.1 To determine which clinical procedures are performed in both urban and rural hospital practices in South Africa.	I perform this procedure in my practice.	Yes / No
2.1.2 To determine the frequency of performance of the procedures determined.	How many times did you perform this procedure in the past year?	More than 20 | 10-20 | 5-10 | Less than 5
2.1.3 To determine the importance rating of clinical procedures by general practitioners in their practice situation.	The performance of this procedure is important in my practice situation.	Essential | Desirable but not essential | Useful | Not necessary
2.1.4 To determine the comfort rating of general practitioners in performing the procedures.	I feel comfortable to perform this procedure.	Very comfortable | Fairly comfortable | Uncomforta-ble | Very uncomforta-ble
2.1.5 To determine the difficulties associated with the procedures.	I find difficulty to perform this procedure due to the following reason/s:	Knowledge of the procedure itself | Equipment necessary for the procedure | Practical skills to perform the procedure | Regional anatomy knowledge
2.1.6 To determine the complications encountered whilst performing the procedures.	I met the following complication/s after performing this procedure: [a]	Oro/nasotracheal intubation is given as an example: Esophageal intubation | Laryngospasm | Not able to visualize vocal cords
2.1.7 To evaluate the assessment of doctors on the role of clinical anatomy competency in reducing difficulties and complications.	The improvement of critical anatomy knowledge necessary to perform this procedure will reduce difficulties and complications.	Strongly agree | Agree | Disagree | Strongly disagree

[a] The complications differ for every procedure. These complications were determined by an extensive literature review and by selecting those that are specifically anatomically relevant.

2.1.8 To evaluate the assessment of doctors on the role of clinical anatomy in improving confidence in the performance of clinical procedures.	Improvement of anatomy knowledge necessary for the procedure will increase my confidence in performing the procedure.	Strongly agree | Agree | Disagree | Strongly disagree

(Table 3 continued)

Practitioners had to respond by ticking the appropriate box or boxes. This way of answering the questionnaire facilitated the practitioner response, eased the evaluation process and provided the means to compare data for various calculations.

A literature survey was performed to determine the most common complications for every procedure which are anatomically related. These were included in the questionnaire. General practitioners had to tick those complications that they have experienced before.
They were able to tick more than one box or add any complications that were not mentioned. When they did not tick any box, they did not experience any complications.

Demographic data for every practitioner was also obtained. This included age, sex, size of practice, type of hospital practice, data on year of graduation, additional postgraduate training, current practice profile and continuing education preferences.

The complete questionnaire is presented as Addendum1.

3.1.2 Conduction of survey

Ethical clearance to conduct the survey was obtained from the Ethics and Research Committee of the Faculty of Health Sciences at the University of Pretoria as well as from the relevant people in charge of the different hospital practices, either the superintendent of the hospital or the senior family physician in charge of the department.

The hospitals were selected in three different provinces namely Gauteng, Mpumalanga and Northern Province. The aim was to reach at least a sample size of 40 fully completed questionnaires for each of the urban and rural hospital practices.
The selection of the hospitals was not done on a random basis in the sense that every hospital in each province had an equal chance of being selected. The hospitals in Gauteng that were selected being Pretoria Academic Hospital, Kalafong Hospital and Mamelodi hospital were all in the municipal boundaries of the Tswane municipality and are regarded as urban. Another urban hospital being Rob Ferreira was also selected from the Mpumalanga province. These hospitals were regarded to sufficiently represent the urban hospital practices.
For the rural hospital practices 4 hospitals were selected for their remote location being Warmbaths (120 km from Pretoria), Elim (100 km from Pietersburg), Tshilidzini (160 km

from Pietersburg) and Donald Fraser Hospitals (> 250 km from Pietersburg) from the Northern Province and Temba Hospital (60 km from Nelspruit) from the Mpumalanga Province. These hospitals being up to 250 km from an urban setting were regarded as a good sample representing the rural hospital practices.

General practitioners in various hospital practices filled out the 21-page descriptive cross sectional questionnaire. The average time to fill out the questionnaire was 45 to 75 minutes. Various hospitals were randomly selected from three provinces in South Africa (Fig 2). Gauteng, Northern Province and Mpumalanga are the provinces from which the Faculty of Health Sciences at the University of Pretoria receives patient referrals and where student training is done.

For Gauteng:	Kalafong Hospital (urban)
(Fig 3)	Pretoria Academic Hospital (urban)
	Mamelodi Hospital (urban)
Northern Province:	Warmbaths Hospital (rural)
(Fig 4)	Elim Hospital (rural)
	Tshilidzini Hospital (rural)
	Donald Fraser Hospital (rural)
Mpumalanga:	Themba Hospital (rural)
(Fig 5)	Rob Ferreira Hospital (urban)

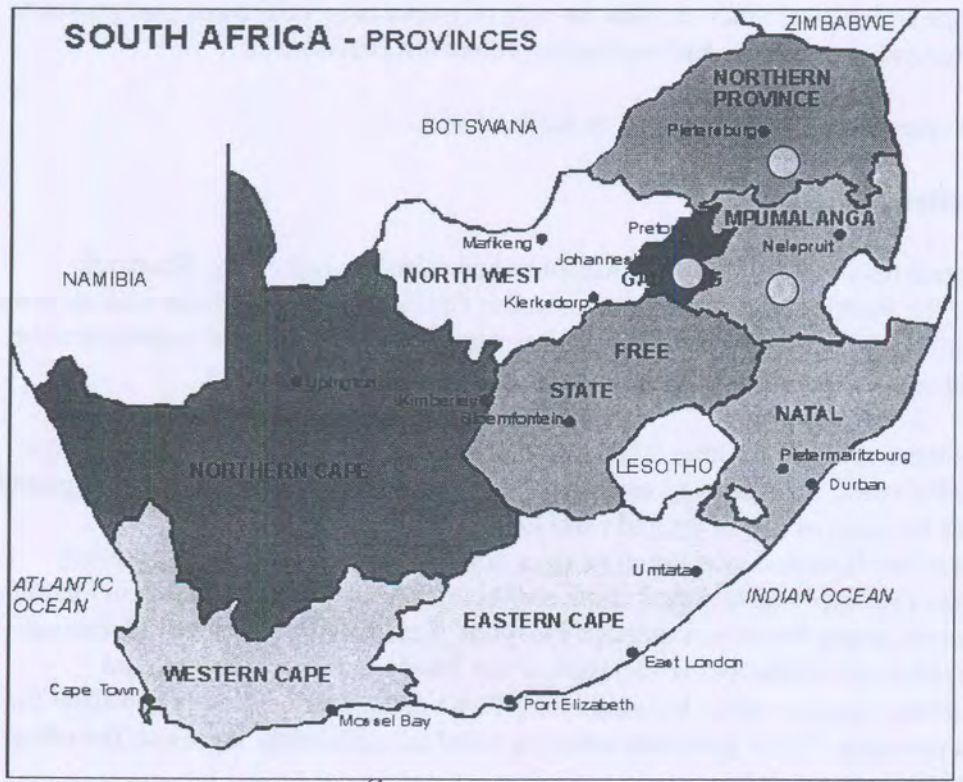

Fig 2. Map of South Africa[61]. The survey was performed in Gauteng, Northern Province and Mpumalanga. (Indicated by the ◯)

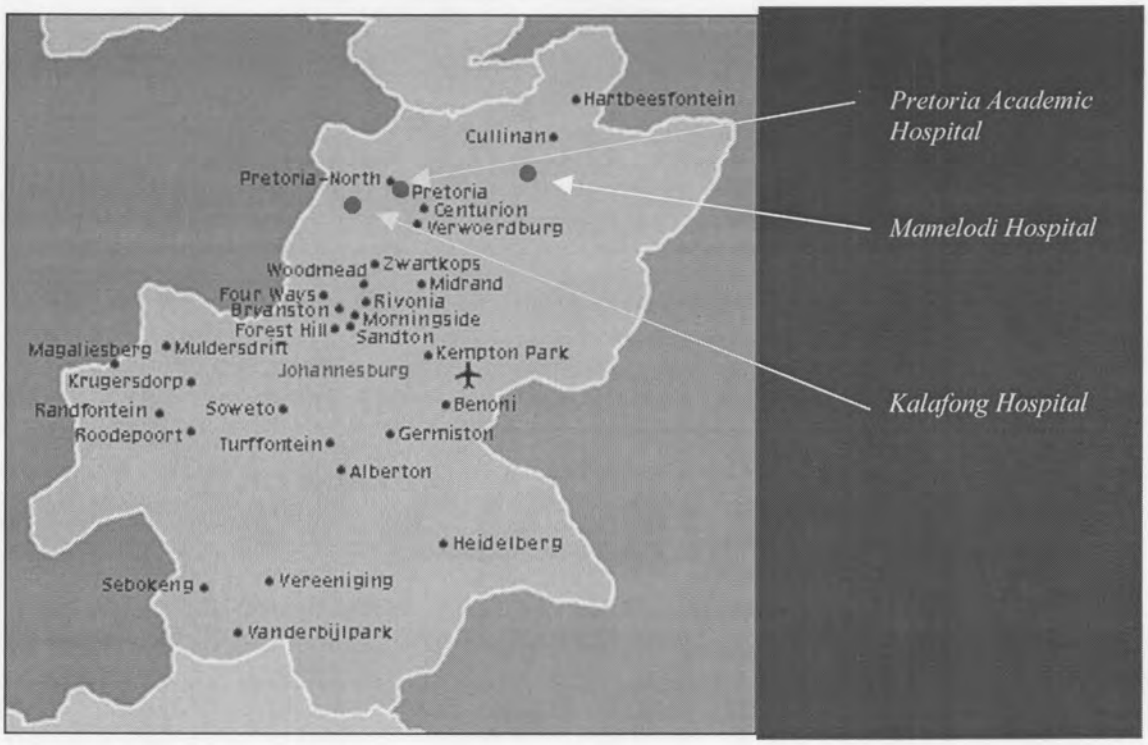

Fig 3. Gauteng[62] with the following hospitals indicated: Kalafong Hospital, Pretoria Academic Hospital and Mamelodi Hospital

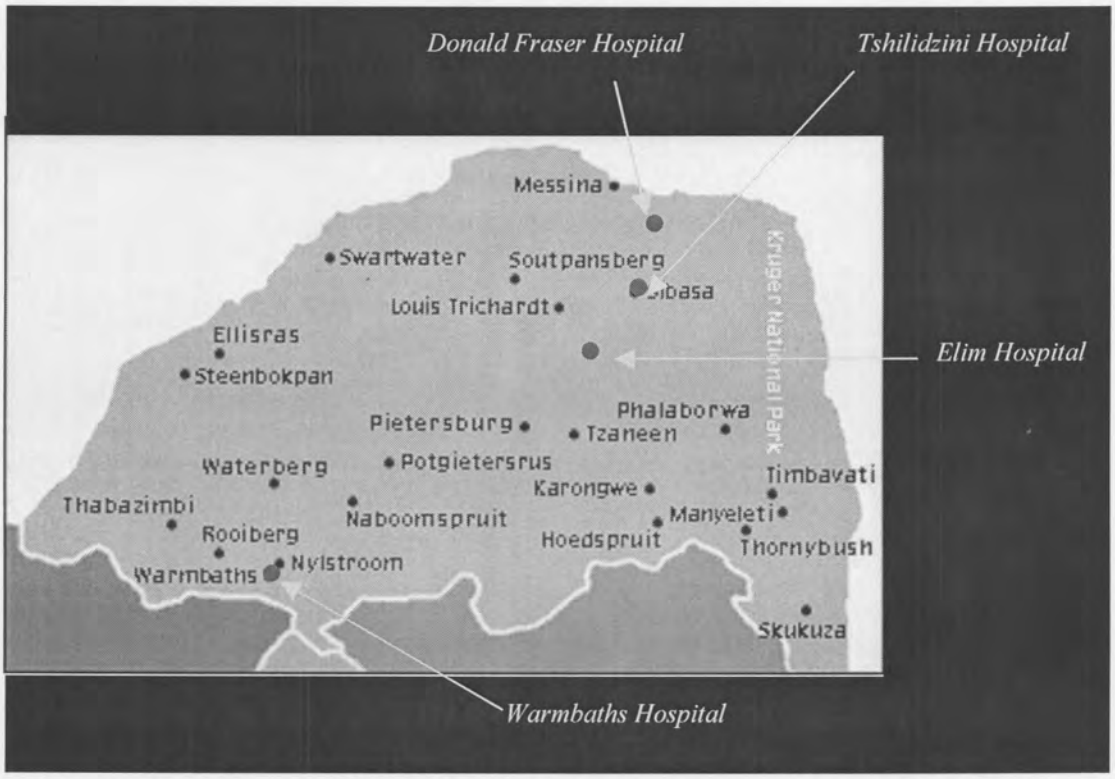

Fig 4. Northern Province[62] with the following hospitals indicated: Warmbaths Hospital, Elim Hospital, Tshilidzini Hospital and Donald Fraser Hospital.

Fig 5. Mpumalanga[62] with the following hospitals indicated: Themba Hospital and Rob Ferreira Hospital

The aim was to reach at least a sample size of 40 fully completed questionnaires for each of the urban and rural hospital practices. An urban hospital practice was defined to lie within the boundaries of a municipally declared urban area and a rural hospital practice outside the urban boundaries.

An appointment was made with the superintendent of the hospital or family physician in charge of the Department of the listed hospitals. This appointment had the following aims:

a) To meet the general practitioners available at the hospital at the time of the appointment (all general practitioners except those busy in either casualty with an emergency or in the operating room busy with an emergency operation or those on leave). The appointment was made during the weekly meeting of the doctors with either the superintendent or the Family Physician in charge. All doctors in the hospital not meeting the exclusion criteria listed below had the opportunity to fill in the questionnaire.
b) To provide a short introduction on the aims of the study and to emphasize that taking part in the study is entirely voluntary and anonymous.
c) To have the questionnaires completed to the best of the physician's knowledge.

All general practitioners except those busy in either casualty with an emergency or in the operating room busy with an emergency operation or those on leave, completed the questionnaire. This figure involved more than 80% of the total general practitioners working at the hospital.

Doctors that were busy in casualty or the operating room, on leave or ill during the conduction of the survey were similar to those completing the questionnaire if they were not excluded by the exclusion criteria.

Only practitioners with the MBChB degree with or without a postgraduate degree in Family Medicine or other diploma's were included in the study.

The following were eclusion criteria:

- Doctor registered a specialist different from Family Medicine
- Part-time doctors
- Doctor in private practice

The study's aim was to involve only doctors in hospital practice and no private practice was involved in the study.

General practitioners in various hospital practices filled out the 21-page descriptive cross sectional questionnaire in there own time. The average time to fill out the questionnaire was 45 to 75 minutes. Because the questionnaire was structured in a way that certain choices had to be made (see attached questionnaire), doctors has to tick the appropriate box. No interviews were performed. The completed questionnaire was handed over in a box supplied for the collection of the completed questionnaires. The researcher was available to answer any questions that may arise, although the questionnaire was self explanatory. There was therefore a slight theoretical chance for the researcher to identify a specific respondees completed questionnaire and therefore abridge anonymity, although the respondee was assured of staying anonymous due to above mentioned measures. The researcher however protected anonymity at all times and refrained from transgressing good ehical conduct.

General practitioners were free to add and rate on the same scales, any unlisted clinical procedure they perform.

3.1.3 Analysis of data produced by the survey

Every data-item on the questionnaire was given a numerical value for all eight questions. The data was meticulously entered into the Excel® statistical program for every procedure. There were 30 data points for every procedure. This means a total of 165 870 data points were entered.

Incidence of performance was calculated as being either yes (1) or no (2). The values were added by simple summation and mean values determined.

For **frequency of performance** analysis the following responses were quantified as follows: More than 20 (1); 10-20 (2); 5-10 (3); Less than 5 (4); no response (0). A simple count function was performed (COUNTIF) to determine how many doctors responded in the various categories.

For the **importance rating** of the various procedures, the different categories were quantified as follows and then summated by a simple count function (COUNTIF) to determine the result of hits in every category: Essential (1); Desirable but not essential (2); Useful (3); Very uncomfortable (4); no response (0).

Regarding the **determination of measure of comfort**, the different categories were quantified as follows and the summated by a simple count function (COUNTIF) to determine the result of hits in every category: Very comfortable (1); Fairly comfortable (2); Uncomfortable (3); Very uncomfortable (4); no response (0).

Regarding analyzing the **difficulties encountered**, the different categories were quantified as follows and then summated by a simple count function (COUNTIF) to determine the result of hits in every category: Knowledge of the procedure itself (1); Equipment necessary for the procedure (2); Practical skills to perform the procedure (3); Regional anatomy knowledge (4); no response (0).

The various **complications** encountered were analysed by quantifying every choice with a numerical value for each procedure and then summating the various categories.

To evaluate the assessment of doctors on the **role of clinical anatomy competency in reducing difficulties and complications**, the different categories were quantified as follows and then summated by a simple count function (COUNTIF) to determine the result of hits in every category: Strongly agree (1); Agree (2); Disagree (3); Strongly disagree (4); no resonse (0).

To evaluate the assessment of doctors on the **role of clinical anatomy in improving confidence in the performance** of clinical procedures, the different catgories were quantified as follows and then summated by a simple count function (COUNTIF) to determine the result of hits in every category: Strongly agree (1); Agree (2); Disagree (3); Strongly disagree (4); no response (0).

The chi-square test for categorical data was employed by means of the STATISTIX for Windows version 7 statistical software to compare data from urban and rural hospital practice groups.

3.2 Selection of procedures and criteria for selection

Various selection models were developed to select a total of 15 problem procedures proportional in every category (emergency procedures, surgical procedures, office procedures and imaging procedures). This was done for no other means of selection criteria were found in the literature.

Scoring options A, B,C and D were developed and are attached as Addendum 2.

Scoring option C was selected to best represent the selection criteria of the study. These were the following:

1. Incidence of performance (>50%)	1 point
2. Essentiality (>60%)	1 point
3. Comfortability (more are uncomfortable than comfortable)	1 point
4. Difficulty or complication related to anatomy experienced by more than 25% of doctors	1 point
5. More than 80% thought that improvement of critical anatomy knowledge necessary to perform the procedure will reduce difficulties and complications.	1 point
6. More than 80% thought that improvement of anatomy knowledge necessary for the procedure will increase confidence in performing the procedure.	1 point
Total:	**6 points**

Procedures that scored highest in every section (emergency procedures, surgical procedures, office procedures and imaging procedures) were subjected to the following to select the number (emergency procedures = 6, surgical procedures = 4, office procedures = 4 and imaging procedures = 1) in every category: Sum of the following categories: Uncomfortable + very uncomfortable + the highest difficulty or complication.

Due to the fact that the focus of this study is on the influence of clinical anatomy on the performance of procedures, procedures were scored in a way by giving aspects of difficulties and complications met and the assessment of the influence of clinical anatomy on performance, more weight than for instance frequency of performance alone. The fact whether the procedure was regarded as essential in the specific practice situation was regarded as important as well, because of its reflection on the need in the practice and the life saving nature of the procedure.

Scoring option C was therefore eventually chosen to select the procedures which general practitioners ranked important where most difficulties and complications were met and where the influence of clinical anatomy knowledge on the safe and successful performance of the procedure, was ranked highest.

3.3 Comparing urban and rural hospital practices

Data from the questionnaire was compared for the urban and rural hospital practices for objectives 2.1.1 to 2.1.8 regarding the selected problem procedures identified in 3.2 (Selection of procedures and criteria for selection). Statistical analysis to compare the urban and rural group regarding various aspects was done by the student t-test.

3.4 Development of a clinical anatomy knowledge base for each selected problem procedure.

After selecting the problem procedures according to the criteria in Scoring option C, the clinical anatomy content for every procedure was developed. This was done by developing a clinical anatomy knowledge base for every selected procedure with the following standard pattern for every procedure:

1. Indications
2. Contraindications/ Precautions
3. Step by step procedure
4. Materials
5. Anatomical pitfalls
6. Complications (anatomically relevant)
7. References

The clinical anatomy reference for the selected procedures was developed by an extensive literature study of the most recent and relevant publications, both in the basic medical and clinical sciences.

The Medline database was studied via an interactive windows-based search engine OVID WEB via the online service of the Academic Information Service of the University of Pretoria, as well as the catalogue of both the libraries of the University of Pretoria and the University of Cambridge. Publications in the following languages were included: Afrikaans, Dutch, English and German.

Content experts[i] in Cambridge (UK), Pretoria (South Africa), New York (USA), London (UK), Bath (UK) and Nijmegen (The Netherlands), were consulted in person on relevant and important references on the essential clinical anatomy for the 15 selected procedures.

3.5 Development of a clinical anatomy training program for the selected problem procedures

Due to the unique circumstances of general practitioners in hospital practices in South Africa, a training program was developed that took the following factors into account:

1. General practitioners in hospital practices are often practicing in rural areas, far from tertiary care institutions.
2. General practitioners have limited time to attend a program based at a tertiary teaching center like the Faculty of Health Sciences at the University of Pretoria. This is due to constrained resources in hospital practices.
3. Most general practitioners have access to computers but often have difficulty to get online[13].
4. General practitioners need an accessible program addressing their specific needs.

Therefore a program was developed with the following characteristics:

1. A strong emphasis is laid on self-directed learning.
2. A multimedia platform is used from a CD-ROM. There is consequently no dependence on online facilities.
3. A non-linear mode to access the program is used to address specific and relevant needs and questions in a time efficient way.
4. No previous computer skills are necessary.
5. The platform used is easy to run and widely available (like PowerPoint®).
6. The platform can also be used both by teacher in teaching and small group interactions at hospital practices.
7. Various media are included to produce a Virtual Procedures Room, with the following components:

---

[i] The following content experts are named:
Prof PH Abrahams, Kigezi International School of Medicine, Girton College, Cambridge, UK
Prof JH Meiring, Department of Anatomy, University of Pretoria, South Africa
Mr T Welsh, Queens College, Cambridge, UK
Dr IG Parkin, Department of Anatomy, Univeristy of Cambridge, UK
Mr RH Whitaker, Department of Anatomy, University of Cambridge, UK
Mr B Logan, Department of Anatomy, University of Cambridge, UK
Prof T Olson, Albert Einstein School of Medicine, New York, USA
Dr Helen Bloch, Long Island Jewish Medical Centre, New York, USA
Dr W Rennie, Long Island Jewish Medical Centre, New York, USA
Dr R Kneebone, St Mary's Hospital, London and Bath University, UK
Dr T Silver, St Georges Hospital Medical School, London, UK
Mr V Mahadevan, Royal College of Surgeons of England, London, UK
Prof J Kauer, Katholieke Universiteit Nijmegen, The Netherlands

- Orientation Room
- Clinical anatomy laboratory to illustrate the anatomical pitfalls and complications.
- Simulation room for simulation of the procedure by animated sequences, which for example show the path of a needle puncture.
- Clinical background room with the following information: Indications, contraindications, step by step approach and materials necessary for the procedure.
- Library with all the full text papers and references.

Relevant high-resolution dissection images were selected to correlate with the clinical anatomy knowledge base in order to illustrate and animate key points relevant to the specific procedure. The prosection collection of the Departments of Anatomy at the University of Cambridge[i] and the University of Pretoria[ii] were used to obtain images for every selected procedure, illustrating the key anatomical pitfalls and complications as well as using them as the basis for the creation of animations. Photographs of the images were taken by the author and digitized.
Various key people[iii] in the field of multimedia educational development and medical

[i] A word of special thanks to Mr B Logan, University prosector at the Department of Anatomy, University of Cambridge, as well as his team Mal Lazenby, Lucie Whitehead and Martin Watson who prosected most of the prosections used in the training program.

[ii] A word of special thanks to Mr EO Brüne and several medical and dental students in the Department of Anatomy, University of Pretoria, who prosected a number of the prosections used in the training program, especially a substantial number of the section on knee joint aspiration.

[iii] The following multimedia and medical educational experts in and outside the field of clinical anatomy are named:
Prof PH Abrahams, Kigezi International School of Medicine, Girton College, Cambridge, UK
Prof JH Meiring, Department of Anatomy, University of Pretoria, South Africa
Prof S Stensaas, University of Utah, Salt Lake City, USA
Prof C Van der Vleuten, University of Maastricht, The Netherlands
Dr IG Parkin, Department of Anatomy, Univeristy of Cambridge, UK
Prof T Olson, Albert Einstein School of Medicine, New York, USA
Dr W Rennie, Long Island Jewish Medical Centre, New York, USA
Dr R Kneebone, St Mary's Hospital, London and Bath University, UK
Prof J Dacre, Whittington Hospital, University College London, London, UK
Prof JA Boon, Telematic Learning and Education Innovation, University of Pretoria, South Africa
Prof J Kauer, Katholieke Universiteit Nijmegen, The Netherlands
Dr J Bulte, Katholieke Universiteit Nijmegen, The Netherlands
Dr C Daetwyler, Bern, Switzerland
Mr V Mahadevan, Royal College of Surgeons of England, London, UK
Mr T Welsh, Queens College, Cambridge, UK
Mr L Wiseman, Primal Pictures, London, UK
Prof E April, Columbia University, New York, USA
Prof B Bogart, New York University, New York, USA
Dr Mtui, Cornell University, New York, USA
Dr Levine, Downstate Brooklyn Hospital, New York, USA
Dr C Goodmurphy, St Georges University Grenada, West Indies
Prof I Treadwill, Skills Laboratory, University of Pretoria, South Africa
Dr Rupert Gabriel, Bath University, UK

education were consulted in person to develop a program with various multimedia platforms and based on sound educational philosophy. These included the following people from Cambridge (UK), Pretoria (South Africa), London (UK), Salt Lake City (USA), New York (USA), Maastricht (The Netherlands), Nijmegen (The Netherlands), Bern (Switzerland), Leiden (The Netherlands), Norwich (UK) and Grenada (West Indies).