Sexual Health Screening Tools:  
An Adaptation for Immigrants and Refugees

Abstract

Sexual health information is medical information of a personal nature that is often not well gathered by healthcare providers. When there are added barriers of a linguistic, cultural, gender, ethnic, or social nature – as there are with immigrants and refugees – it becomes even more difficult. The information, however, is critical to understanding the sexual health problems that immigrants and refugees face and key to adapting our healthcare, education, community outreach and public policy to address these problems. This research project adapts sexual health screening tools, linguistically and culturally, for immigrant and refugee populations so that sexual health history is easier to obtain. The effectiveness of the adapted screening tools will be analyzed by comparing both patient and provider satisfaction before and after the tools are implemented. An increase in effective sexual health information gathering will lead to better standard of care and pave the way for more research to be done on effective methods of improving immigrant and refugee sexual health.

Mentoring Plan

The mentor and the student have common interests in terms of dedication to underserved populations. Specifically, both are interested in advancing the competence and knowledge base of health professionals working with refugee populations. The mentor has advising experience and is dedicated to working with the student. The student and the mentor will meet biweekly and exchange emails twice
weekly. If the project demands more time or more contact the mentor and the student will adjust accordingly.

Environment

The project will be carried out in Maricopa Integrated Health Services (MIHS) facilities. We will use their rooms to carry out the focus groups that evaluate the translated questionnaire tools. Maricopa refugee and immigrant clinics will also be used to distribute the questionnaire tools and then assess the level of staff competency and patient satisfaction with the new surveys.

The project will require access to statistical programs to evaluate the effectiveness of the changes made to the questionnaire tools. These programs will be loaded on the laptops of the mentor and student to facilitate availability. The in-house statistician at MIHS will be available to help the mentor and the student with any issues related to data analysis or manipulation.

Project Specific Curriculum

To be able to complete the statistical portion of the project the student will use the knowledge acquired in public health courses as a part of the Masters in Public Health program. Specifically, the student has taken biostatistics which reinforced knowledge of data entry, manipulation and analysis. The course used Stata as a statistical tool and the student feels confident in using Stata for the scholarly project. The student will also attend any planning meetings between the mentor and the head of the Phoenix Integrated Residency Program in Obstetrics & Gynecology. This will facilitate knowledge of protocol and presentation style in research settings.

Specific Aims

1. Improve sexual history taking in refugee and immigrant populations through adapting a sexual health questionnaire tool and assessing its effectiveness from the patient’s perspective.
2. Improve provider competence and assess the effectiveness of the adapted questionnaire tools from the provider’s perspective.

**Introduction/Significance**

Sexual health is an extremely important portion of good health for people of all backgrounds. Addressing the issues relating to sexual health cross-culturally can be a difficult task due to linguistic, cultural, gender, and racial/ethnic barriers. Adapting a sexual health diagnostic screening tool that assesses sexual health concerns in immigrant and refugee populations is an important step that will encourage open dialogue between patients and providers surrounding sexual issues.

An examination of the literature of cross-cultural sexual history taking revels that there has not been much research done in the field. The majority of articles that address competency in sexual history taking address individuals of diverse sexual orientation\(^1,4,5,6\). There are many articles on cross-cultural competency in a history taking in general but most do not address sexual history taking \(^1,2\).

An examination of sexual health in refugee and immigrant populations demonstrates that sexual health of these patients requires attention by health care personnel; especially by primary healthcare personnel. *The Annual Review of Public Health* in 2004 published an overview of the ten health issues that immigrants face – termed leading health indicators (LHIs)\(^7\). The LHIs were selected due to their importance as public health issues, their ability to motivate action, and the availability of data to measure their progress\(^7\). The authors of the paper argue that the LHIs will pave the way for the health issues that need to be addressed in immigrant populations\(^7\).

Responsible sexual behavior was one of the ten LHIs. The report found that sexual risk behavior among immigrants is widely varied. Adolescent immigrants on average have less parental support on sexual issues and thus are more likely to engage in risky behavior\(^7\). Female immigrants from many cultures were found to be much less likely to use condoms to prevent STDs\(^7\). HIV transmission among immigrants was found to be more likely due to sexual encounters rather than injection drug use\(^7\).
conclusion the report states that data for sexual behavior demonstrates diverse cultural perceptions, norms, and expectations; and that cultural, ethnic, and gender difference are also widely observed within subgroups.

This indicates that sexual health is an extremely important issue that has not been thoroughly researched in immigrant populations. Adapting sexual history screening tools and passing them through rigorous assessment to ensure effectiveness both for patients and practitioners is a valid first step in fortifying our knowledge basis so that further research can be undertaken.

Preliminary Information/Data:

1. Adapting the sexual history questionnaire tool – the student and mentor will work together to make a prototype of the adapted sexual health questionnaire tool and then enlist the assistance of translators to translate it into the appropriate languages.

2. Organizing the focus groups – the student and the mentor will work within the circles of refugees or immigrants that work at MIHS or frequently attend the clinic to recruit a focus group for each culture that we are adapting the tool for. We will organize a meeting between them to discuss the translated tool and its level of acceptability culturally. The adapted tool will arise from these meetings. Organizations that work with refugees and immigrants can be contacted for assistance in recruiting.

3. Developing the surveys that will be administered to test the efficacy of the tools – the student will research survey development and design surveys that accurately and easily request the information we are looking to evaluate. The survey can easily be added to the paper work that both staff and patients routinely have to fill out. An informed consent describing the study will be included. No personal identifying information will be collected.

4. Data entry, manipulation and analysis – this will be completed by the student with any assistance offered by the mentor and the statistician at MIHS.
Plan:

1. Improve sexual history taking in refugee and immigrant populations through adapting a sexual health questionnaire tool and assessing its effectiveness from the patient’s perspective.

   a. **Rationale:** The effectiveness of the adapted tool needs to be assessed by the patient for satisfaction and cultural competency. This will ensure that patient does not feel that the tool violates cultural barriers and that they feel respected and satisfied with the encounter.

   b. **Design:** The study will be a qualitative cross-sectional study that evaluates whether there is a statistical difference in patient satisfaction before and after the adapted tool is implemented. The project will use data from a survey that assesses patient satisfaction and perceived level of cultural competence. Data from surveys taken prior to the introduction of the adapted sexual history tool will be used as control data and will be compared to the same data from surveys taken after the adapted tool has been implemented. At least 200 surveys in both the control and non-control group will be evaluated.

   The independent variables will be the changes made in the sexual history tool and the dependent variables will be the level of satisfaction and the perceived level of cultural competency.

   Outcomes will be measured in terms of changes in patient satisfaction and perceived cultural competence with the adapted sexual history tool.

   Data will be collected through surveys completed by patients in MIHS refugee and immigrant clinics. The collected data will be managed on the mentor’s and student’s laptop computers in statistical software.

   c. **Method of Analysis:** Data will be analyzed using statistical software – possibly Stata. A two-sided, two-tailed T-test would be appropriate. The population mean for patient satisfaction and
perceived cultural competence of a sexual history tool is not known, and we would like to ensure that the adaptations do not decrease patient satisfaction or perceived cultural competence.

d. **Expected Results:** We expect that the adapted sexual history tools will increase patient satisfaction and perceived cultural competence.

e. **Interpretation of possible results:** If we get results that show decreased patient satisfaction or perceived cultural competence we will need to reevaluate the tool and possibly reform a focus group to reexamine the translation and cultural competency of the tool.

f. **Pitfalls and Workarounds:** Problems may arise with literacy of the survey - if patients are not able to read and write English we will translate the surveys. If patients are unable to read or write their native language we may have to have translators for assistance.

2. Improve provider competence and assess the effectiveness of the adapted questionnaire tools from the provider’s perspective.

a. **Rationale:** The effectiveness of the adapted tool needs to be assessed by the healthcare professionals (staff) for effectiveness in gathering all the pertinent information and for their perceived level of competence in gathering the information. This will ensure that the adapted form still collects all the pertinent information and that the staff member feels at ease in using the tool.

b. **Design:** The study will be identical to that of aim one except now examining the effectiveness from the staff member’s perspective. The survey will be administered before and after the adapted tool is implemented to assess for statistically significant difference between them. The project will use data from a survey that assesses level of information gathered and perceived level of competence. Data from surveys taken prior to the introduction of the adapted sexual history tool will be used as control data and will be compared to the same data from surveys taken after the
adapted tool has been implemented. At least 200 surveys in both the control and non-control group will be evaluated.

The independent variables will be the changes made in the sexual history tool and the dependent variables will be the level of information gathered and the perceived level of competence. Outcomes will be measured in terms of changes in the level of information gathered and perceived competence with the adapted sexual history tool.

Data will be collected through surveys completed by staff in MIHS refugee and immigrant clinics. The collected data will be managed on the mentor’s and student’s laptop computers in statistical software.

c. **Method of Analysis:** Data will be analyzed using statistical software – possibly Stata. A two-sided, two-tailed T-test would be appropriate. The population mean for the level of information gathered in a sexual history taking session and perceived level of cultural competence is not known, and we would like to ensure that the adaptations do not decrease patient satisfaction or perceived cultural competence.

d. **Expected Results:** We expect that the adapted sexual history tools will increase the level of information that the staff is able to gather and their perceived competence in doing gathering it.

e. **Interpretation of possible results:** If we get results that show decreased levels of information being gathered or a decrease in perceived competence we will need to reevaluate the tool and possibly reform a focus group to reexamine the translation and medical information on the tool.

f. **Pitfalls and Workarounds:** Problems may arise with variable inherent levels of cultural competency in staff members – possibly we can design a survey that will evaluate the baseline level of competence of each staff member than partakes in the study.

Compliance
The prospectus that is to be submitted to the Institutional Review Board (IRB) is currently in progress and will be submitted for review in July 2011. Depending on the response from the IRB the project will be accordingly adapted or proceed as planned.

**Timeline**

**Summer 2011:**

- The prospectus will be submitted for IRB approval in July 2011.
- The student and the mentor will be in contact via email over the summer and work on constructing the sexual history questionnaire tools and the survey that will be used to collect data on staff competency and patient satisfaction.

**Fall 2011:**

- Survey the staff and patients who come to the clinics at MIHS to collect baseline data on staff competency and patient satisfaction with the current sexual history taking questionnaires.
- Focus groups meetings with specific community groups to discuss the adapted questionnaire tools and the validity of the translation and cultural adaptations.
- The tools will then be adjusted according to the feedback from the focus groups.

**Spring 2012:**

- Begin to utilize the questionnaire tools in the clinics at MIHS.
- Survey the staff and patients to get comparative data on staff competency and patient satisfaction with the new sexual history taking questionnaires.

**Summer 2012:**
• Analyze the data comparing the new and old sexual history taking questionnaires for statistically significant difference in both staff competency and patient satisfaction.

Fall 2012 and Spring 2013:

• Write up the data report and attempt to publish.

References


Brown Adipose Tissue Detection with Infrared Thermography

Abstract

Overweight and obesity have reached epidemic levels worldwide costing hundreds of billions of dollars.\(^1\) In US alone, two out of three Americans are affected, resulting in elevated risks for many other diseases.\(^2\) Unfortunately, it is often challenging to get people to adhere to a lifestyle that is favorable to maintaining a healthy body weight. One alternative solution is to find a way to increase resting energy expenditure by stimulating brown adipose tissue (BAT), an organ that has been recently discovered to be biologically relevant in adult humans.\(^3\) BAT takes fat from the body and burns it to generate heat for the rest of the body in a process called non-shivering thermogenesis. It is estimated from rodent studies that only 50g of BAT could consume several hundred kcal per day. However, before this promising strategy can become a reality, we need to learn more about BAT. Current methods to study BAT are prohibitively expensive, time consuming, and expose subjects to radioactive materials.\(^4\) Given BAT’s profound heat-generating capacity, we propose to use infrared (IR) thermography for BAT detection and to confirm its validity with well-established conventional data (\(^{18}\text{F-FDG PET/CT}). By comparing data produced by each of these methods, we can see if there is a correlation between BAT activation and temperature changes in the IR images. If IR can be used to identify BAT, large-scale population studies can be performed safely and inexpensively to further our understanding of BAT and its potential to treat obesity and related diseases.
Mentoring Plan

Given that a new technology is being developed to understand human physiology, frequent sessions between student and mentor are required. We will meet at least three times a week to review the research plan, data acquired, and interpretation of the literature and results. The structure will vary depending on the specific questions at hand, from informal discussions to more formal reports of progress and plans and preparation for oral presentations. These meetings are facilitated by the student and mentor having similar scholarly interests, the understanding of integrated physiology. Input on this high-impact project will come from multiple sources within the Joslin Diabetes Center and Harvard Medical School community, but there will be no formal co-mentors.

Environment

Student has full access to infrared images and PET/CT scans of the patients in the study. Infrared images are analyzed using FLIR Reporter Professional 8.5 software (FLIR Systems, Inc., North Billerica, MA). PET/CT scans are analyzed using PET-CT Viewer software (Beth Israel Deaconess Medical Center, Boston, MA). In addition, JMP® statistical discovery software and MS Excel are available for statistical analysis. All of these tools are available on a desktop for the student to use. Workspace, computer, software, Internet connection, and stationary supplies are all in place for the student to carry out the plan.

Project Specific Curriculum

Student will attend five didactic sessions at Joslin Diabetes Center to help understand topics related to diabetes, metabolism, brown adipose tissue, and clinical research. Also, student is responsible for watching eight online lectures provided by The Vanderbilt Diabetes Center to gain perspective on diabetes. There will be opportunities to learn about how to give effective scientific
presentations through special sessions and constructive feedbacks from the mentor. To further improve student’s presentation skills, two presentations are required of the student. The first one is a 10 minutes PowerPoint presentation with at least 5 minutes of discussion to follow in front of other summer internship students on 7/27/11 at Joslin Diabetes Center. The second one is a poster presentation on 8/3/11 at a research symposium sponsored by NIDDK.

**Specific Aim**

Aim 1: To show that infrared thermography can detect changes in skin surface temperature overlying regions of thermogenic brown adipose tissue.

**Introduction/Significance**

Obesity has already reached an epidemic level in the U.S. and worldwide. According to the World Health Organization, in 2008, more than 1.5 billion adults were overweight with more than 500 millions of them obese. Each year at least 2.8 million adults die as a result of being overweight or obese due to increase risks for a variety of diseases such as cardiovascular diseases and diabetes. In the U.S., obesity and diabetes are costing almost two hundred billions dollars in healthcare cost annually, negatively impacting quality of life and productivity.¹

Obesity occurs when there is a higher energy intake than expenditure.⁵ In humans, there are two known types of fat: white and brown adipose tissue (WAT and BAT). White adipocytes are large, unilocular, and responsible for energy storage. Brown adipocytes on the other hand are smaller, multilocular, and capable of thermogenesis. They contain numerous mitochondria and are able to generate heat through their cell-specific uncoupling protein 1 (UCP-1), which uncouples oxidative phosphorylation from ATP synthesis,⁶ and thus increase energy expenditure when activated.
It has recently been discovered that adult humans have active BAT that could be biologically useful, and research started to gain momentum in 2009. By using positron-emission tomography and computed tomography (PET/CT) with the radiotracer $^{18}$F-fluorodeoxyglucose ($^{18}$F-FDG), active BAT can be detected. This technology takes advantage of the functional and structural information PET/CT provides, and the fact that uptake of $^{18}$F-FDG can be used to distinguish BAT from WAT. There is evidence suggesting that 50g of maximally-stimulated BAT could consume the equivalent of 20% of daily basal caloric need.

In order to explore if BAT can potentially become an important therapeutic tool for treating people with energy imbalance, the ability to detect its activity is paramount. While $^{18}$F-FDG PET/CT can monitor the presence and activity of BAT, it has two critical limitations. First, it requires injecting radioactive substances into subjects. This introduces health risks and prevents its use in certain populations. Second, it is an expensive and time consuming procedure. It takes about an hour to perform the scan and costs thousands of dollars.

A promising alternative is to use infrared (IR) thermography for BAT detection. Few studies have been published to date, but they lack the confirmatory $^{18}$F-FDG PET/CT data to support their results. The problem is resolved in this study since IR images were collected at the same time that BAT activity was measured via $^{18}$F-FDG PET/CT. If IR can be used as a method to identify superficial BAT depots, the implication is significant. Large scale population studies can be performed safely and inexpensively to learn more about the characteristics of BAT and its potential to treat obesity and diabetes.

**Preliminary Information/Data**

PET/CT has been confirmed by various groups over the years to positively identify the activities of BAT. In addition, another group has begun exploring the utilization of IR to detect BAT activities and have achieved promising, however,
not yet definitive results.⁹ These two sets of preliminary results strongly suggest the feasibility of the Plan, namely, to show that IR thermography can detect changes in skin surface temperature overlies regions of thermogenic BAT by utilizing both PET/CT and IR images when subjects are being stimulated in various conditions. As the data was being collected from subjects, preliminary data analysis has shown some interesting patterns. It is our goal to analyze more data set in a systematic way to provide definitive proof of the merits of the proposed novel method.

Plan

Rationale

Since BAT helps mammals to maintain body temperature through exothermic reactions, using IR to detect changes in skin surface temperature overlying regions of thermogenic BAT to monitor their presence and activities is a reasonable hypothesis with the potential of allowing large population studies on BAT to be performed with minimum risks and lower cost. By using¹⁸F-FDG PET/CT, it has been confirmed that the most common place of metabolically active BAT is located in the cervical-supraclavicular region and sometimes extending to the thoracic region.³ Due to the superficial location of these BAT depots – within 10mm of the skin surface, it is hypothesized that IR could detect the heat they release when they are activated. The amount of BAT each adult has depends on multiple factors, but overall, it appears the prevalence of BAT is quite high. In a study with young healthy males, researcher were able to detect the presence of BAT in 96% of the subjects under certain conditions.¹⁰ Recent findings suggest age is inversely associated with the amount of BAT, and the same association is true for BMI with older individuals. Furthermore, female appears to have more BAT than male.⁴ Although much progress was made in the past few years, and some
correlations have been found regarding BAT, it is not enough to be useful at the bedside yet. Having a safe, fast, and inexpensive method to detect BAT activity such as IR thermography is important for practical large population studies, to better understand the BAT activities, their relationship with characteristics of the population, their interaction with the environment, and eventually the utilization in tackling the obesity and diabetes epidemic.

**Design**

From both retrospective and prospective studies, it had been demonstrated that ambient temperature affects BAT detection rates and activation. In particular, there is a positive correlation between cold temperature and BAT activity. A temperature of 55-61 °F is shown to be effective for activating BAT without inducing muscle shivering that generates heat through a very different mechanism. Knowing how to stimulate BAT and having a method, \(^{18}\)F-FDG PET/CT, to serve as a positive control for quantifying BAT metabolism and location, a new experiment can be performed to test the effectiveness of IR as another detection tool.

Brief description regarding how PET/CT and IR images were collected:
1.) In a prospective, non-blinded study with an experimental cohort design, 10 sets of patient data were collected.
2.) All subjects are healthy volunteers (e.g. no hypertension, heart diseases, etc). Completion rate was 100%.
3.) There were 3 separate, independent study visits for each subject.
   a. Day A: basal condition
   b. Day B: pharmacological stimulation by ephedrine
   c. Day C: environmental stimulation at 55-61 °F
The order of the studies was randomized according to a Latin square design.

First, indirect calorimetry (IC) was used to measure the subject’s resting metabolic rate (RMR). Then the subject either received saline, 1mg/kg ephedrine, or cool stimulation by putting on a cooling vest. One hour later a bolus of $^{18}$F-FDG was injected. For the next hour, RMR was measured again via IC, and this time period allows $^{18}$F-FDG to distribute and be taken up by the body tissues. Finally, PET/CT scan is performed.

4.) In order to see if there is a correlation between BAT activity as measured by $^{18}$F-FDG PET/CT and activity measured by IR thermography, skin surface temperature is measured every 15 minutes by taking two sets of IR images from the beginning of the first IC up to the $^{18}$F-FDG PET/CT scan. Besides taking IR and digital images at the subject’s ventral cervical and upper thorax regions, which are commonly known BAT locations, images are also taken at the humerus as a negative control.

5.) IR and digital images are taken by the T300 InfraRed Camera (FLIR Systems, Inc., North Billerica, MA), which has a thermal resolution of 0.05 °C at 30 °C. Both IR and standard digital images are needed in order to correlate the thermal images (function) with specific anatomical sites (structure), analogous to the way CT provides the structural correlation for the functional information provided by PET.

Please note a lot of data were collected in this study for answering various questions such as how effective can ephedrine stimulate BAT, connection between BAT activity with metabolic parameters such as plasma insulin, hormones, etc. Only a subset of the collected data pertinent to the aim is scrutinized.
For positive control, we know cold stimulation activates BAT, and $^{18}$F-FDG PET/CT scan is able to locate and detect its activity. We expect to see the corresponding temperature changes in IR images before and after the cold stimulations in areas where BAT is located according to the $^{18}$F-FDG PET/CT scan. One observation we would like to make is the changes in temperature (dependent variable) over time (independent variable). Our negative control is the intervention with saline. We do not expect to see any difference in the temperature changes before and after the saline injection. In addition, images taken at the humerus serve as a negative internal control. We do not expect to see any temperature changes in areas where we know there is no BAT before and after the stimulation.

**Method of Analysis**

For each of ten subjects there are three sets of image data: cold, saline, and ephedrine. Each condition consists of approximately 40 IR images with 40 corresponding digital images and one $^{18}$F-FDG PET/CT scan collected as outlined in the design section. BAT locations can be identified using the PET/CT Viewer software and with the help of the digital image, a good estimate of the corresponding region can be located on the IR image.

Using the Reporter software, a region of interest (ROI) is drawn on the IR image over the area with BAT. Additional ROIs are drawn on a few different locations including as the humerus to serve as negative internal controls or biomaker candidates. Minimum, maximum, and average temperatures of the ROIs are recorded in Excel. As mentioned in the design section, two IR images are taken every 15 minutes. The parameters of the ROIs in these two images are averaged together to form one set of data points to increase accuracy.
Data can be analyzed using paired t-test on averages between ROIs with BAT and without and see if there are significant differences. Depending on the data, line or curve fitting might be appropriate to further support differences in mechanism responsible for changes in body temperature. Trends and temperature recovery rates, if any, will be noted and undergo further analysis. Different comparisons between conditions, patients, etc., will be performed to see if they are any significant patterns. Other questions include, for example, does the temperature oscillate before reaching a stable plateau after stimulations? If so, how much time does it take before stable readings are acquired?

Expected Results

We expect data support our aim that IR thermography can detect changes in skin surface temperature overlies regions of thermogenic BAT and thus can be a practical tool for large population studies.

- We expect to see the corresponding temperature changes in IR images before and after the cold stimulation in areas where BAT is located according to the $^{18}$F-FDG PET/CT scan.
- We do not expect to see any temperature changes in IR images before and after the saline injection.
- We do not expect to see any temperature changes in IR images in areas where we know there is no BAT before and after the cold stimulation.

Interpretation of possible results

There can be three different possible scenarios for our experiment:
1.) IR thermography can detect BAT thermogenesis directly.
2.) Temperature changes detected by IR serve as a biomarker for BAT thermogenesis.
3.) IR thermography cannot monitor changes in BAT thermogenensis.

Result 1: This is a positive and expected result of our experiment. If IR thermography can detect BAT thermogenensis, a large-scale clinical study of subjects of diverse backgrounds is the logical next step to help understand BAT function in diverse populations. Subjects' lifestyle, diet, and physical activities should also be recorded as this can help us further understand the interaction between BAT and the subjects' environment. Pharmacological interventions designed to activate BAT can be tested in a high throughput manner.

Result 2: This is also a possible result although it is not our primary expected target. Even if IR thermography cannot directly detect thermogenensis of BAT, there might be a correlation between changes in temperature in other regions of the skin and BAT activity. If a biomarker for BAT thermogenensis is found, it can further help us identify and understand BAT and its prevalence. This result should warrant more work in studying BAT, particularly reconfirming with $^{18}$F-FDG PET/CT images whether the new biomarker can be detected with $^{18}$F-FDG PET/CT. If this is not the case, one can see if BAT has an alternative mechanism for thermogenesis that is detectable by IR thermography but not $^{18}$F-FDG PET/CT. This can potentially open up a new direction in BAT study.

Result 3: This is a negative and unanticipated result, especially given the promising preliminary results and the theoretical support of the hypothesis. If IR thermography cannot detect BAT thermogenensis and no biomarker is found, sources of error have to be critically scrutinized to avoid drawing premature conclusion. Possible sources of error include:

1.) Interfering effects of other high metabolic/temperature releasing sources such as blood vessels, inflammation, shivering, etc. Proper
image processing methods combine with prior knowledge of subjects’ anatomy are critical in reducing these interfering effects.

2.) BAT not near the skin surface will not be detected as well via IR as it is using $^{18}$F-FDG PET/CT. As a result, $^{18}$F-FDG PET/CT imaging will still be critical for measuring activity of BAT depots that are deeper inside the body where IR radiation are harder to get out to the skin surface and detected by the IR camera. The $^{18}$F-FDG PET/CT images will have to be scrutinized to ensure only contributions from BAT near skin surfaces are compared to the IR images.

3.) IR images will likely suffer from thermal diffusion, i.e. heat, and thus IR radiation generated at BAT tends to spread to other regions over time, while $^{18}$F-FDG PET/CT does not. However, data on the total amount of BAT activity should still be valid as the total heat generated from BAT should be related to the total amount of BAT activities. Nevertheless, BAT location determined from IR images and BAT activities within small ROI will not be as accurate as from $^{18}$F-FDG PET/CT images. To address this issue, one of the three methods, thermal diffusion modeling, expanded ROI area, and data processing with only images shortly after the cold stimulations, i.e. before diffusion can smear the data, should be explored.

**Pitfalls and Workarounds**

In addition to the potential pitfalls relating to alternative results mentioned previously, another challenge anticipated is differences in ROIs from subject to subject. Ideally, ROIs should be drawn on the same region of skin on every image throughout each set. This is unlikely to be the case due to the fact that the IR images are typically taken at different angles even though they are somewhat similar. In addition, anatomical
differences will also make it impossible to have the exact replication of ROI from subject to subject. To remedy this issue, efforts will be made to ensure similarities of ROIs from subject to subject. Body features can be used to identify and correct for differences in camera angles. In addition, multiple pictures can be used in an attempt to reduce variability from picture to picture. Care has to be taken if too many chronological images are taken in averaging, time resolution of BAT activities will be smoothed out, losing valuable mechanism-related information.

Compliance

Trainings Completed
1.) Group 1 - Basic Human Subjects Protection Required Training for Beth Israel Deaconess Medical Center from Collaborative Institutional Training Initiative (CITI) (5/31/11)
2.) Radiation Safety Training for Joslin Diabetes Center (6/8/11)
3.) Lab Safety Training for Joslin Diabetes Center (6/14/11)

Timeline

- 5/31/11 - Environment setup and start to collect data
- 6/30/11 - Collect second half of the data
- 7/13/11 - Perform 1st pass data analysis
- 7/20/11 - Perform 2nd pass data analysis
- 7/27/11 - Preliminary results and conclusions
- 8/4/11 and beyond... Other activities depending on data and results
References

Does Growth Disturbance of the Proximal Femur after Intentional Physeal Closure for Slipped Capital Femoral Epiphysis Increase the Risk of Premature Arthritis?

Abstract

The standard of care in the US for the treatment of slipped capital femoral epiphysis (SCFE) is in-situ fixation with a single cannulated screw [1] a procedure that prematurely closes the physis of the capital femoral epiphysis. Premature closure of the physis may cause growth disturbances of the proximal femur. Indeed, growth disturbances have been noted in the juvenile SCFE population [2,3,4]. These growth disturbances are of particular concern, as they may pose a risk for development of osteoarthritis of the hip [3, 4, 5, 6]. Kirschner wire fixation, another approach for the treatment of SCFE allows for continued femoral growth, thereby reducing the risk of growth disturbance and perhaps future osteoarthritis of the hip [3,4]. The goal of this project is to evaluate growth disturbances of the proximal femur and compare the risk for premature arthritis after single screw fixation and intentional physeal closure with Kirschner wire fixation for treatment of SCFE. A retrospective chart review and a computer model to analyze forces at and about the hip joint (HIPSTRESS model)[7] will be used to evaluate growth disturbance of the proximal femur and risk for developing premature arthritis.
**Mentoring Plan**

Dr. Wade Shrader and I will communicate primarily via email. We will meet at Dr. Shrader’s office at Phoenix Children’s Hospital every few weeks or as needed to move the project forward. Dr. Lee Segal will serve as a co-mentor. Meetings with Dr. Segal will be scheduled at Phoenix Children’s hospital on an as-needed basis.

**Environment**

For this project, I will need access to patient chart and radiographic data from Phoenix Children’s Hospital (PCH) and from a site in Germany led by Dr. Rudy Krauspe, MD Chief of Orthopaedics, Dusseldorf. After IRB approval, Dr. Shrader and Dr. Segal will access radiographic and chart data at Phoenix Children’s Hospital. Dr. Segal will be instrumental in obtaining the records from Germany. The radiographic data will be analyzed with the help of a hip stress computer model (HIPSTRESS method, Zupanc) [7] which can be accessed at PCH. Statistical analysis software, such as SPSS, will be used to analyze results. SPSS can be accessed at PCH or at University of Arizona College of Medicine-Phoenix.

**Project Specific Curriculum**

Project specific curriculum consists of literature review.
Specific Aims

Aim 1:

Our first aim is to evaluate growth disturbances about the proximal femur and the risk of developing premature arthritis following in-situ single cannulated screw fixation and intentional physeal closure for treatment of SCFE.

Aim 2:

Our second aim is to evaluate growth disturbances and the risk of developing premature arthritis following Kirschner wire fixation, a surgical treatment for SCFE that allows for continued femoral growth.

Aim 3:

Our third aim is to compare growth disturbances and the risk of developing premature arthritis following single screw fixation with growth disturbances following Kirschner wire fixation for treatment of SCFE.

Introduction

Slipped capital femoral epiphysis (SCFE) is the most common hip disorder of adolescence with an incidence of 10.8 per 100,000 in the United States [8] and is one of the most important pediatric and adolescent hip disorders [9, 10, 11, 12]. SCFE occurs when torsional forces applied to the femoral head exceed the strength of the capital femoral physis.
and the femoral neck metaphysis displaces anterior and superiorly relative to the capital femoral epiphysis leaving the appearance of posterior and inferior displacement of the epiphysis, which, in fact, remains in normal position in the acetabulum[13, 14]. The etiology of SCFE is not fully understood, but factors that are thought to play a role in weakening the physeal plate include normal periosteal thinning and widening of the physis, trauma, obesity, inflammatory changes, and endocrine and metabolic disorders [15].

The classic presentation of a patient with SCFE is a young, obese adolescent with a limp and externally rotated leg, reporting pain in the groin, thigh, or knee. The male to female ratio is approximately 1.5: 1. The mean age of presentation is 13.5 in boys and 12 in girls [16]. Physical examination reveals decreased range of motion, particularly internal rotation [17]. The symptoms of SCFE may be acute (as with trauma) or more frequently, chronic and insidious in onset. The slip may be classified as stable or unstable, with the latter unable to walk. Unstable SCFE is associated with a worse prognosis and increased risk of avascular necrosis [1, 18].

The diagnosis of SCFE is confirmed with plain film radiograph of the pelvis (Anteroposterior, lateral, and frog leg lateral views)[1]. The prevalence of bilateral SCFE is commonly reported as 20-35% [19]. However, Swedish studies have reported bilaterality in as many as 60% [20, 21]. The differences in reported percentages of contralateral slips may play a role in recommendation for prophylactic pinning of the contralateral hip. In Europe, contralateral pinning is more commonly accepted [20], but remains controversial in North America [22]. However, contralateral hips may slip in a much higher proportion patients with
underlying endocrine disorders, and should therefore be strongly considered for prophylactic pinning [1, 20, 21, 22, 24, 25].

The standard of care for treatment of SCFE is surgical fixation. The goals of surgery include preventing further progression of the slip while minimizing the risks of complications such as avascular necrosis and chondrolysis. Essentially, two methods of fixation are used predominantly today: in situ single cannulated screw fixation and Kirschner wire fixation [3, 4, 26]. Single screw fixation has become the standard of care in the US [1], while Kirschner wire fixation is an alternative recognized treatment method of fixation in German speaking countries [3, 4]. See appendix [1] for background of the procedures and appendices [2] and [3] for procedure protocols.

Clinical outcomes for Kirschner wire and single screw fixation have been comparable [27]. Both methods show good results and low rates of complications [1, 3, 4, 28, 29]. There are, however, important differences between the two methods. Single screw fixation intentionally closes the physis [30], risking potential growth disturbance of the proximal femur [2, 31, 32, 33], while Kirschner wire fixation leaves the physis open, but may require reoperation to insert longer wires to maintain fixation with proximal femoral [3, 4, 34]. Maintaining an open physis to reduce risk of growth disturbance seems to be a priority for treatment of SCFE in Europe [3, 4, 31, 32, 34, 35].

Our current study aims to evaluate the risks of intentional physeal closure in surgical treatment of SCFE. We will focus on the growth disturbances of the proximal femur and the potential risk of premature arthritis. Using the HIPSTRESS method of mathematically modeling
and evaluating forces at and about the hip joint, we will assess growth disturbances about the proximal femur and the risk of developing premature arthritis following single cannulated screw fixation and intentional physeal closure [7]. Secondly, we will evaluate growth disturbances and the risk of developing premature arthritis following Kirschner wire fixation, a treatment that allows continued femoral growth [3,4]. Growth disturbances following in-situ single screw fixation will then be compared to growth disturbances following Kirschner wire fixation.

The single screw fixation procedure prematurely closes the physis of the capital femoral epiphysis in an attempt to arrest further slippage [30]. Early closure of the physis is intentional and regarded favorably as continued growth of the femoral neck may cause the metal fixture to lose grip on the epiphysis. This outcome risks the possibility of further slippage and may require reoperation [31, 36-39].

Premature closure of the physis in patients nearing skeletal maturity may not be expected to cause significant growth [2, 35, 40]. However, in younger SCFE patients, premature closure of the physis may lead to growth disturbance of the proximal femur [2, 3, 4, 35, 39]. Kumm 2001 noted that an increase in longitudinal growth of 1-3 cm can occur in patients with SCFE [34]. Disturbing this growth by premature closure of the physis may lead to undesirable geometric and biomechanical changes to the femoral head and neck [2, 4, 35].

For example, premature closure of the physis can lead to shortening of the femoral neck and overgrowth of the greater trochanter. This abnormality results in a decrease of the abductor lever arm, leg length discrepancy, and decreased pelvic-femoral stability. These
decreases in efficiency in the architecture and function of the hip joint result in a Trendelenberg
gait, with pain and fatigue associated with increased energy expenditure [2, 4, 20, 31, 32].

Additionally, the deformity produced by a SCFE, (particularly acute, unstable or severe
SCFE) reduces hip range of motion and predisposes a patient to developing femoroacetabular
impingement, which may lead to labral and chondral lesions and eventually to osteoarthritis of
the hip [1, 6]. Growth disturbance of the proximal femur may lead to abnormal abutment of the
femoral head-neck junction and the acetabular rim during hip motion, which causes pain and
decreased range of motion. With SCFE, the usual contributing factors are a prominent proximal
femoral metaphysis and the decreased femoral head-neck offset [5]. Over time, an abnormal or
impinged hip joint may lead to tearing at the chondrolabral junction and subsequent cartilage
delamination, eventually progressing to osteoarthritis of the hip [6, 14].

To avoid possible growth disturbance of the proximal femur, there are several surgical
treatments for SCFE that allow the physeal plate to remain open. Kirschner-wire fixation of the
femoral head is a recognized alternative treatment in German speaking countries [3, 4, 26, 27].
In a comparative study of K-wire fixation and single-cannulated screw fixation, Maus 2008
found that the results of both methods of fixation were comparable at one-year follow up [27].
Seller et al. 2006 showed good clinical outcomes and low complication rates with K-wire
fixation of unstable slipped capital femoral epiphysis [4]. Hansson has suggested use of a hook-
pin [32]. Segal 1991 has suggested using a smooth pin to prevent premature closure of the
physeal plate in children with significant growth potential remaining [2]. Several authors have
had success with dynamic or gliding screw fixation, a procedure that is similar to single screw
fixation, but leaves the physis open [34, 35, 41, 42]. For the purposes of this study, we will focus on Kirschner wire fixation as a surgical method that maintains an open physis.

To our knowledge, no current study exists with longitudinal data to address the risks of growth disturbances and osteoarthritis due to premature closure of the physis in surgical treatment of SCFE. The goal of our current study is to evaluate growth disturbances of the proximal femur, regarding them as potential risk factors for developing osteoarthritis. Using the HIPSTRESS method [7], we will study growth disturbances of the proximal femur following intentional premature closure of the physis by in situ single screw fixation for SCFE. Secondly, we aim to compare growth disturbances following intentional physeal closure to growth disturbances following surgical treatment for SCFE that allows continued femoral growth (Kirschner wire fixation). As Kirschner wire fixation allows for continued femoral growth [4], we hypothesize that there will be less growth disturbance of the proximal femur, and therefore lower potential risk for developing osteoarthritis of the hip.

**Preliminary Information/Data**

This project is a feasible retrospective chart review study. The data already exist, and the HIPSTRESS model has been developed, validated, and used by other authors. Following IRB approval, we will access the chart data and begin measurements and analysis.

**Plan**

Aim 1:
Evaluate the risks of intentional physeal closure in the treatment of slipped capital femoral epiphysis (SCFE). Our focus will be on growth disturbances about the proximal femur and the risk of developing premature arthritis following single cannulated screw fixation and intentional physeal closure for treatment of SCFE.

a. Rationale:

Single screw fixation, the standard of care in the US for treatment of SCFE [1] leads to intentional premature physeal closure of the femoral epiphyseal physis. Premature closure of the physis can lead to growth disturbances of the proximal femur. These growth disturbances can lead to undesirable geometric changes in the hip joint that may eventually lead to osteoarthritis of the hip joint [1, 2, 5, 6], an outcome that warrants further investigation.

b. Design:

We will compare post-operative x-rays of single cannulated screw fixed SCFE hips with the contralateral healthy hips (after ensuring no SCFE in the contralateral hip). This will provide a baseline difference to which growth disturbance may be compared over time. We will then compare follow-up x-rays of the single cannulated screw fixed SCFE hips with the contralateral healthy hips over time to evaluate growth disturbance of the fixed hip. X-ray measurements will be entered into the HIPSTRESS model [7] to mathematically determine the forces at the hip joint.
The independent variable is in-situ single cannulated screw fixation. The dependent variables are growth disturbance of the proximal femur and forces at the hip joint. Measures of growth disturbance will include articulotrochanteric distance (ATD) for trochanteric overgrowth, length of the femoral neck, leg length discrepancy, neck-shaft angle, change in pin/physis position if relevant, sphericity of the femoral head, lateral center edge angle (LCEA), Tonnis angle (TA), pelvic tilt, and the presence or absence of cross-over and posterior wall signs[2, 5, 6, 33, 43].

Additional measures used for the HIPSTRESS model will include interhip distance, pelvic height and width, radius of the femoral head, Wiberg center-edge angle, and the vertical and horizontal distance from the center of the femoral head to the muscle attachment point [7].

c. Method of Analysis:

Statistical analysis software such as SPSS will be used to evaluate the significance of differences in growth disturbance measures and hip forces in single screw fixed SCFE hips from baseline post-operative measures to follow-up measures. Student’s t test will be used to compare data.

d. Expected Results:

Premature closure of the physis is predicted to prevent normal growth of the proximal femur [2-4, 35]. At long term follow-up, signs of growth disturbance of the SCFE hip
fixed with single screw fixation are expected relative to the contralateral healthy hip. Specifically, relative to the healthy hip, we expect to see decreased ATD (with trochanteric overgrowth), decreased length of the femoral neck [2, 4, 44], increased leg length discrepancy [4], and loss of sphericity of the femoral head [4, 45]. Additionally, relative to the healthy contralateral hip we may see changes in neck-shaft angle, pin/physis position if relevant, lateral center edge angle (LCEA), Tonnis angle (TA), pelvic tilt, and the presence or absence of cross-over and posterior wall signs.

Forces at the hip joint evaluated by the HIPSTRESS model are also expected to be significantly different in the fixed hip vs. the healthy contralateral hip at follow-up. We expect to find increased contact forces, which may, over time pose a risk for developing osteoarthritis [4].

Of note, if the SCFE was unstable, the slip itself is thought to cause impairment of the femoral growth plate. Therefore, with unstable SCFEs we would expect to find growth disturbance independent of the fixation method [4].

e. Interpretation of possible results:

Following with intentional premature closure of the physis in treatment of SCFE, growth disturbance of the proximal femur and changes in the forces at the hip joint would indicate increased risks of development of osteoarthritis [2-6]. Lack of growth disturbance of the proximal femur and no change in forces at the hip joint would
indicate less risk of development of osteoarthritis with intentional premature close of the physis in treatment of SCFE.

It may prove valuable to analyze data in groups classified by age and/or bone age. It is not expected that older adolescents or adolescents nearing skeletal maturity will experience as much growth disturbance of the proximal femur. Younger adolescents, however, may be at an increased risk for growth disturbance [2]. However, it may be that even in older children, minimal growth disturbance may impact risk of future osteoarthritis. Preliminary analysis will determine if younger vs. older adolescent groups are sufficiently different to warrant separate analyses.

f. Pitfalls and work-arounds:

   Difficulty obtaining records from German site

   - Dr. Segal may travel to Germany to obtain records in person from Dr. RudyKrauspe, MD  Chief of Orthopaedics Dusseldorf.

   Data text written in German

   - Locate and hire a translator to translate the necessary documents

   Inability to open HIPSTRESS computer program

   - Seek assistance from tech support
- Seek assistance from Zupanc et al. [7]
- Analyze hip forces using another model (such as Richolt et al.) [46]

Aim 2:

Evaluate growth disturbances and the risk of developing premature arthritis following surgical treatments for SCFE that allow continued femoral growth, such as Kirschner wire fixation.

a. Rationale:

Kirschner wire fixation, the standard of care in Germany for treatment of SCFE does not lead to intentional premature physeal closure of the femoral epiphyseal physis [3, 4]. Premature closure of the physis can lead to growth disturbances of the proximal femur. These growth disturbances can lead to undesirable geometric changes in the hip joint that may eventually lead to osteoarthritis of the hip joint [2-6]. As such, procedures that do not lead to premature closure of the physis and subsequent growth disturbances warrant further investigation.

b. Design:

We will compare post-operative x-rays of Kirschner wire fixed SCFE hips with the contralateral healthy hips. This will provide a baseline difference to which growth disturbance may be compared over time. We will then compare follow-up x-rays of the K-wire fixed SCFE hips with the contralateral healthy hips over time to evaluate growth
disturbance of the fixed hip. X-ray measurements will be entered into the HIPSTRESS model to mathematically determine the forces at the hip joint [7].

The independent variable is Kirschner wire fixation. The dependent variables are growth disturbance of the proximal femur and forces at the hip joint. Measures of growth disturbance will include articulotrochanteric distance (ATD) for trochanteric overgrowth, length of the femoral neck, leg length discrepancy, neck-shaft angle, change in pin/physis position if relevant, sphericity of the femoral head, lateral center edge angle (LCEA), Tonnis angle (TA), pelvic tilt, and the presence or absence of cross-over and posterior wall signs. Additional measures used for the HIPSTRESS model will include interhip distance, pelvic height and width, radius of the femoral head, Wiberg center-edge angle, and the vertical and horizontal distance from the center of the femoral head to the muscle attachment point.

c. Method of Analysis:

Statistical analysis software such as SPSS will be used to evaluate the significance of differences in growth disturbance measures and hip forces in Kirschner wire fixed SCFE hips from baseline post-operative measures to follow-up measures. Student’s t test will be used to compare data.

d. Expected Results:
At long term follow-up, no growth disturbance of the SCFE hip treated with Kirschner wire fixation is expected relative to the contralateral healthy hip. Allowing continued femoral growth and remodeling are expected to protect against growth disturbances [2-4, 26 34, 35, 41]. By the same reasoning, forces at the hip joint evaluated by the HIPSTRESS method are not expected to be significantly different in the fixed hip vs. the healthy contralateral hip at follow-up.

Of note, if the SCFE was unstable, the slip itself is thought to cause impairment of the femoral growth plate. Therefore, in the case of unstable SCFE we would expect to find some growth disturbance independent of fixation method [4]. However, we would expect less growth disturbances in unstable SCFE hips repaired by Kirschner wire fixation than in unstable SCFE hips fixed by single screw fixation.

e. Interpretation of possible results:

Lack of growth disturbance of the proximal femur after Kirschner wire fixation for SCFE would indicate the safety of this technique in terms of diminished risk for development of osteoarthritis. Presence of growth disturbance would indicate risk of development of osteoarthritis after Kirschner wire fixation for SCFE.
Again, separate analyses for younger vs. older adolescents may be warranted. Less skeletally mature adolescents would be expected to benefit more from a surgical technique that allows for continued femoral growth [2].

f. Pitfalls and work-arounds:

   See Aim 1

Aim 3:

Compare growth disturbances following single screw fixation with growth disturbances following Kirschner wire fixation.

a. Rationale:

   Single screw fixation, the standard of care in the US for treatment of SCFE [1] leads to intentional premature physeal closure of the femoral epiphyseal physis. Kirschner wire fixation, an alternative recognized method in Germany for treatment of SCFE, allows for continued femoral growth and remodeling [3, 4]. Premature closure of the physis can lead to growth disturbances of the proximal femur. These growth disturbances can lead to undesirable geometric changes in the hip joint that may eventually lead to osteoarthritis of the hip joint [1, 2, 5, 6]. A comparison of surgical treatments for SCFE focusing on risk of growth disturbances and subsequent risk for development of osteoarthritis is warranted.

b. Design:
Growth disturbances following single-screw and Kirschner wire fixation will be compared.

c. Method of Analysis:

Growth disturbances measured and analyzed in Aims 2 and 3 will be compared using Student’s t tests in SPSS.

d. Expected Results:

We expect significantly greater growth disturbances following single screw fixation than following Kirschner wire fixation [2-6, 35].

e. Interpretation of possible results:

Significantly greater growth disturbances following single screw fixation than Kirschner wire fixation would indicate that Kirschner wire fixation may be a safer surgical treatment for SCFE in terms of growth disturbances and risk of developing osteoarthritis of the hip. No differences in growth disturbance or hip forces would indicate that the methods are equally safe in terms of risk of developing osteoarthritis of the hip following surgical treatment of SCFE.

f. Pitfalls and work-arounds:

See Aim 1

Methods
Criteria for Inclusion:

a. Unilateral SCFE treated with single crew fixation or K-wire fixation
b. No underlying endocrine or systemic disorder
c. Minimum length of follow-up of 3 year or until skeletal maturity is reached
d. Adequate clinical records and radiographs

Compliance

IRB approval must be obtained before data can be obtained and analyzed. The application is planned for submission this summer. The help of Dr. Joan Shapiro and Rachel Langhofer will be enlisted for their expertise in compliance issues.

Timeline

July 1, 2011

Submit mentor-approved Topic and Mentor Selection Form
Submit mentor-approved SP prospectus

August 1, 2011

Submit compliance applications (IRB, etc.)

Fall, 2011

Pending IRB approval, obtain data, begin measurements

Spring, 2012
Begin data analysis

Summer, 2012

Write up results, discussion, conclusions

Fall, 2012

Continue thesis activities as needed, submit project for publication

Spring/Summer, 2013

Finalize thesis, create poster, presentations

Appendix [1]

The optimal treatment of SCFE has been a subject debated throughout the literature. The following section outlines the background of current surgical treatments.

In situ fixation with a single cannulated screw has become widely accepted as a treatment in the US for stable SCFE because of percutaneous placement with minimal soft tissue damage, a high success rate, high patient satisfaction rate, low incidence of slip progression, and low incidence of complications such as avascular necrosis and chondrolysis [1]. Single screw fixation is generally preferred over multiple screw fixation because the overall rate of complications appears to be directly related to the number of pins or screws used [28, 47, 48]. However, in the case of unstable SCFE, the increased stability of two screw fixation under torsional loading may justify its use [49-51].
Kirschner wire fixation is an alternate treatment option with comparable clinical outcomes [3, 4, 27]. Konig 2006, in a comparative study of methods of internal fixation, found that K-wire fixation was the safest method with the lowest complication rate when compared with stabilization using screws or Smith-Peterson nails. They found better outcomes regarding pain, Harris Hip score, osteoarthritis, sphericity of the femoral head, and differences in limb length [45]. They attributed the success of the method to leaving the physis open to allow femoral neck growth. The results of Konig’s study and Seller 2006 led Seller to recommend K-wire fixation over screw fixation, stating that “the advantage of further growth of the femoral neck outweighs the ‘complication’ of probable re-operation due to the pins becoming too short during the growth period” [4, 45].

Several authors have had success with a modified single-screw or pin fixation (dynamic or gliding screw fixation) such that the threads lie entirely in the epiphysis with the unthreaded portion of the screw bridging the physis. The head of the screw or pin is allowed to protrude several centimeters to allow for expected growth of the femoral neck [34, 35, 41, 42]. The procedure is as easy to perform as any screw fixation technique using one cannulated screw, provides sufficient fixation, does not stimulate physeal closure, and allows for normal hip growth and development [34, 41, 42]. Guzzanti et al. did not find any growing away of the epiphysis from the fixation with this method [35]. However, some authors have reported cases of the femoral epiphysis growing away from pins, thereby increasing the possibility of further slippage and requiring re-operation [37, 38, 52]. For our study, we focus on Kirschner wire fixation as a treatment that maintains an open physis, but this method may be a good alternative for future studies.
Management of unstable SCFE is similar to stable SCFE, but is more controversial with debate about reduction, positioning of the patient on the operating table, decompression of hematoma, and single-versus double screw fixation [1, 29, 53]. An important consideration of treatment of unstable SCFE is the increased risk of avascular necrosis. The majority of slips are stable [14, 18, 28].

Prophylactic pinning of the contralateral, healthy hip remains controversial [1, 28], although recent studies suggest that it may be beneficial for long term outcomes [1, 3, 4, 42, 44, 54-58]. For example, using a decision analysis model, Schultz et al have shown that patients who are first seen with unilateral SCFE have a 2335 times greater risk of developing an additional contralateral slip compared to the risk of the initial slip [56]. Hagglund et al. showed that 25% of patients who did not undergo prophylactic pinning developed osteoarthrosis of the hip before the age of 50 in the secondary slipped hip joint, whereas no osteoarthrosis developed in hips on which prophylactic stabilization had been performed [58]. In German-speaking countries, the predominant recommendation is for prophylactic fixation of the contralateral side [3, 4, 26, 58]. In the United States, the current recommendation is to use clinical judgment with respect to the patient’s age, sex, endocrine status, as well as to consider preferences of the patient and family before recommending prophylactic fixation of the contralateral hip [1, 29].

Appendix [2]

Briefly, the standard of care procedure in the US, single screw fixation, involves placing the patient supine on a fracture or radiolucent table. To locate the proper incision site, a guide
pin is positioned on the skin projecting over the center of the epiphysis, perpendicular to the physis on the anterior posterior image. A line is drawn on the skin along the guide pin. The same procedure is used for the lateral image, and a small incision is made at the intersection of the two lines. The guide pin is advanced and adjusted before drilling into the bone where it is placed, ideally, in the center of the epiphysis and perpendicular to the physis. The screw length is measured with a depth gauge and a channel is widened over the guide pin. A 7.3 mm stainless steel cannulated screw is advanced over the guide pin until 4 to 5 threads are in the epiphysis. Care is taken not to advance the pin so far that it penetrates the joint as this may cause chondrolysis [1]. This technique has provided excellent results with few complications [59].

Appendix [3]

The standard of care procedure in German speaking countries, Kirschner wire fixation, is similar to the procedure for single screw fixation. However, this method involves locating the incision site, and inserting 2 to 4 K-wires of 2 mm thickness. After confirmation of correct location, the wires are advanced through the physis and into the epiphysis. Care is taken not to advance the wires into the hip joint. To prevent postoperative migration of the K-wires into the hip joint, the ends are clipped to leave an overhang of about 1.5 cm and the ends are bent and twisted so they lie caudally and flush with the lateral femoral cortex [26]. A smooth pin with semitubular plate construct may also be used to prevent backing out of the smooth pins [2].
References


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