Asymmetry in forensic 3-D facial reconstruction: An assessment of facial asymmetry in adult First Nations Nova Scotian facial soft tissue depth data.

By

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Abstract

Facial soft tissue depth data was collected from 50 First Nations Nova Scotian volunteers, using ultrasonic methods, in order to create a tissue depth database for use by forensic artists and to examine facial asymmetry in the population. The existence of significant asymmetry would suggest a revision for the current method of measuring only one side of the face. The analysis of facial soft tissue depth revealed that facial asymmetry in this population group is not significant. There were also few relationships found between age and facial tissue depth and little difference found between males and females. These findings suggest that the current method of measuring only one side of the face, in facial soft tissue depth studies, is sufficient for collecting data from First Nations Nova Scotians. This data is reported in an effort to improve the tools with which missing individuals from this population group can be identified.

March 29, 2011

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Chapter 1: Introduction

1.1 Project Objectives

Does normal facial asymmetry, in living populations, affect the accuracy of forensic 3-D facial reconstructions when the reconstructions are created using facial soft tissue depth data from specific populations of origin? Although the importance of facial asymmetry and its effects on the accuracy of facial reconstructions has been recognized by forensic anthropologists for many years (Snow et al. 1970), current methods of soft tissue depth data collection often focus on measurements from only one side of the face (Manhein et al. 2000). Some researchers state that facial asymmetry is only slight in the average individual and, therefore, data from one side of the face is sufficient for use in 3-D facial reconstruction (De Greef et al. 2006:S143-S144; Manhein et al. 2000:49).

Studies demonstrate that the normal range of facial asymmetry in the general population, among individuals with no disease or trauma affecting the face, is quite large (Shaner et al. 2000). Facial asymmetry is shown to be caused not only by genetic factors of inheritance but also by environmental and mechanical stresses (Lundström 1961:105; Mulick 1965:125-126) such as chewing preferentially on one side of the mouth (Shah and Joshi 1978:146). In their study of facial asymmetry, Shah and Joshi (1978:146) conclude that even though an individual may have asymmetric bony structures of the face, as revealed by radiographs, this asymmetry is not always reflected by the soft tissues of the face. Shaner et al. (2000:145) understand this to mean that stronger mastication on one side of the face is reflected by increased skeletal development on that side, and that this skeletal asymmetry is compensated for by the soft tissue. Recent research reports that

facial asymmetry, present in individuals without trauma or disease, can be distinct and warrants further investigation (Sahni et al. 2008:143).

According to many studies, the collection of facial soft tissue depth data should be performed on living individuals, as opposed to cadavers, in order to avoid potential inaccuracies caused by the change in soft tissues after death (Galdames et al. 2008:165; Phillips and Smuts 1996:52; Prag and Neave 1997:18-19; Todd and Lindala 1928; Wilkinson 2004:129). Ultrasound technology is used by many researchers to measure the facial soft tissue depth of living individuals as it provides accurate tissue depth measurements and is safer and more accessible than other modern imaging technologies (Baker and Dalrymple 1978; El-Mehallawi and Soliman 2001:100; Wilkinson 2004:135).

There is currently some debate over whether facial soft tissue depth data should be reported in population specific subcategories as it may not vary significantly between peoples of different geographic origins (Stephan and Simpson 2008). It is worthwhile, however, to examine populations for which there is no previous data so this new facial soft tissue depth data can be compared to previously published data. Researchers can then determine whether the data collected is a unique and discrete data set. It is also useful to examine facial soft tissue depth asymmetry within geographically distinct groups as results indicate that asymmetry varies from population to population (De Greef et al. 2006:S143-S144; Domaracki and Stephan 2006:7; Sahni et al. 2008:143).

The lack of facial soft tissue depth data for Canadian Aboriginal populations is currently being remedied (Peckmann et al. 2007). An assessment of the facial asymmetry for Canadian First Nations peoples will provide valuable information on the data collection methods currently used by researchers. If facial asymmetry is found to be

significant in this population it may warrant a change in current methodology. This is the primary goal of the current research. The other objectives of the current study include the collection and presentation of First Nations Nova Scotian data, the comparison of this data to other population groups, and the analysis of the affects of age and sex on First Nations Nova Scotian facial soft tissue depth.

1.2 Collecting population specific data

Peckmann et al. (2007) are currently working with Nova Scotia Aboriginal communities to collect the first facial tissue depth measurements for Canadian First Nations populations. Their research follows the methods outlined by Manhein et al. (2000). Canadian Aboriginals are currently not represented in facial soft tissue depth databases. Due to the lack of data, 3-D facial reconstructions of unidentified Aboriginal peoples are created using published data from other populations, such as White European Americans (Hodson et al. 1985; Rhine and Moore 1984), leading to reconstructions that may not accurately reflect the living person's face. For this reason, it is important to collect facial soft tissue depth data for specific populations. It is also important to note that 'pure' populations do not exist. This is due to genetic mixing between population groups. Three dimensional facial reconstruction techniques aim to create approximations that reflect the characteristics of the modern population to which an unidentified individual belongs, therefore, collecting data from a modern mixed population group will provide forensic artists with the appropriate tools for creating the best representation of what that person may have looked like when alive.

Because asymmetry varies between populations and between individuals within populations (Bishara et al. 1994; Burke 1971; De Greef et al. 2006:S143-S144; Sahni et al. 2008:143), it is important to assess the degree to which facial asymmetry, in Canadian Aboriginal populations, might affect 3-D facial reconstructions. The use of facial tissue depth data from only one side of the face may not reflect the asymmetries that exist within Aboriginal populations. This research aims to provide data on facial asymmetry for this population in order to assess whether the current data collection methods are sufficient.

1.3 Identifying population groups in forensic anthropology

The idea of separating specific groups of individuals based on phenotypic characteristics into sometimes poorly defined 'racial' groups is heavily debated (Cartmill 1999; Kaszycka et al. 2009; Lieberman et al. 1989; Littlefield et al. 1982; Mukhopadhyay and Moses 1997; Smedley 1999; Smedley and Smedley 2005). A study of the lack of consensus on the concept of 'race' explains that "the concept does not have a firm base in theory and data as applied to the human species" (Lieberman et al. 1989:72). In the same study, the authors suggest that the term "ethnic group" be used when referring to the cultural concept of 'race' (Lieberman et al. 1989:70), while the term "cline" or "variation" be used when referring to biological concepts of 'race' (Lieberman et al. 1989:70-72).

In a review of anthropological and historical perspectives, Smedley and Smedley (2005:17) explain that "ethnicity refers to clusters of people who have common cultural traits" such as language, geographic locale or place of origin, sense of histories,

traditions, beliefs, and values. The authors of this study explain that "physical features should not be included in a *definition* of ethnic identity" (Smedley and Smedley 2005:18) supporting the recommendation by Lieberman et al. (1989:70-72) that the term "ethnic group" be used to represent the cultural aspects of 'race' but should not be used in reference to biological traits.

Forensic anthropologists are often charged with the task of identifying the population group to which an unknown individual may belong (Byers 2005:158; Thompson & Black 2007:213). This involves careful analyses of specific traits of the skull including the shape of eye orbits, size of the nasal spine, and facial profile, as well as other traits (Byers 2005:160-179). The term *biological affinity* is often used as the more appropriate term to indicate the population group of origin. The need for forensic anthropologists to identify the biological affinity of individuals, in order to aid in personal identification, conflicts with the notion that humans should not be separated into biologically distinct groups based on physical characteristics. Sauer (1992:110) and Brace (1995:174) however, argue that forensic anthropologists, in estimating biological affinity of unknown individuals, are translating biological characteristics into culturally constructed labels or regional kinships that may have been applied to that person when alive. This ultimately serves to help identify the individual by contributing to the overall biological profile created by a trained forensic anthropologist. Kennedy (1995) outlines the paradox that exists in forensic anthropology, where experts are often asked to identify the 'race' of unknown individuals while being aware of the fact that 'race' is a cultural idea with no scientific merit. Kennedy (1995:800) clarifies that forensic anthropologists provide analyses of "ancestral background" through the examination of phenotypic traits

that vary in frequency with the geographical range of the human species. This "ancestral background" reflects a geographic origin, not a 'race'.

Sauer (1992:110) suggests that the term *ancestry* be used in place of the largely rejected term 'race'. It is argued that skeletal analyses, performed by forensic anthropologists, allow for "an accurate estimation of original geographic origins" or *ancestry* (Brace 1995:172). Although the current study follows protocol outlined by Manhein et al. (2000), including the use of data sheets that ask participants to identify their *ancestry* as well as their *ethnicity*, the focus is to collect data from Nova Scotian individuals who self-identify as being of First Nations *ancestry*. The question of *ethnicity*, while it is requested on the data sheet, is ignored. While Manhein et al. (2000) use the terms *ethnicity* and *ancestry* and 'race' interchangeably, the current study will use the term *ancestry* to refer to the population of origin of participants; ancestry refers not to the culturally constructed label of 'race' but to the biological variation of a specific population.

1.4 Construction of identity: Participant self-identification

Aboriginal peoples in Canada include First Nations, Inuit, and Métis. Based on profiles from the 2001 census, Statistics Canada states that:

> The Aboriginal identity population is composed of persons who reported identifying with at least one Aboriginal group, i.e. North American Indian, Métis or Inuit (Eskimo), and/or who reported being Treaty Indians or Registered Indians as defined by the *Indian Act* of Canada and/or who were members of an Indian Band or First Nation. (2001 Aboriginal population profiles, 2001)

The population group identified for the current research project, First Nation Nova Scotians, consisted of adult Aboriginal residents of Nova Scotia who identified

themselves as having First Nations ancestral backgrounds. The author worked closely with the Mi'kmaq Child Development Centre in Halifax, Nova Scotia, which fosters a sense of community and belonging for the Aboriginal population in the urban area, as well as the faculty and staff of L'nu Sipuk Kina Matuokuom (LSK) School in Indian Brook, Nova Scotia. It was from the development of relationships with these groups that the participants were identified. The participant population reflects the communities that these organizations service. The focus of this research was on the First Nations individuals from these communities, as the scope and time frame of the current project would not allow for the expansion of the study group to include the greater Aboriginal group (Inuit and Métis).

In a review of published adult facial soft tissue depth data, Stephan and Simpson (2008) note that many population groups have been studied but that these groups are often defined by subjective criteria. The authors point out that the assignment of these individuals into population groups is often done "in the absence of supporting genetic data or participant self-reports of ancestral background" (Stephan and Simpson 2008:1257). The current method of participant selection reflects the importance of self-identification, suggested by Stephan and Simpson (2008:1257), and takes into account input from Aboriginal community groups in Nova Scotia. Statistics Canada also highlights the importance of self identification/ self reporting criteria in their population studies (2001 Aboriginal population profiles, 2001).

The term *ancestry* appears on the data sheets filled out by each participant in the current study. The term is used to indicate the population group to which the participant feels they belong (Appendix A). This was clearly explained to each participant. In

following with the suggestion by Sauer (1992), the term *ancestry* is used in this study to represent the biological variation that has previously been attached to the word 'race' without the culturally implied concepts that are also attached to the term. Participants, in identifying their *ancestry*, are indicating their population of origin. This identifies a specific biological variation and not a cultural or *ethnic* group.

Chapter 2: Historical background

2.1 Development of 3-D facial reconstruction

Forensic 3-D facial reconstruction is a term used to describe a technique employed by forensic artists to recreate the living face of an unidentified skull in an effort to have that person recognized and identified (Byers 2005:406). This can be a very important tool in an investigation where other methods of identification have proven unsuccessful, i.e. dental or DNA analyses (De Greef et al. 2006:S126; Starbuck and Ward 2007:130). The first scientific facial reconstruction is credited to the German anatomist His who, in 1895, after collecting facial soft tissue depth data from twenty-four males and four females, created a three dimensional facial reconstruction on a skull cast believed to be that of Johann Sebastian Bach (Prag and Neave 1997:15). The accuracy of this technique was later confirmed when the 3-D reconstruction was compared to portraits of the deceased composer. In 1898, the anatomist Kollman reconstructed the face of Dante on what was believed to be his skull (Verzé 2009:7).

Many other attempts at facial reconstructions were undertaken during the early part of the 20th century. A systematic approach to recreating a face on a skull did not exist until 1927, when Mikhail Gerasimov developed what became known as The Russian Method of 3-D facial reconstruction (Prag and Neave 1997:17; Taylor 2001: 342; Verzé 2009:8). This method involves building up individual facial muscles on the skull, one at a time, in order to develop the shape of the overall face (Prag and Neave 1997:17; Stephan 2006; Taylor 2001:341; Verzé 2009:8).

Other methods for creating three dimensional recreations include the American Method and the Manchester Method. These methods employ the use of facial soft tissue

depth data collected from the measurement of specific points on the faces of living and deceased individuals. The American Method, the development of which began in earnest in 1946 with the anthropologist Wilton Krogman and sculptors McCue and Frost, involves the use of average facial tissue depth data to build up specific landmarks on the face to appropriate depths producing a 3-D reconstruction of the living individual (Prag and Neave 1997:17; Verzé 2009:9). Subsequent studies built on the work of Krogman in order to further develop the technique (Snow et al. 1970). The Manchester Method, developed by Richard Neave at Manchester University (Prag and Neave 1997), incorporates aspects of both the Russian Method, by using "detailed traces of muscle insertion on the skull to ascertain facial detail and form" (Verzé 2009:10), and relying on "tissue thickness data, as in the American method, to model soft tissue depth" (Verzé 2009:10). Today, in order to create more accurate 3-D facial reconstructions, forensic artists use population-based tissue depth data derived from specific landmarks on the face. These tissue depth databases cite the average measurement, at each facial landmark, for specific age groups of both males and females. As outlined by Brown et al. (2004) the number of facial tissue landmarks collected for any study can vary from 14 to 54 points and depends on the researcher and the forensic artist completing the 3-D facial reconstruction. More recent studies of facial soft tissue depth have used as few as 12 landmarks (Utsuno et al. 2007).

To complete a 3-D facial reconstruction using the American Method, the artist begins by placing small pegs or dowels on the specific facial landmarks of the skull or cast of the unidentified individual. The length of each peg is based on the average facial tissue depth measurement recorded at that specific landmark (Figure 2.1). The

population, from which an unidentified skull is estimated to have originated, will determine which tissue depth database is utilized, e.g. Canadian First Nations, African-American, etc. Next, the artist applies clay at depths matching those of the pegs creating a living representation of the individual (Taylor 2001:426).

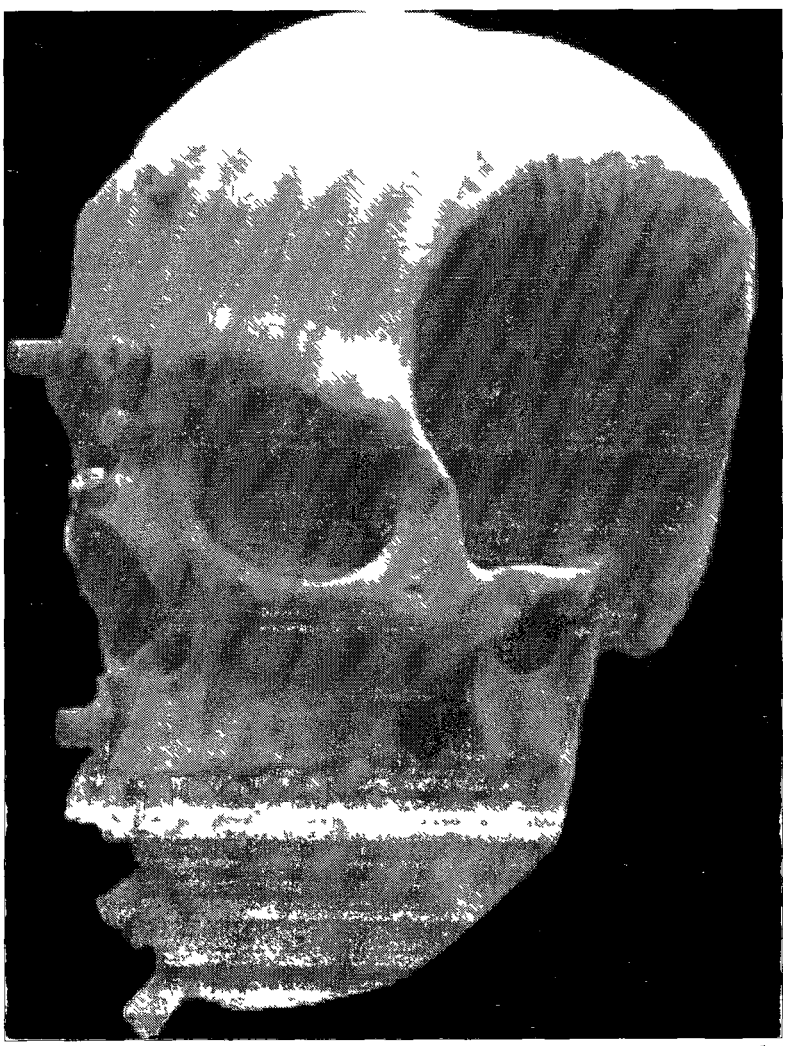

Figure 2.1 - The preliminary steps in a forensic facial reconstruction involve the placement of tissue depth markers on specific points on the skull, as seen here in a reconstruction performed by the author (photo by Alex MacNeil).

2.2 Facial tissue depth data collection: Living or deceased subjects?

The first facial tissue depth data were published in the late 19th century and were obtained from cadavers (Prag and Neave 1997:27). With this method, a needle was inserted into the flesh of the cadaver's face at specific landmarks until it struck bone. Covering the needle with soot and measuring the distance that soot is displaced, or pushing the needle through a rubber stopper, were some of the techniques used to gauge the distance the needle travelled through the soft tissue. These measurements were reported for each particular landmark on the face (Codinha 2009; Domaracki and Stephan 2006; Galdames et al. 2008; Rhine and Campbell 1980; Rhine and Moore 1984).

This technique has been criticized, as it does not take into account the changes that occur in the body after death. These changes include the loss of body fluid, the effects of gravity when a subject is in the horizontal position, the changes in soft tissue during rigor mortis, the loss of muscle tone and shrinkage, and putrefaction with bloating of the face (Aulsebrook et al 1996:83; Galdames et al. 2008; Phillips and Smuts 1996:52; Prag and Neave 1997:18-19; Todd and Lindala 1928; Tyrrell et al. 1997:654; Wilkinson 2004:129). Such changes are believed to make tissue depth measurements obtained from cadavers unreliable in the representation of living tissue depth. In order to ensure accuracy, and to avoid the obvious intrusiveness involved with the 'needle-puncture' method, other methods of facial soft tissue depth measurement have been developed. Many of these methods are specifically aimed at collecting data from living individuals in an effort to provide forensic artists and forensic anthropologists with more accurate data (Byers 2005:408-409).

2.3 Methods of facial soft tissue depth measurement

Despite the criticisms levied against it, the use of cadavers persists in facial soft tissue depth research due to its ease of application and the inexpensive tools required for its performance (Domaracki and Stephan 2006:5). The issues of accuracy related to this method are problematic and have led to the development of more technologically advanced techniques for collecting soft tissue depth measurements from living participants. These methods include the use of radiographic imaging, magnetic resonance imaging (MRI), computed tomography (CT), and ultrasound.

2.3.1 Radiography

Radiographic methods provide accurate measurements of facial soft tissue thickness, however, due to the imaging technology itself, it is difficult to develop images other than from lateral or posterior-anterior orientations. In a study of facial soft tissue depth of Japanese children, Utsuno et al. (2007:138) record data for 12 points using radiographs. The radiographic method limited their study to measuring only two lateral points (right and left gonion) with the remaining 10 points running along the midline of the face. Other studies using radiographic techniques have also been limited to measuring soft tissue along only the midline of the face (Garlie and Saunders 1999). Smith and Throckmorten (2006:246) also outline the limitations involved in using radiographs for soft tissue depth determination. They explain that left and right structures are superimposed in lateral radiographs.

Dumont (1986:1468) explains that lateral measurements of facial soft tissue depth can also be recorded using radiographs from a three-quarters view and using a head positioner for the participant. This, however, does not eliminate the subjectivity involved with orientation of the radiograph. Lateral facial reconstructions have been created from facial soft tissue data derived from lateral radiographs (George 1987). However, the likeness generated from such a reconstruction would not be as immediately recognizable as a full 3-D facial reconstruction. This technique is meant to supplement existing methods and not to replace them. Other drawbacks to radiographic methods include: limitations of the measurements obtained and participant exposure to radiation (Wilkinson 2004:132).

2.3.2 Magnetic resonance imaging and computed tomography scans

Magnetic resonance imaging (MRI) and computed tomography (CT) scans provide very accurate measurements of facial soft tissue depth (Domaracki and Stephan 2006:5) and data collection has been undertaken using both methods. A study of Northwest Indian adults used an MRI technique to measure facial soft tissue depth at 29 points on the faces of 173 males and 127 females (Sahni et al. 2008) while a study of 32 'Coloured' South African participants (peoples of mixed 'racial' origin) used a CT technique to measure 10 midline and 11 bilateral points (Phillips and Smuts 1996). Magnetic resonance imaging and CT scanning techniques are not appropriate for this research due to the unavailability and high cost associated with utilizing this type of equipment (Domaracki and Stephan 2006:5). Phillips and Smuts (1996) claim that while these techniques are accurate, they are also "relatively expensive procedures and are not

freely available unless the research project can be combined with a diagnostic procedure" (Phillips and Smuts 1996:52). These methods are also unfavourable and unethical for collecting mass amounts of data because both expose participants to high levels of radiation (Domaracki and Stephan 2006:5; Wilkinson 2004:132).

An additional issue associated with using MRI and CT scanning techniques involves the orientation of participants while they are being measured. Participants are normally in a horizontal, or prone, position when undergoing MRI or CT scanning. Facial soft tissue depth measurements, taken from individuals who are in this position, are considered to be inaccurate due to the forces of gravity acting on the face (Wilkinson 2004:129). A 3-D facial reconstruction is meant to resemble a person who is upright, in a position that most people would be used to seeing them. Using data from individuals that are prone would result in reconstructions that are not easily recognizable.

2.3.3 Ultrasound

Ultrasound involves the generation of high frequency sound waves that travel through human tissue, are reflected back from internal structures to be recaptured, and are converted into images (Brogden 1998:5). Ultrasound technology is used to measure facial tissue depth by focusing on specific points on the face. A transducer is placed on each individual point and tissue density is analyzed by the ultrasound machine. The ultrasound machine then provides a visual representation of the tissues being examined so that the ultrasound operator can determine the depth at which the bone lies underneath the soft tissue. This technology has proven to be very useful for soft tissue depth measurement

(Aulsebrook et al. 1995; De Greef et al. 2006; De Greef and Willems 2005; El-Mehallawi and Soliman 2001; Hodson et al. 1985; Manhein et al. 2000).

There are several ultrasound modes, including *A-mode*, *B-mode*, *M-mode*, and *C-mode* (Bamber and Tristam 1988:347-348). The simplest is the *A-mode* (Shung 2006:79). When an ultrasound machine is used in the *A-mode* it collects data pertaining to the depth of tissues of varying densities (Borkan et al. 1982:307) but provides no visual representation of the underlying tissue configuration. Tissue depth is determined from spikes in a one-dimensional line graph representing "echo amplitude versus time" (Bamber and Tristam 1988:347). In *B-mode*, the ultrasound machine produces a visual representation of the underlying tissues being scanned (Bamber and Tristam 1988:348), allowing the ultrasound technician to find specific organs or anatomical points on the bone. Both *A-mode* and *B-mode* ultrasound techniques have been applied to the collection of facial soft tissue depth measurements (De Greef at al. 2006:S128; Stephan and Simpson 2008:1257).

A study by Manhein et al. (2000:52-57) uses ultrasound images, or sonograms, produced using the *B-mode* to determine facial soft tissue thickness in "American White", "American Black", and "American Hispanic" children, as well as "American White" and "American Black" adults. The *B-mode* proves useful for this type of data collection (Stephan and Simpson 2008:1270) as the distance from the outer surface of the less dense soft tissue to the more dense bone underneath can be easily visualized by the sharp contrast on the displayed image of the tissues being examined. This image can be frozen when the operator feels they have a clear representation of the specific point being

measured. The depth of the tissue can be measured on the monitor with the use of built-in electronic callipers. The image can then be printed or saved electronically for analysis.

There is research indicating that the more simplistic *A-mode*, which requires smaller equipment and less electronic storage space, may be useful in developing a semi-automated and very portable facial soft tissue system (De Greef et al. 2005:1). However, the ease of use of these systems would not overcome the complication of not being able to visualize the underlying tissues. Without a visualization of the landmark being measured it is impossible to know if the data being collected is accurate.

Ultrasound techniques are preferable to other imaging methods, such as radiography, magnetic resonance imaging, and computed tomography scans, because they are less invasive and do not expose participants to harmful levels of radiation (Baker and Dalrymple 1978; Borkan et al. 1982:307). In addition, ultrasound equipment is less expensive and more freely available (El-Mehallawi and Soliman 2001:100; Stephan and Simpson 2008:1269-1270). Measurements taken with ultrasound equipment, unlike measurements taken with MRI or CT scans, can be taken while participants are sitting upright (De Greef et al. 2006:S128). Such measurements allow for a more faithful representation of a facial image of the living individual. De Greef et al. (2005:5-6), in a comparison of supine and upright methods of soft tissue depth measurement, demonstrated that gravity does affect soft tissue depth measurements in terms of positioning the subject being measured.

2.4 Reporting facial soft tissue depth data

In comparing data from numerous studies, Stephan and Simpson (2008:1266) state that data should be reported as broadly as possible with no subcategorization by

variables such as 'race' and sex. Some researchers argue that facial soft tissue depth, at particular facial landmarks, varies between different 'races' (Sahni et al. 2008:144; El-Mehallawi and Soliman 2001:106) therefore warranting the collection of facial soft tissue depth data from specific population groups. However, a study by Stephan and Simpson (2008) reviews 62 previously published reports of facial soft tissue depth data and concludes that differences between population groups are negligible. Stephan and Simpson (2008:1262) compared studies focusing on the three major 'racial' groups, which they refer to as "Caucasoid, Negroid, and Mongoloid" and explain that defining human 'races' is both problematic and controversial. They found that the variability within each population group was broad while differences in tissue depths between groups were small (Stephan and Simpson 2008:1266). The authors conclude that reporting facial soft tissue depth data that is subcategorized by 'race' is of little practical value (Stephan and Simpson 2008:1266). It is important to note, however, that when examining population groups for which there are no previous data published, i.e. Canadian Aboriginal groups, it cannot be assumed that inter-population differences do not exist. This study aims to provide the data necessary for a comparison of First Nations Nova Scotian data to previously reported data from other population groups. This will determine whether the trends reported by Stephan and Simpson (2008) apply to the current study group.

There is also disagreement over whether a marked sexual dimorphism exists in facial soft tissue depth data. Stephan and Simpson (2008:1264) argue that subcategorization by sex is also of little practical benefit due to the small differences that exist between males and females in the published data. Stephan et al. (2005) conclude

that sexual dimorphism of facial tissue depth is minimal, due to the large variability within each sex, and so subcategorizing data into male and female groupings is not warranted. Other studies argue that, at some points on the face, a marked sexual dimorphism in facial soft tissue depth data does exist in studied population groups (Codinha 2009:80.e3; El-Mahallawi and Soliman 2001:106) and that this sexual dimorphism appears in tissue depth measurements of participants beginning at the age of twelve years old (Dumont 1986:1467; Utsuno et al. 2007:142). The conflicting reports suggests that, while data may be of more use if reported without male and female subcategories, it is important to consider statistical evaluations of sex differences in population groups that are not yet represented in the literature.

Several studies have reported noticeable changes that occur to both skeletal and soft tissue morphology as individuals age (Albert et al. 2007:7; Burke and Hughes-Lawson 1988:117; Farkas et al. 2004:292). This suggests that it may be useful to separate facial soft tissue depth data into age-related categories. In collating data from 62 facial soft tissue depth studies, Stephan and Simpson (2008:1259) pooled data into only two broad age categories: adults (18 years of age and above) and sub-adults (under 18 years of age). Although pooling adult data into one broad group increases sample size, and may be warranted when little age related differences exist, it is useful to report data in age categories that have been implemented in previous studies for the purposes of comparing data from different population groups.

Emphasis has also been placed on the need for researchers to properly assess the distribution of data in order to determine the strength of the statistical tests used in the analysis of facial soft tissue depth data (Domaracki and Stephan 2006:9; Stephan and

Simpson 2008:1266). Past studies have focused on reporting mean facial soft tissue depth for various population groups and using these means in statistical analyses of facial soft tissue depth trends in those groups. Domaracki and Stephan (2006:9) and Stephan and Simpson (2008:1266) however, point out that facial soft tissue depth data are not always normally distributed and other descriptive statistics, such as medians and modes, should be more heavily relied upon.

A list of provisions for future facial soft tissue depth measurement collection is proposed by Stephan and Simpson (2008:1266) in an effort to ensure that research in this field improves the present standards of practice. These provisions include:

1. Individuals should not be excluded based on their body build.
2. Complete descriptive statistics, not just means, should be reported.
3. Measurement errors should be recorded and minimized.
4. A minimal set of standardized data points should be measured.
5. Raw data should be stored and made available for future large-sample analysis.

These provisions have been utilized in the present study in order to ensure that the reporting and analyses of data are completed appropriately and that the data will be useful to future researchers and forensic experts.

2.5 Facial asymmetry

Numerous studies show that humans exhibit varying degrees of facial asymmetry (Figure 2.2) which is within a normal range not driven by disease or trauma (Burke 1971; Farkas and Cheung 1981; Figalova 1969; Mulick 1965; Shah and Joshi 1978; Sutton 1968; Vig and Hewitt 1975). Although some studies of facial soft tissue thickness have examined facial asymmetry and determined that collecting data from one side of the face

would be sufficient for the purposes of 3-D facial reconstruction (Chan 2007:44; De Greef et al. 2006:S143-S144; Domaracki and Stephan 2006:7), Sahni et al. (2008:143) found that soft tissues of the left side of the face were thicker than those of the right side in most individuals in their study population. The authors also suggest that this facial soft tissue asymmetry should be examined further if such data are to be used for 3-D forensic facial reconstruction.

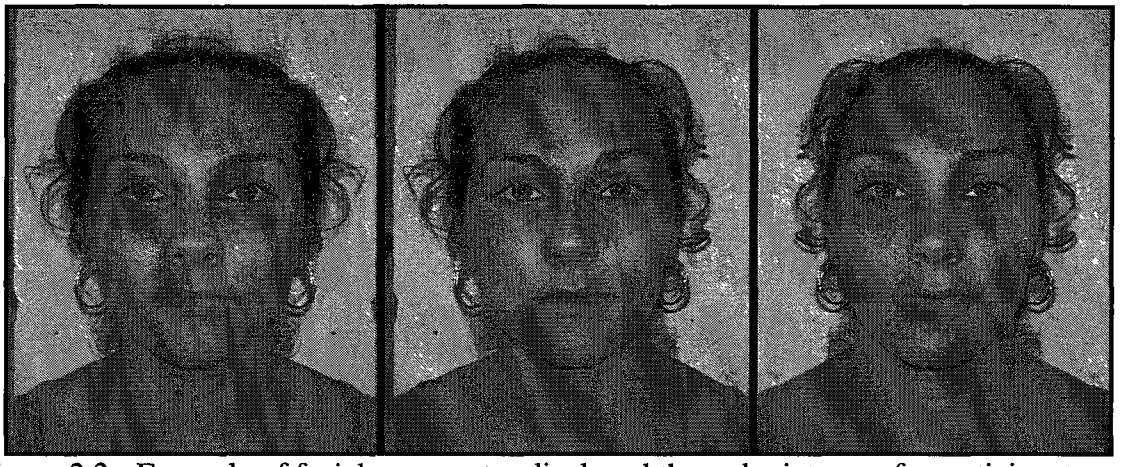

Figure 2.2 - Example of facial asymmetry displayed through pictures of a participant from the current study. The photo array includes an original photo (center), a mirror image of the right side of the face (left), and a mirror image of the left side of the face (right). Permission was obtained from the participant to use their photo in this document. (photo by Alex MacNeil)

Some studies describe thicker soft tissue on the left side of the face (Sahni et al. 2008:143) while others describe a tendency for soft tissue to be thicker on the right side of the face (Sutton 1969:305). Research also indicates that normal facial asymmetry (not caused by disease or trauma) is not controlled exclusively by heredity but is also affected by environmental factors after birth (Lundström 1961:105; Mulick 1965:125-126). Craniofacial morphology, in general, is shown to be affected by factors of both inheritance and the environment (Baydaş et al. 2007:508). Ingervall and Thilander (1974)

report clear correlations between muscle activity and the shape of the face. Shah and Joshi (1978:146) suggest stronger mastication on one side of the face may lead to increased skeletal development on that side and that soft tissue may compensate for any underlying skeletal asymmetry that exists. Shah and Joshi (1978:143) also suggest that the age of participants measured is an important factor in the assessment of facial asymmetry and that accurate results can only be derived from the study of adults whose facial structures are completely grown.

Chapter 3: Methodology

3.1 Ultrasonic equipment

This study uses the ultrasonic methods outlined by Manhein et al. (2000) for facial soft tissue depth data collection. The use of ultrasound to measure facial tissue depth involves the examination of specific points on the face. The ultrasound operator places a transducer, which produces ultrasonic sound waves, onto each point individually. Differences in how these sound waves bounce off tissues of different densities, at each point, are analyzed by the ultrasound machine as these waves travel back to the transducer. The pulse-echo information is then transformed into an image which appears on the ultrasound's monitor (Bamber and Tristam 1988:319). This image can be frozen when the operator has a clear representation of the specific landmark and the depth of the tissue can be measured on the display with the use of electronic callipers built into the system (Figure 3.1). The image, with the tissue depth measurement recorded, can then be printed for analysis.

The ultrasound system used in this study consisted of an Aloka SSD-500 OB/GYN ultrasound system with an integrated monitor, an Aloka UST-5521 7.5 MHz transducer, and a Sony UP 890 MD black and white thermal printer which used Sony UPP 1100HD thermal paper. The Aloka SSD-500 OB/GYN also had a peripheral trackball for manipulating electronic callipers and other controls within the system. The integrated electronic callipers measure distances to the nearest millimetre. Use of this ultrasound equipment was made possible by private anonymous donation by an ultrasound clinic in Nova Scotia. Training in proper use of the equipment was provided by the clinic's ultrasound technologist.

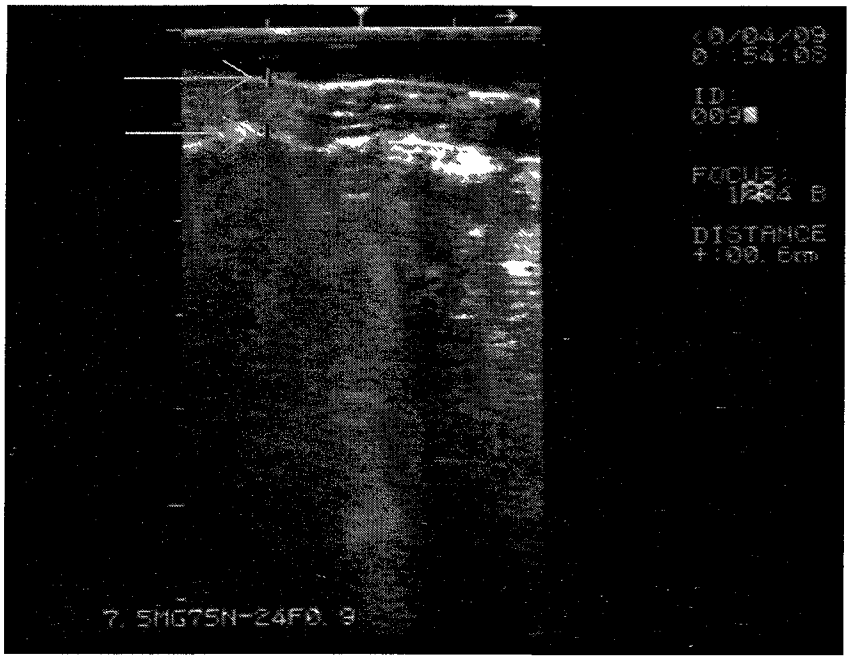

Figure 3.1 - An example of a sonogram showing the author's forehead. The arrows indicate the crosshairs ("+") of the electronic callipers that can be used to measure tissue depth when examining facial landmarks. The distance (6 mm) between the two crosshairs is displayed to the right of the image.

3.2 Reasons for using ultrasound in this study

The reasoning behind using ultrasound as a tool to measure facial soft tissue for this project is twofold. Firstly, it enables an investigator to measure the facial soft tissue depth of living individuals. Some researchers have supplied facial tissue depth data for other populations by collecting samples from deceased individuals (Domaracki and Stephan 2006; Rhine and Campbell 1980; Rhine and Moore 1984). This technique has been criticized for not taking into account the changes that occur in the body after death. The loss of fluid, the effects of gravity when a subject is in a horizontal position, the changes in soft tissue during rigor mortis, the loss of muscle tone and shrinkage, and putrefaction with bloating of the face are believed to make tissue depth measurements

taken from cadavers unreliable in the representation of living tissue depth (De Greef et al. 2006:S143; Galdames et al. 2008:168; Phillips and Smuts 1996:52; Prag and Neave 1997:18-19; Todd and Lindala 1928; Wilkinson 2004:129).

Secondly, ultrasound was chosen over other in-vivo methods such as radiography, computed tomography scanning (CT scanning), and magnetic resonance imaging (MRI) techniques, due to the relatively minor operation costs compared to these other methods. Other in-vivo methods also bring with them several complications that make it difficult to adapt to the applications needed for this project. Radiographic methods normally focus only on the midline of the face (Garlie and Saunders 1999) or include very few lateral measurements (Utsuno et al. 2005) as it can be difficult to obtain accurate lateral measurements due to the precision needed in placement of the head and the overlap of features in radiographic images (Smith and Throckmorton 2006:246). Computerized tomography and MRI methods require the participant to be prone which allows gravity to distort the facial soft tissue (Wilkinson 2004:129). Radiographic, CT, and MRI methods also expose participants to high levels of radiation compared to ultrasonic techniques (Domaracki and Stephan 2006:5; Wilkinson 2004:132).

3.3 Participant recruitment

Participants for this study were recruited within Halifax Regional Municipality and surrounding communities through university groups, community groups, and word of mouth. An in-depth process involving information meetings with community representatives and local media was undertaken in an effort to bring about awareness of the project and to establish a relationship of trust with the First Nations community. A

relationship was established with the Mi'kmaq Child Development Center in Halifax, which provides many services to Aboriginal families in the community, as well as the LSK School in Indian Brook, Nova Scotia. Meetings with staff at these locations led to regular measurement workshops where staff and visitors to the Mi'kmaq Child Development Center, and faculty and staff from LSK School, volunteered their time for the project. Compensation for each participant was provided in the form of a $5.00 restaurant gift certificate. A grand prize draw for a $100 grocery gift card was also offered and each participant had their name entered into this draw. The decision to draw for a gift certificate to a local grocery store was made after consulting with local First Nations community leaders who indicated that this would be an appropriate and useful prize for individuals in their community.

Members of the First Nations community were involved throughout the planning stages of this study in an effort to ensure that they had a stake in the project, understood clearly the intentions of the study, and had the opportunity to raise any concerns about the collection and use of the data. Working with First Nations community members, a consent form was produced outlining exactly how the data would be used and the steps that would be put in place to ensure the security of the personal information collected. The consent form was finalized (Appendix A) and provided thereafter to each participant in the study.

Fifty participants were recruited, consisting of 11 male and 39 female adults (19 years of age or older). Participants were provided with the consent form to review and sign as well as a participant data sheet (Appendix A). After reviewing the consent form, participants were asked if they had any questions about the procedure or the project in

general. If the volunteers were satisfied, they were asked to fill out the participant data sheet and sign the consent form. On this data sheet participants recorded their name, birth date, age, sex, and ancestry. The author and an assistant measured the height and weight of each participant and were responsible for filling in this section of the data sheet. The author also assigned an ID number to each participant, for the purposes of anonymity, and recorded this on the data sheet. Frontal and lateral (right and left side) photographs were then taken of the face of each participant by the author or by an assistant. These were taken in order to provide forensic artists with examples of soft tissue characteristics, such as the size and shape of ears and noses, which cannot be determined from skeletal remains. Once this was completed, participants were seated in order to begin ultrasonic measurement.

3.4 Ultrasonic measurement

The first step in the measurement of a participant was the preparation of the ultrasonic transducer. The transducer was cleaned with an alcohol wipe then coated liberally with EcoGel 200 multipurpose ultrasound gel which had been kept cold in a refrigerator when not in use. A uniform layer of ultrasound gel was placed on the transducer. This was necessary in order to clearly visualize tissue on the ultrasound monitor and to avoid depressing the soft facial tissue of the participant. Ultrasound gel has little effect on the transmission of sound waves and ensures that any compression of the soft tissue during the measurement process is minimized (Stephan and Simpson 2008:1270).

When the transducer was coated with gel it was placed on the anatomical location to be measured. The image was frozen when it became in clear focus on the monitor. The electronic callipers in the ultrasound machine were used to measure the distance from the surface of the skin to the underlying bone directly on the digital image present on the monitor. This distance was then recorded on the image and appears on the print out of the sonography. Images were printed for each point on the face and then archived with the individual data sheets. Throughout the measuring process, participants were provided with tissue paper and allowed to clean the gel from their face at their discretion if they did not feel comfortable allowing the ultrasound operator to do so.

3.5 Points measured and their location

The points measured in this study are those outlined by Manhein et al. (2000) (Figure 3.2) with the addition of measuring both sides of the face for each lateral point. The protocol for locating each point was followed as outlined by Manhein et al. (2000) (Table 3.1).

There is some disagreement with respect to the quantity and location of the data points necessary to compile a useful facial soft tissue depth database (Stephan and Simpson 2008:1259). Nelson and Michael (1998:173) also point out that a major source of measurement error arises from inaccurate identification of data points caused by ambiguous descriptions. The resulting inconsistency between data sets makes it difficult to compare the different populations represented by the various databases. Manhein et al. (2000) describe, in clear and detailed language, the point locations used for collecting facial soft tissue depth data in their study. The use of such detailed point descriptions

enables other researchers to repeat the same methodology thereby producing data sets that are directly comparable.

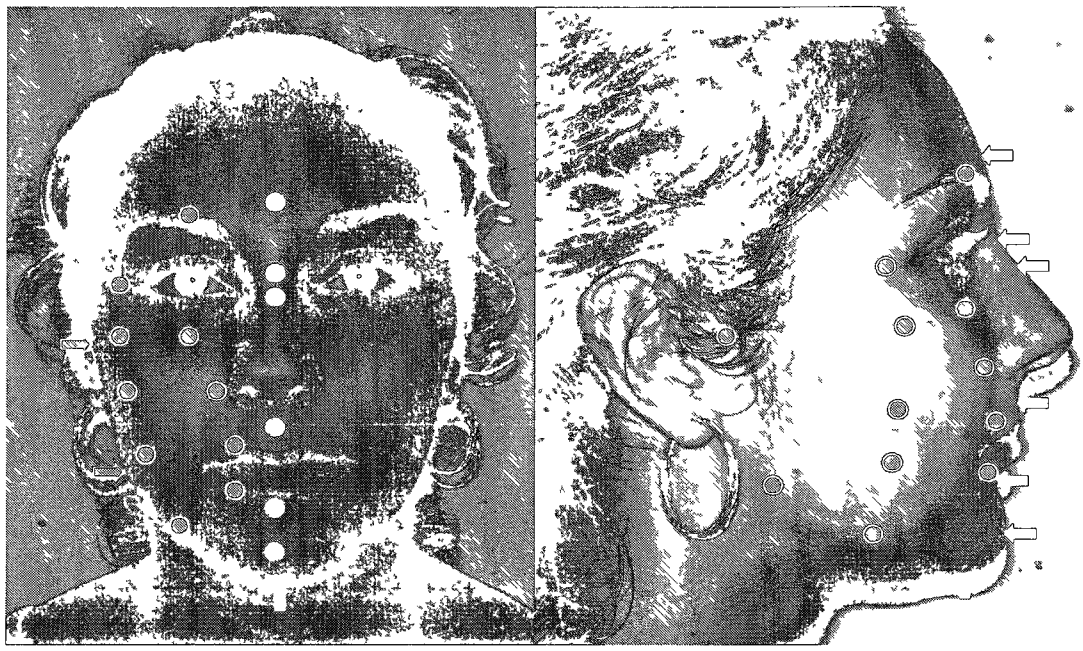

Figure 3.2 - Location of points measured on each participants face. All measurements other than those on the midline (indicated by red dots and arrows) were measured on both sides of the face. Permission was obtained from the participant to use their photo in this document. (photo by Alex MacNeil)

For the purposes of the current study it was decided that the protocol outlined by Manhein et al. (2000) would be employed and that the 19 landmarks described in that study would be sufficient for bi-lateral comparisons of facial tissue depth. This decision was made based on the fact that the points described in Manhein et al. (2000) are done so with instructions describing how to locate each point with reference to soft tissue landmarks on the face. In following these instructions, the likelihood of measurement errors due to inaccuracies in point location is decreased. This served to ensure, through the use of these detailed landmark descriptions (Table 3.1), minimal intra observer error.

Table 3.1 – Points measured on each participant and the descriptions of soft tissue landmarks used to locate them from Manhein et al. (2000).

Point measured	Location
1 Glabella	Approximately 1 cm above and directly between the subject's eyebrows.
2 Nasion	Directly between the eyes.
3 End of nasals	Palpating to determine where bone ends and cartilage begins.
4 Lateral nostril (right and left)	Approximately 0.5 cm to the right (if measuring the right side) or left (if measuring the left side)of the nostril.
5 Mid-philtrum	Centered between nose and mouth.
6 Chin-lip fold	Centered in fold of chin, below lips.
7 Mental eminence	Centered on forward-most projecting point of chin.
8 Beneath chin	Centered on inferior surface of mandible.
9 Superior eye orbit (right and left)	Centered on eye, at level of eyebrow.
10 Inferior eye orbit (right and left)	Centered on eye, where inferior bony margin lies.
11 Supra canine (right and left)	Upper lip, lined up superiorly/inferiorly with lateral edge of nostril.
12 Sub canine (right and left)	Lower lip, lined up superiorly/inferiorly with edge of nostril.
13 Supra M2 (right and left)	Cheek region, lateral: lined up with bottom of nose; vertical: center of transducer lined up beneath lateral border of eye, measurement taken 0.5 cm to the left (if measuring the right side) or right (if measuring the left side) of center mark.
14 Lower cheek (right and left)	Cheek region, lateral: lined up with mouth; vertical: same as Supra M2.
15 Mid mandible (right and left)	Inferior border of mandible, vertically lined up same as Supra M2.
16 Lateral eye orbit (right and left)	Lined up laterally with corner of the eye, on the bone.
17 Zygomatic (right and left)	Lined up with the lateral border of the eye, on the zygomatic process.
18 Gonion (right and left)	Found by palpating.
19 Root of zygoma (right and left)	Anterior to and 0.5 cm superior to tragus.

Stephan and Simpson (2008:1266), in their review of current facial soft tissue depth studies, suggest as their fourth provision that researchers measure a minimal amount of standardized points. Therefore, the current study will follow the already established protocol from Manhein et al (2000), which includes several of the points

recommended by Stephan and Simpson (2008). The author of the current study recognizes that the data points suggested by Stephan and Simpson (2008) offer the opportunity for researchers to adopt a standardized set of data points, however, in the interest of being able to directly compare data with a previous study, it was deemed appropriate to use the data set from Manhein et al. (2000).

3.6 Organization of data

Data from each participant was tabulated into subcategories for sex and age. Following the protocol outlined by Manhein et al. (2000), the data was grouped by sex into four age groups (19-34 years of age, 35-45 years of age, 46-55 years of age, and 56 years of age and older). The mean tissue depths for each location were calculated for each age group and for both sexes. The standard deviation and soft tissue depth range for each point were also recorded. In addition to calculating the mean soft tissue depths, the median soft tissue depths for each point were also calculated for each age group and for males and females separately. These were reported with the first and third quartiles for each point. Mean soft tissue depth was calculated in order to compare these values with those of previous studies. Median values were also reported as recent studies have shown that soft tissue depth data is often skewed, with a non-normal distribution, indicating that it should be reported with more appropriate indicators of central tendency such as medians and modes (Domaracki and Stephan 2006:9; Stephan and Simpson 2008:1265-1266). This addresses the second provision outlined by Stephan and Simpson (2008:1266) which indicates the need for more descriptive statistics of facial soft tissue depth measurements.

Stephan and Simpson (2008:1264) also state that the variability within each population group was broad while the mean tissue depths for each group were similar to each other. They also found little difference between male and female tissue depth values. The authors argue that facial tissue depth data should be reported as broadly as possible, with all male and female data from all age groups pooled together. Therefore, the data in this study was pooled together in this way to calculate mean and median soft tissue thickness for the entire study population.

3.7 Body mass index

The BMI (body mass index) of participants in facial tissue depth studies has been used to further subcategorize data (Codinha 2009). In the current project however, no BMI subcategorization was implemented. One of the aims of the current project is to compare data from First Nations Nova Scotians to data from other populations. A study of percent fat and body mass index (BMI) (Deurenderg et al. 1998) revealed that individuals of the same age and sex, from different population groups, who shared the same percent fat actually measured differently on a BMI scale. This study indicates that BMI ranges and indices for categories such as 'obese' cannot be translated from one population group to another. Therefore, comparing facial tissue depth data between populations that are subcategorized by BMI would not provide an accurate assessment of tissue depth differences between those populations. Instead, the author chose to compare data from the current project to data from Manhein et al. (2000), whose participants were from an area of the United States known to have higher rates of obesity than the general

population (Menifield et al. 2008), as is the case with First Nations peoples in Canada (Katzmarzyk & Malina 1998).

3.8 Data analysis

3.8.1 Comparing First Nations Nova Scotian data with other populations

Although a standardized set of landmarks, or data points, has yet to be agreed upon and adopted globally by researchers in this field, the need for such a universally accepted protocol is recognized as an important step in improving upon current methods of facial soft tissue depth measurement and 3-D forensic facial reconstruction (Brown et al. 2004; Stephan and Simpson 2008:1266). In the absence of a universally accepted protocol, data from the current study was compared to data from population groups that have been collected using the same set of data points, and the same methodology, i.e. ultrasound. These population groups included "American Black" adults and "American White" adults from Manhein et al (2000:56-57).

Mean facial tissue depth data from 19 points (12 of which were measured on both the right and left sides in the current study) were compared between First Nations Nova Scotian adults and the two American adult populations from Manhein et al (2000). Raw data from Manhein et al (2000) was not available, so no statistical comparison of these populations was possible, however trends in mean facial tissue depth were examined.

3.8.2 Testing for normality

A test for normality was performed in order to determine what statistical analyses would be most appropriate for the data in the current study. This is a required step in

determining whether the distributions of facial soft tissue depth measurements are normal or skewed. The *Kolmogorov-Smirnov* test and the *Ryan-Joiner* test were both performed using Minitab 15 Statistical Software on pooled data from all males and females from all age groups. These tests were also performed on male and female data separately. The results indicated that the facial soft tissue depth values were skewed at many of the points measured for this population indicating that non-parametric tests would be more appropriate for this data.

3.8.3 Examining changes in facial soft tissue depth with age

The change in facial soft tissue depth with age was analyzed statistically for males and females using the *Spearman's Correlation* which can be used with non-parametric, or skewed, data (Heiman 2006: np). This analysis was performed using SPSS Statistics 17.0 and the results were reported separately for males and females.

3.8.4 Comparing males and females

Male and female mean and median facial soft tissue depth values were compared to determine if there was a relationship between tissue thickness and sex. Using Minitab 15 Statistical Software, a *Mann-Whitney* test, used for comparing two independent samples of non-parametric data (Heiman 2006: np), was performed to analyze whether there was a significant difference between male and female facial soft tissue depths at each of the points measured.

3.8.5 Estimation of error rate

Prior to analyzing the facial asymmetry that may exist in this population, it was important to first take into account the error rate associated with the ultrasonic measurement technique employed in this study. Estimating the error rate of this technique was required in order to ensure that any bilateral facial soft tissue depth measurements, that appear to be asymmetrical, were in fact due to facial asymmetry and not simply due to the inherent error associated with the act of measuring itself. As outlined by their third provision, Stephan and Simpson (2008:1266) cite that it is important that the error rates associated with facial soft tissue depth measurement techniques be calculated and reported. Inter-observer error was avoided by ensuring that only the author operated the ultrasound equipment throughout the study.

Intra-observer error was assessed by calculating the mean error associated with repeated measurements of the same data points by the same investigator. Five of the participants from the current study were measured twice by the author. The differences between the first and second measurements, for each point, were calculated for each of the five participants. The mean difference between measurements across all points, for all five participants, was then calculated. An estimate of error rate was then reported as the mean error across the five participants plus the standard deviation calculated by the Microsoft Excel software program. The detailed descriptions of facial landmarks, provided by Manhein et al. (2000), were used in the current study to locate data points as accurately as possible thereby minimizing error associated with inaccurate anatomical location.

3.8.6 Analysis of asymmetry

Although past studies of facial soft tissue thickness (Chan 2007:44; De Greef et al. 2006:S143-S144; Domaracki and Stephan 2006:7) have examined facial asymmetry and determined that collecting data from one side of the face would be sufficient for the purposes of 3-D facial reconstructions, Sahni et al. (2008:143), in a study of 173 male and 127 female subjects of Northwest Indian origin, found that soft tissue of the left side of the face was thicker than that of the right side in most individuals. Sahni et al. (2008:143) suggest that this asymmetry of facial soft tissue should be examined further if such data is to be used for 3-D forensic facial reconstructions. Furthermore, the assessment of asymmetry in these studies is often performed only on a small subset of the study group sometimes examining as few as two individuals (Chan 2007:28-29).

An initial examination of asymmetry, in the current study, involved calculating the difference between right and left measurements for each of the twelve bi-lateral points for each participant. The differences were then compared to the estimated error rate calculated from the repeated measurements of five participants. A difference between right and left measurements was considered to be an indication of asymmetry when it exceeded the estimated error rate.

Further statistical analyses of asymmetry involved testing the differences between right and left measurements for normality. A *Ryan-Joiner* test was performed on the difference values using the Minitab 15 statistical software package. The non-normal, or skewed, distribution of many of the values indicated that a non-parametric statistical test was necessary to statistically analyze asymmetry. Therefore, the *Wilcoxin* paired signed

rank test was used to compare right and left measurements using the Minitab 15 statistical software package.

Chapter 4: Results

4.1 Review of Mean and Median Tissue Depth Data

Soft tissue depth measurements of 31 points were measured on the faces of 50 adult First Nations Nova Scotian participants. Of these 31 points, seven were on the midline of the face (points 1, 2, 3, 5, 6, 7, and 8), 12 were on the right side of the face (points 4R, 9R, 10R, 11R, 12R, 13R, 14R, 15R, 16R, 17R, 18R, and 19R), and 12 were on the left side of the face (points 4L, 9L, 10L, 11L, 12L, 13L, 14L, 15L, 16L, 17L, 18L, and 19L) (Table 4.1). The tissue depth data was organized into four age groups (ages 19 to 34 years, 35 to 45 years, 46 to 55 years, and 56 years and older) following the protocol established in Manhein et al. (2000). These age groupings were also separated by sex in order to compare the facial soft tissue depths between males and females.

A general overview of facial soft tissue depth ranges in males reveals variability in tissue depths at certain points. For males aged 19 to 34 years, the points that displayed the greatest range of facial soft tissue depths include 4 L (14 mm), 11 R (13 mm), 13 R (15 mm), 14 R (22 mm), 15 R (15 mm), and 14 L (20 mm). For males aged 35 to 45 years, the points that displayed the greatest range of facial soft tissue depths included points 13 R (28 mm), 15 L (15 mm), 16 R (22 mm), 16 L (22 mm), 17 L (21 mm), 18 R (17 mm), and 18 L (17 mm). For males aged 46 to 55 years, the point that displayed the greatest range of facial soft tissue depth was point 18 R (21 mm) with the rest of the points displaying a range of less than 10 mm.

A general overview of facial soft tissue depth ranges in females also reveals variability in tissue depths at certain points. Females, aged 19 to 34 years, displayed several very large facial soft tissue depth ranges (30 mm or more) at five points. These included 13 L (44 mm), 14 L (34 mm), 15 R (30 mm), 15 L (34 mm), and 18 L (40 mm).

Other points displaying large facial soft tissue depth ranges included 4 R (26 mm), 4 L (23 mm), 7 (20 mm), 13 R (29 mm), 14 R (28 mm), and 16 R (24 mm). For females aged 35 to 45 years, the points that displayed the greatest range of facial soft tissue depths included 4 R (23 mm), 11 R (20 mm), 13 L (28 mm), 14 R (21 mm), 14 L (23 mm), 18 R (27 mm), and 18 L (24 mm). For females aged 46 to 55 years, the greatest range of facial soft tissue depths were seen at points 13 R (16 mm), 13 L (13 mm), 14 L (13 mm), 15 L (14 mm), 17 L (14 mm), 18 R (18 mm), and 18 L (11 mm). For females aged 56 years and older, the points with the greatest range of facial soft tissue depths included 13 L (18 mm), 14 R (25 mm), 14 L (11 mm), 15 R (13 mm), 15 L (17 mm), 18 R (18 mm), and 18 L (17 mm). The youngest age group (19 to 34 years of age) of females displayed the greatest ranges of soft tissue depths when comparing all male and female age groups. This indicates that, in this population, this group is the most variable in terms of facial soft tissue depth.

It has been reported, previously, that facial soft tissue depth data can sometimes be skewed, i.e. displaying a non-normal distribution (Domaracki and Stephan 2006; Stephan and Simpson 2008). In these cases, it is helpful to provide additional descriptors of central tendency apart from the means alone. For this reason, the medians for this facial soft tissue depth data, grouped by age and sex, were also calculated and are reported in Table 4.2. Pooled mean (Table 4.3) and median (Table 4.4) facial soft tissue depth data from the entire study population, with no subcategorization by sex or age, were also compiled.

Table 4.1 - Facial soft tissue depth means (mm) for Nova Scotian Aboriginal adults. (Continued on next page)

		19-34 years						35-45 years					
		Male (N=5)			Female (N=18)			Male (N=4)			Female (N=13)		
Point numbers and descriptions		Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
1	Glabella	6.4	1.14	5-8	6.7	1.71	5-11	6.5	1.00	6-8	6.5	1.04	5-8
2	Nasion	6.0	0.71	5-7	6.6	1.65	4-10	8.3	1.26	7-10	6.8	1.22	5-9
3	End of nasals	3.4	1.14	2-5	4.0	1.59	2-7	3.5	1.29	2-5	3.9	0.95	2-5
5	Mid-philthrum	11.8	3.27	7-16	10.2	2.26	8-15	12.3	1.26	11-14	9.1	1.69	5-11
6	Chin lip fold	12.6	2.07	11-16	13.0	2.66	10-21	12.8	0.96	12-14	13.6	1.55	11-17
7	Mental eminence	12.2	3.11	9-16	14.8	4.90	9-29	13.3	2.99	10-17	15.3	2.91	10-20
8	Beneath chin	8.6	1.52	7-10	10.3	4.21	5-22	10.0	1.63	8-12	10.9	2.63	6-14
4 R	Right lateral nostril	21.2	3.19	17-25	24.3	6.20	16-42	17.8	6.45	10-24	24.2	5.87	17-40
9 R	Right supraorbital	6.6	2.70	4-11	8.4	2.76	4-16	8.5	4.20	3-13	8.3	2.10	5-14
10 R	Right suborbital	6.2	3.35	4-12	11.2	5.51	4-23	9.5	2.38	8-13	10.5	4.76	5-19
11 R	Right supracanine	14.4	5.13	10-23	12.9	4.22	8-24	12.3	2.50	11-16	14.7	6.00	8-28
12 R	Right subcanine	13.6	2.51	11-16	13.6	4.38	4-23	13.8	0.50	13-14	12.8	1.69	9-16
13 R	Right posterior maxilla	23.6	6.43	14-29	30.0	7.43	16-45	28.0	11.92	12-40	32.9	5.20	23-42
14 R	Right superior mid mandible	24.6	8.99	9-31	28.1	7.25	13-41	28.5	3.11	25-32	29.5	6.06	19-40
15 R	Right inferior mid mandible	11.4	5.77	6-21	14.0	7.25	8-38	11.8	6.29	6-19	13.7	6.27	7-26
16 R	Right lateral eye orbit	4.4	0.89	4-6	6.9	5.25	3-27	10.5	10.38	4-26	6.2	3.41	4-17
17 R	Right anterior zygoma	8.8	2.77	5-12	9.3	4.34	5-21	7.5	3.70	5-13	9.9	4.44	5-21
18 R	Right gonion	6.8	1.30	5-8	12.2	5.34	6-21	14.5	8.74	6-23	14.4	8.47	5-32
19 R	Right root of zygoma	5.6	1.82	4-8	4.7	1.24	3-7	4.8	0.50	4-5	4.9	1.61	3-8
4 L	Left lateral nostril	19.0	5.05	11-25	23.6	5.92	16-39	21.5	2.38	19-24	23.9	4.62	18-35
9 L	Left supraorbital	7.4	1.82	5-10	7.7	2.11	4-11	10.5	2.38	8-13	7.3	2.32	4-12
10 L	Left suborbital	6.0	1.58	4-8	10.1	4.87	5-23	11.8	1.89	9-13	11.2	4.39	6-18
11 L	Left supracanine	12.8	2.49	11-17	12.1	4.17	7-24	13.5	2.38	11-16	12.7	5.06	8-24
12 L	Left subcanine	12.4	2.30	10-16	12.3	3.37	7-20	13.5	2.38	10-15	12.5	2.27	8-15
13 L	Left posterior maxilla	28.6	2.97	25-32	28.3	9.50	6-50	32.8	6.08	26-40	29.3	7.63	12-40
14 L	Left superior mid mandible	22.4	7.73	9-29	25.9	8.51	8-42	28.5	3.70	24-33	29.3	6.73	21-44
15 L	Left inferior mid mandible	8.8	3.35	5-13	12.0	7.79	6.5-40	12.3	6.70	7-22	10.6	4.09	6-21
16 L	Left lateral eye orbit	5.0	0.71	4-6	5.4	1.81	3-9	17.0	12.70	6-28	5.4	1.00	4-7
17 L	Left anterior zygoma	6.6	1.82	4-9	8.8	4.17	5-18	10.8	10.18	5-26	9.5	3.93	5-18
18 L	Left gonion	6.4	1.95	4-9	11.9	9.45	4-44	11.5	7.77	6-23	11.8	7.86	5-29
19 L	Left root of zygoma	4.4	0.55	4-5	4.9	1.81	2-10	6.0	2.16	4-9	4.6	0.98	3-6

Table 4.1 (Continued) - Facial soft tissue depth means (mm) for Nova Scotian Aboriginal adults.

		46-55 years						≥56		
		Male (N=2)			Female (N=3)			Female (N=5)		
Point numbers and descriptions		Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
1	Glabella	7.0	0.00	7-7	6.7	1.53	5-8	5.9	1.60	4-8
2	Nasion	7.0	0.00	7-7	6.7	2.08	5-9	6.4	2.30	4-10
3	End of nasals	5.5	2.12	4-7	5.3	0.58	5-6	4.0	2.00	2-7
5	Mid-philthrum	12.0	4.24	9-15	9.3	0.58	9-10	8.0	1.87	5-10
6	Chin lip fold	14.0	2.83	12-16	13.7	0.58	13-14	13.6	1.14	12-15
7	Mental eminence	14.5	0.71	14-15	15.0	1.00	14-16	14.7	2.22	12-17
8	Beneath chin	9.0	0.00	9-9	9.7	3.79	7-14	9.4	2.07	7-12
4 R	Right lateral nostril	23.0	1.41	22-24	21.7	3.06	19-25	22.4	1.95	21-25
9 R	Right supraorbital	10.5	0.71	10-11	8.3	1.53	7-10	8.2	2.77	5-12
10 R	Right suborbital	9.5	2.12	8-11	10.0	1.73	9-12	8.6	2.19	6-12
11 R	Right supracanine	11.0	2.83	9-13	8.7	0.58	8-9	9.4	1.82	7-12
12 R	Right subcanine	11.0	1.41	10-12	12.3	4.04	8-16	11.5	2.18	8-13.5
13 R	Right posterior maxilla	35.0	0.00	35-35	29.0	8.19	20-36	25.1	2.79	22.5-29
14 R	Right superior mid mandible	28.5	4.95	25-32	23.3	4.04	19-27	26.2	9.47	13-38
15 R	Right inferior mid mandible	17.5	4.95	14-21	13.7	3.79	11-18	12.6	5.13	7-20
16 R	Right lateral eye orbit	6.5	2.12	5-8	6.0	1.00	5-7	5.0	1.22	4-7
17 R	Right anterior zygoma	9.5	6.36	5-14	10.7	4.51	6-15	6.6	1.82	5-9
18 R	Right gonion	15.5	14.85	5-26	11.3	7.77	5-20	12.5	7.43	4-22
19 R	Right root of zygoma	5.5	0.71	5-6	4.7	0.58	4-5	4.8	1.79	4-8
4 L	Left lateral nostril	22.0	7.07	17-27	22.0	2.65	20-25	22.1	3.40	18-27
9 L	Left supraorbital	9.5	0.71	9-10	7.7	0.58	7-8	7.2	2.28	5-10
10 L	Left suborbital	11.5	0.71	11-12	10.0	1.73	8-11	9.3	1.99	6.5-11
11 L	Left supracanine	9.5	2.12	8-11	9.0	0.00	9-9	9.3	1.57	8-12
12 L	Left subcanine	12.5	2.12	11-14	14.7	1.53	13-16	11.4	2.88	7-15
13 L	Left posterior maxilla	33.0	1.41	32-34	26.3	6.51	20-33	21.8	7.01	10-28
14 L	Left superior mid mandible	25.0	7.07	20-30	30.3	6.66	23-36	29.1	4.72	25-36
15 L	Left inferior mid mandible	21.0	4.24	18-24	13.0	7.21	7-21	12.5	6.28	6-23
16 L	Left lateral eye orbit	5.0	0.00	5-5	6.0	1.00	5-7	5.2	0.84	4-6
17 L	Left anterior zygoma	12.0	2.83	10-14	10.3	7.57	5-19	7.3	1.57	5-9
18 L	Left gonion	22.0	2.83	20-24	11.0	5.57	6-17	12.3	6.36	5-22
19 L	Left root of zygoma	4.5	0.71	4-5	4.7	2.08	3-7	6.6	3.36	3-11

Table 4.2 - Facial soft tissue depth medians (mm), with 1st and 3rd quartiles, for Nova Scotian Aboriginal adults. (Continued on next page)

Point numbers and descriptions		19-34 years						35-45 years					
		Male (N=5)			Female (N=18)			Male (N=4)			Female (N=13)		
		Q1	Median	Q3	Q1	Median	Q3	Q1	Median	Q3	Q1	Median	Q3
1	Glabella	6.0	6.0	7.0	6.0	6.0	7.0	6.0	6.0	6.5	6.0	6.0	7.0
2	Nasion	6.0	6.0	6.0	6.0	6.0	7.8	7.8	8.0	8.5	6.0	7.0	8.0
3	End of nasals	3.0	3.0	4.0	3.0	4.0	5.5	2.8	3.5	4.3	3.0	4.0	5.0
5	Mid-philthrum	11.0	12.0	13.0	8.3	10.0	11.0	11.8	12.0	12.5	8.5	9.0	10.0
6	Chin lip fold	11.0	12.0	13.0	11.6	12.0	14.0	12.0	12.5	13.3	13.0	13.0	14.0
7	Mental eminence	9.0	13.0	14.0	12.0	13.5	16.5	11.5	13.0	14.8	14.0	15.0	17.0
8	Beneath chin	7.0	9.0	10.0	8.0	9.5	12.5	9.5	10.0	10.5	9.0	12.0	13.0
4 R	Right lateral nostril	19.0	22.0	23.0	21.0	23.0	26.8	13.8	18.5	22.5	20.0	23.0	27.0
9 R	Right supraorbital	5.0	6.0	7.0	7.3	8.0	9.0	6.8	9.0	10.8	7.0	8.0	9.0
10 R	Right suborbital	4.0	5.0	6.0	7.6	9.8	13.8	8.0	8.5	10.0	6.5	9.0	13.0
11 R	Right supracanine	12.0	12.0	15.0	9.6	12.0	15.8	11.0	11.0	12.3	12.0	12.0	18.0
12 R	Right subcanine	11.0	14.0	16.0	11.3	12.8	16.0	13.8	14.0	14.0	12.0	13.0	14.0
13 R	Right posterior maxilla	20.0	27.0	28.0	25.0	30.5	32.8	23.3	30.0	34.8	30.0	33.0	36.0
14 R	Right superior mid mandible	25.0	29.0	29.0	24.0	26.8	32.3	26.5	28.5	30.5	27.0	29.0	34.0
15 R	Right inferior mid mandible	8.0	11.0	11.0	9.3	12.5	15.8	6.8	11.0	16.0	9.5	12.0	16.0
16 R	Right lateral eye orbit	4.0	4.0	4.0	5.0	6.0	7.0	5.5	6.0	11.0	5.0	5.0	6.5
17 R	Right anterior zygoma	7.0	10.0	10.0	6.3	7.0	10.8	5.8	6.0	7.8	7.0	8.0	12.0
18 R	Right gonion	6.0	7.0	8.0	8.0	10.5	18.3	7.5	14.5	21.5	8.0	11.0	17.0
19 R	Right root of zygoma	4.0	5.0	7.0	4.0	5.0	5.8	4.8	5.0	5.0	4.0	4.5	5.0
4 L	Left lateral nostril	19.0	20.0	20.0	19.3	22.0	25.8	19.8	21.5	23.3	21.0	23.5	26.0
9 L	Left supraorbital	7.0	7.0	8.0	6.3	7.8	9.0	8.8	10.5	12.3	5.0	7.0	9.0
10 L	Left suborbital	5.0	6.0	7.0	6.6	9.5	12.5	11.3	12.5	13.0	8.5	10.0	15.0
11 L	Left supracanine	11.0	12.0	13.0	9.3	11.3	13.5	11.8	13.5	15.3	9.0	11.0	15.0
12 L	Left subcanine	11.0	12.0	13.0	9.6	12.0	13.4	13.0	14.5	15.0	12.0	12.0	14.5
13 L	Left posterior maxilla	26.0	30.0	30.0	23.5	30.0	32.8	29.0	32.5	36.3	27.0	29.0	35.0
14 L	Left superior mid mandible	24.0	25.0	25.0	20.5	24.3	31.5	27.0	28.5	30.0	24.0	28.0	34.0
15 L	Left inferior mid mandible	6.0	9.0	11.0	8.0	10.0	12.0	8.5	10.0	13.8	8.0	9.5	12.0
16 L	Left lateral eye orbit	5.0	5.0	5.0	4.0	6.0	6.0	6.0	17.0	28.0	5.0	5.0	6.0
17 L	Left anterior zygoma	6.0	7.0	7.0	6.0	7.0	10.8	5.8	6.0	11.0	7.0	8.0	12.0
18 L	Left gonion	5.0	7.0	7.0	6.6	9.0	13.5	7.5	8.5	12.5	6.0	8.5	16.0
19 L	Left root of zygoma	4.0	4.0	5.0	4.0	4.8	5.8	4.8	5.5	6.8	4.0	4.5	5.0

Table 4.2 (Continued) - Facial soft tissue depth medians (mm), with 1st and 3rd quartiles, for Nova Scotian Aboriginal adults.

		46-55 years						≥56		
		Male (N=2)			Female (N=3)			Female (N=5)		
	Point numbers and descriptions	Q1	Median	Q3	Q1	Median	Q3	Q1	Median	Q3
1	Glabella	7.0	7.0	7.0	6.0	7.0	7.5	5.0	5.5	7.0
2	Nasion	7.0	7.0	7.0	5.5	6.0	7.5	5.0	6.0	7.0
3	End of nasals	4.8	5.5	6.3	5.0	5.0	5.5	3.0	3.0	5.0
5	Mid-philthrum	10.5	12.0	13.5	9.0	9.0	9.5	8.0	8.0	9.0
6	Chin lip fold	13.0	14.0	15.0	13.5	14.0	14.0	13.0	14.0	14.0
7	Mental eminence	14.3	14.5	14.8	14.5	15.0	15.5	13.5	14.0	17.0
8	Beneath chin	9.0	9.0	9.0	7.5	8.0	11.0	8.0	9.0	11.0
4 R	Right lateral nostril	22.5	23.0	23.5	20.0	21.0	23.0	21.0	21.0	24.0
9 R	Right supraorbital	10.3	10.5	10.8	7.5	8.0	9.0	7.0	7.0	10.0
10 R	Right suborbital	8.8	9.5	10.3	9.0	9.0	10.5	8.0	8.0	9.0
11 R	Right supracanine	10.0	11.0	12.0	8.5	9.0	9.0	9.0	9.0	10.0
12 R	Right subcanine	10.5	11.0	11.5	10.5	13.0	14.5	11.0	12.0	13.0
13 R	Right posterior maxilla	35.0	35.0	35.0	25.5	31.0	33.5	23.0	24.0	27.0
14 R	Right superior mid mandible	26.8	28.5	30.3	21.5	24.0	25.5	23.0	25.0	32.0
15 R	Right inferior mid mandible	15.8	17.5	19.3	11.5	12.0	15.0	9.0	12.0	15.0
16 R	Right lateral eye orbit	5.8	6.5	7.3	5.5	6.0	6.5	4.0	5.0	5.0
17 R	Right anterior zygoma	7.3	9.5	11.8	8.5	11.0	13.0	5.0	6.0	8.0
18 R	Right gonion	10.3	15.5	20.8	7.0	9.0	14.5	6.0	14.5	16.0
19 R	Right root of zygoma	5.3	5.5	5.8	4.5	5.0	5.0	4.0	4.0	4.0
4 L	Left lateral nostril	19.5	22.0	24.5	20.5	21.0	23.0	20.0	22.5	23.0
9 L	Left supraorbital	9.3	9.5	9.8	7.5	8.0	8.0	5.0	7.0	9.0
10 L	Left suborbital	11.3	11.5	11.8	9.5	11.0	11.0	8.0	10.0	11.0
11 L	Left supracanine	8.8	9.5	10.3	9.0	9.0	9.0	8.5	9.0	9.0
12 L	Left subcanine	11.8	12.5	13.3	14.0	15.0	15.5	11.0	12.0	12.0
13 L	Left posterior maxilla	32.5	33.0	33.5	23.0	26.0	29.5	22.0	23.0	26.0
14 L	Left superior mid mandible	22.5	25.0	27.5	27.5	32.0	34.0	26.0	26.5	32.0
15 L	Left inferior mid mandible	19.5	21.0	22.5	9.0	11.0	16.0	11.0	11.0	11.5
16 L	Left lateral eye orbit	5.0	5.0	5.0	5.5	6.0	6.5	5.0	5.0	6.0
17 L	Left anterior zygoma	11.0	12.0	13.0	6.0	7.0	13.0	7.0	7.0	8.5
18 L	Left gonion	21.0	22.0	23.0	8.0	10.0	13.5	9.0	11.5	14.0
19 L	Left root of zygoma	4.3	4.5	4.8	3.5	4.0	5.5	4.0	6.0	9.0

Table 4.3 - Facial soft tissue depth means (mm) for entire study population of Nova Scotian Aboriginal adults (N=50)

	Point numbers and descriptions	Mean	SD	Range
1	Glabella	6.5	1.35	4-11
2	Nasion	6.7	1.52	4-10
3	End of nasals	4.0	1.42	2-7
5	Mid-philthrum	10.0	2.39	5-16
6	Chin lip fold	13.2	1.97	10-21
7	Mental eminence	14.5	3.61	9-29
8	Beneath chin	10.1	3.11	5-22
4 R	Right lateral nostril	23.0	5.44	10-42
9 R	Right supraorbital	8.3	2.58	3-16
10 R	Right suborbital	10.0	4.50	4-23
11 R	Right supracanine	12.8	4.64	7-28
12 R	Right subcanine	13.0	3.11	4-23
13 R	Right posterior maxilla	29.6	7.16	12-45
14 R	Right superior mid mandible	27.7	6.81	9-41
15 R	Right inferior mid mandible	13.5	6.15	6-38
16 R	Right lateral eye orbit	6.5	4.63	3-27
17 R	Right anterior zygoma	9.1	3.99	5-21
18 R	Right gonion	12.5	6.99	4-32
19 R	Right root of zygoma	4.9	1.35	3-8
4 L	Left lateral nostril	22.8	4.89	11-39
9 L	Left supraorbital	7.8	2.16	4-13
10 L	Left suborbital	10.1	4.00	4-23
11 L	Left supracanine	11.9	3.89	7-24
12 L	Left subcanine	12.5	2.71	7-20
13 L	Left posterior maxilla	28.3	7.79	6-50
14 L	Left superior mid mandible	27.2	7.19	8-44
15 L	Left inferior mid mandible	11.8	6.26	5-40
16 L	Left lateral eye orbit	6.3	4.60	3-28
17 L	Left anterior zygoma	9.0	4.52	4-26
18 L	Left gonion	11.7	7.81	4-44
19 L	Left root of zygoma	5.0	1.78	2-11

Table 4.4 - Facial soft tissue depth medians (mm). With 1st and 3rd quartiles, for entire study population of Nova Scotian Aboriginal adults (N=50)

	Point numbers and descriptions	Q1	Median	Q3
1	Glabella	6.0	6.0	7.0
2	Nasion	6.0	6.3	8.0
3	End of nasals	3.0	4.0	5.0
5	Mid-philthrum	8.6	10.0	11.0
6	Chin lip fold	12.0	13.0	14.0
7	Mental eminence	12.3	14.0	16.0
8	Beneath chin	8.0	10.0	12.0
4 R	Right lateral nostril	20.3	22.5	25.0
9 R	Right supraorbital	7.0	8.0	10.0
10 R	Right suborbital	6.6	9.0	12.0
11 R	Right supracanine	9.1	12.0	14.8
12 R	Right subcanine	11.3	13.0	14.0
13 R	Right posterior maxilla	24.3	30.0	34.8
14 R	Right superior mid mandible	24.3	27.0	31.8
15 R	Right inferior mid mandible	9.1	12.0	16.0
16 R	Right lateral eye orbit	4.0	5.0	6.9
17 R	Right anterior zygoma	6.0	7.3	11.0
18 R	Right gonion	7.0	9.3	18.5
19 R	Right root of zygoma	4.0	5.0	5.0
4 L	Left lateral nostril	20.0	21.5	25.0
9 L	Left supraorbital	6.3	8.0	9.0
10 L	Left suborbital	7.0	10.0	12.0
11 L	Left supracanine	9.0	11.0	12.8
12 L	Left subcanine	11.0	12.0	14.9
13 L	Left posterior maxilla	25.0	29.5	32.8
14 L	Left superior mid mandible	23.3	26.8	32.0
15 L	Left inferior mid mandible	8.0	10.0	12.0
16 L	Left lateral eye orbit	5.0	5.5	6.0
17 L	Left anterior zygoma	6.0	7.0	10.0
18 L	Left gonion	6.1	9.0	15.5
19 L	Left root of zygoma	4.0	4.8	6.0

4.2 Comparing First Nations Nova Scotian Data to other populations

The mean facial soft tissue depth values from the current study were compared to "American Black" and "American White" adult data from Manhein et al. (2000:56-57). First Nations Nova Scotian data was subcategorized by sex and age with measurements from 19 points on the face, with 12 of the 19 points measured on both the right and left sides of the face; Manhein et al. (2000) only reported lateral measurements from the right side of the face, i.e. points 4 and 9-19. Therefore the bilateral measurements from the current study are compared to measurements taken on the right side of the face for the American populations (Tables 4.5 and 4.6).

4.2.1 Comparison to "American Black" population data

Compared to "American Black" adults (Manhein et al. 2000:56), the First Nations Nova Scotian group had greater mean facial soft tissue depths at the majority of points in all age groups for males and females with the exception of males aged 19-34 years (Tables 4.5 and 4.6). Female First Nations Nova Scotians, aged 19-34 years, had greater mean facial soft tissue depths (Table 4.5) at all but four of the 19 points reported by Manhein et al. (2000:56) when compared to "American Black" adults of the same sex and age group. These include points 17 and 18 which were smaller than the "American Black" values on both the right and left sides of the face, point 15 which was greater than the "American Black" value on the right side of the face but smaller on the left, and point 19 which was greater than the "American Black" value on the left side of the face but smaller on the right (Table 4.5).

Table 4.5 - Comparison of female First Nations Nova Scotian data to female "American Black" and female "American White" data (mm).

Point numbers and descriptions		19-34 years			35-45 years			46-55 years			≥56 years	
		FNNS (N=18)	AB (N=18)	AW (N=52)	FNNS (N=13)	AB (N=21)	AW (N=15)	FNNS (N=3)	AB (N=5)	AW (N=6)	FNNS (N+5)	AW (N=9)
1	Glabella	6.7	4.6	4.8	6.5	4.5	4.7	6.7	4.8	4.8	5.9	5.2
2	Nasion	6.6	6.0	5.5	6.8	5.2	5.3	6.7	6.0	6.2	6.4	6.0
3	End of nasals	4.0	1.7	1.8	3.9	1.5	1.6	5.3	2.0	1.8	4.0	1.8
5	Mid-philthrum	10.2	9.2	9.1	9.1	8.8	7.4	9.3	8.2	8.0	8.0	8.0
6	Chin lip fold	13.0	11.8	10.3	13.6	11.7	9.6	13.7	10.0	9.8	13.6	11.4
7	Mental eminence	14.8	10.8	9.2	15.3	11.2	9.2	15.0	10.8	10.7	14.7	12.3
8	Beneath chin	10.3	6.7	6.0	10.9	6.4	5.4	9.7	7.2	6.7	9.4	8.0
4 R	Right lateral nostril	24.3	8.4	8.6	24.2	8.4	8.0	21.7	8.4	10.8	22.4	9.8
9 R	Right supraorbital	8.4	6.1	5.7	8.3	6.0	5.5	8.3	5.8	6.5	8.2	6.3
10 R	Right suborbital	11.2	6.2	6.1	10.5	6.9	5.7	10.0	5.8	7.3	8.6	7.0
11 R	Right supracanine	12.9	10.0	9.3	14.7	9.6	7.8	8.7	9.0	7.7	9.4	8.0
12 R	Right subcanine	13.6	10.9	9.4	12.8	11.5	8.7	12.3	12.4	9.0	11.5	9.7
13 R	Right posterior maxilla	30.0	26.6	26.3	32.9	26.8	25.1	29.0	26.8	27.2	25.1	29.4
14 R	Right superior mid mandible	28.1	21.7	23.4	29.5	22.5	20.1	23.3	21.2	21.7	26.2	27.2
15 R	Right inferior mid mandible	14.0	12.6	13.7	13.7	13.1	12.6	13.7	13.4	13.0	12.6	17.4
16 R	Right lateral eye orbit	6.9	5.0	4.7	6.2	4.9	4.3	6.0	4.8	4.5	5.0	4.9
17 R	Right anterior zygoma	9.3	10.2	9.3	9.9	9.8	8.7	10.7	9.8	10.2	6.6	11.0
18 R	Right gonion	12.2	17.0	17.4	14.4	16.2	15.3	11.3	14.8	14.7	12.5	16.9
19 R	Right root of zygoma	4.7	6.4	7.4	4.9	5.6	4.9	4.7	6.0	6.0	4.8	7.4
4 L	Left lateral nostril	23.6	8.4*	8.6*	23.9	8.4*	8.0*	22.0	8.4*	10.8*	22.1	9.8*
9 L	Left supraorbital	7.7	6.1*	5.7*	7.3	6.0*	5.5*	7.7	5.8*	6.5*	7.2	6.3*
10 L	Left suborbital	10.1	6.2*	6.1*	11.2	6.9*	5.7*	10.0	5.8*	7.3*	9.3	7.0*
11 L	Left supracanine	12.1	10.0*	9.3*	12.7	9.6*	7.8*	9.0	9.0*	7.7*	9.3	8.0*
12 L	Left subcanine	12.3	10.9*	9.4*	12.5	11.5*	8.7*	14.7	12.4*	9.0*	11.4	9.7*
13 L	Left posterior maxilla	28.3	26.6*	26.3*	29.3	26.8*	25.1*	26.3	26.8*	27.2*	21.8	29.4*
14 L	Left superior mid mandible	25.9	21.7*	23.4*	29.3	22.5*	20.1*	30.3	21.2*	21.7*	29.1	27.2*
15 L	Left inferior mid mandible	12.0	12.6*	13.7*	10.6	13.1*	12.6*	13.0	13.4*	13.0*	12.5	17.4*
16 L	Left lateral eye orbit	5.4	5.0*	4.7*	5.4	4.9*	4.3*	6.0	4.8*	4.5*	5.2	4.9*
17 L	Left anterior zygoma	8.8	10.2*	9.3*	9.5	9.8*	8.7*	10.3	9.8*	10.2*	7.3	11.0*
18 L	Left gonion	11.9	17.0*	17.4*	11.8	16.2*	15.3*	11.0	14.8*	14.7*	12.3	16.9*
19 L	Left root of zygoma	4.9	6.4*	7.4*	4.6	5.6*	4.9*	4.7	6.0*	6.0*	6.6	7.4*

FNNS = First Nations Nova Scotians
AB = "American Black" from Manhein et al. (2000)
AW = "American White" from Manhein et al. (2000)
* = Lateral measurements were taken from right side only in Manhein et al. (2000). Values are listed for comparison purposes only.

Table 4.6 - Comparison of male First Nations Nova Scotian data to male "American Black" and male "American White" data (mm).

	Point numbers and descriptions	19-34 years			35-45 years			45-55	
		FNNS (N=5)	AB (N=19)	AW (N=28)	FNNS (N=4)	AB (N=3)	AW (N=10)	FNNS (N=2)	AW (N=5)
1	Glabella	6.4	5.2	5.0	6.5	5.3	5.5	7.0	6.0
2	Nasion	6.0	6.6	6.0	8.3	5.7	6.4	7.0	7.2
3	End of nasals	3.4	2.2	1.9	3.5	1.7	2.4	5.5	1.8
5	Mid-philthrum	11.8	13.0	11.9	12.3	11.0	10.6	12.0	8.0
6	Chin lip fold	12.6	12.7	11.1	12.8	12.7	13.1	14.0	11.6
7	Mental eminence	12.2	12.1	10.0	13.3	12.3	12.0	14.5	11.0
8	Beneath chin	8.6	8.8	7.2	10.0	7.0	8.0	9.0	7.2
4 R	Right lateral nostril	21.2	9.2	7.5	17.8	10.3	9.8	23.0	10.4
9 R	Right supraorbital	6.6	6.4	5.3	8.5	6.3	5.9	10.5	7.7
10 R	Right suborbital	6.2	5.8	5.8	9.5	7.0	6.2	9.5	6.8
11 R	Right supracanine	14.4	12.8	11.9	12.3	10.3	10.1	11.0	10.0
12 R	Right subcanine	13.6	14.4	11.5	13.8	10.7	10.2	11.0	10.0
13 R	Right posterior maxilla	23.6	28.2	28.5	28.0	27.3	24.6	35.0	28.2
14 R	Right superior mid mandible	24.6	24.5	25.1	28.5	23.7	21.1	28.5	21.4
15 R	Right inferior mid mandible	11.4	14.1	14.8	11.8	13.3	15.6	17.5	15.4
16 R	Right lateral eye orbit	4.4	4.8	4.2	10.5	3.7	4.3	6.5	5.4
17 R	Right anterior zygoma	8.8	8.4	7.8	7.5	6.3	8.2	9.5	8.2
18 R	Right gonion	6.8	21.1	20.0	14.5	20.7	19.6	15.5	19.0
19 R	Right root of zygoma	5.6	7.4	7.8	4.8	5.7	6.6	5.5	5.4
4 L	Left lateral nostril	19.0	9.2*	7.5*	21.5	10.3*	9.8*	22.0	10.4*
9 L	Left supraorbital	7.4	6.4*	5.3*	10.5	6.3*	5.9*	9.5	7.7*
10 L	Left suborbital	6.0	5.8*	5.8*	11.8	7.0*	6.2*	11.5	6.8*
11 L	Left supracanine	12.8	12.8*	11.9*	13.5	10.3*	10.1*	9.5	10.0*
12 L	Left subcanine	12.4	14.4*	11.5*	13.5	10.7*	10.2*	12.5	10.0*
13 L	Left posterior maxilla	28.6	28.2*	28.5*	32.8	27.3*	24.6*	33.0	28.2*
14 L	Left superior mid mandible	22.4	24.5*	25.1*	28.5	23.7*	21.1*	25.0	21.4*
15 L	Left inferior mid mandible	8.8	14.1*	14.8*	12.3	13.3*	15.6*	21.0	15.4*
16 L	Left lateral eye orbit	5.0	4.8*	4.2*	17.0	3.7*	4.3*	5.0	5.4*
17 L	Left anterior zygoma	6.6	8.4*	7.8*	10.8	6.3*	8.2*	12.0	8.2*
18 L	Left gonion	6.4	21.1*	20.0*	11.5	20.7*	19.6*	22.0	19.0*
19 L	Left root of zygoma	4.4	7.4*	7.8*	6.0	5.7*	6.6*	4.5	5.4*

FNNS = First Nations Nova Scotians

AB = "American Black" from Manhein et al. (2000)

AW = "American White" from Manhein et al. (2000)

* = Lateral measurements were taken from right side only in Manhein et al. (2000). Values are listed for comparison purposes only.

Female First Nations Nova Scotians, aged 35-45 years, had greater mean facial soft tissue depths (Table 4.5) at all but three of the 19 points reported by Manhein et al. (2000:56). Points 18 and 19 were smaller than the "American Black" values on both the right and left sides of the face, and point 15 was smaller than the "American Black" values on the left side but greater on the right side of the face (Table 4.5).

Female First Nations Nova Scotians, aged 46-55 years, have greater mean facial soft tissue depths (Table 4.5) at all but six of the 19 points reported by Manhein et al. (2000:56). Points 18 and 19 were smaller than the "American Black" values on both the right and left sides of the face. Points 13 and 15 were greater than the "American Black" values on the right side of the face, but smaller on the left. Point 12 was smaller than the "American Black" value on the right side of the face, but greater on the left. Point 11 was the same mean depth as the "American Black" value on the left side of the face, but smaller on the right (Table 4.5).

Male First Nations Nova Scotians, aged 19-34 years, had greater mean facial soft tissue depths (Table 4.6) at six of the 19 points reported by Manhein et al. (2000:56) when compared to "American Black" adults of the same sex and age group, including points 1, 3, 4 (right and left sides), 7, 9 (right and left sides), and 10 (right and left sides). The midline points 2, 5, 6 and 8 were smaller in male First Nations Nova Scotians in this age group. Points 12, 15, 18, and 19 were smaller than the "American Black" values on both the right and left sides of the face. Points 14 and 17 were greater than the "American Black" values on the right side of the face, but smaller on the left. Points 13 and 16 were smaller than the "American Black" values on the right side of the face, but greater on the

left. Point 11 was the same mean depth as the "American Black" value on the left side of the face, but greater on the right (Table 4.6).

Male First Nations Nova Scotians, aged 35-45, years had greater mean facial soft tissue depths (Table 4.6) at all but three of the 19 points reported by Manhein et al. (2000:56). Points 15 and 18 were smaller than the "American Black" values on both the right and left sides of the face. Point 19 was smaller than the "American Black" value on the right side of the face but greater on the left (Table 4.6). Comparisons of First Nations Nova Scotian adult data to "American Black" adult data, for males aged 46-55 years and females aged 56 years and above, could not be completed as this data was not collected by Manhein et al. (2000).

4.2.2 Comparison to "American White" population data

Compared to "American White" adults (Manhein et al. 2000:57), the First Nations Nova Scotian group had greater mean facial soft tissue depths (Tables 4.5 and 4.6) at the majority of points in all age groups within males and females. Female First Nations Nova Scotians, aged 19-34 years, had greater mean facial soft tissue depths at all but four of the 19 points reported by Manhein et al. (2000:57) when compared to "American White" adults of the same sex and age group. Points 18 and 19 were smaller than the "American White" values on both the right and left sides of the face. Point 15 was greater than the "American White" value on the right side of the face but smaller on the left. Point 17 was the same mean depth as the "American White" value on the right side of the face, but smaller on the left (Table 4.5).

Female First Nations Nova Scotians, aged 35-45 years, had greater mean facial soft tissue depths (Table 4.5) at all but three of the 19 points reported by Manhein et al. (2000:57). Point 18 was smaller than the "American White" value on both the right and left sides of the face. Point 15 was greater than the "American White" value on the right side of the face, but smaller on the left. Point 19 was the same mean depth as the "American White" value on the right side of the face, but smaller on the left (Table 4.5).

Female First Nations Nova Scotians, aged 46-55 years, had greater mean facial soft tissue depths (Table 4.5) at all but four of the 19 points reported by Manhein et al. (2000:57). Points 18 and 19 were smaller than the "American White" values on both the right and left sides of the face. Point 13 was greater than the "American White" values on the right side of the face, but smaller on the left. Point 15 was the same as the "American White" value on the left side of the face but greater on the right (Table 4.5).

Female First Nations Nova Scotians, aged 56 years and above, had greater mean facial soft tissue depths (Table 4.5) at all but seven of the 19 points reported by Manhein et al. (2000:57). Points 13, 15, 17, 18, and 19 were smaller than the "American White" values on both the right and left sides of the face. Point 14 was smaller than the "American White" value on the right side of the face but greater on the left. Midline point 5 was the same as to the "American White" mean tissue depth value (Table 4.5).

Male First Nations Nova Scotians, aged 19-34 years, had greater mean facial soft tissue depths (Table 4.6) at all but eight of the 19 points reported by Manhein et al. (2000:57) when compared to "American White" adults of the same sex and age group. Points 14, 15, 18, and 19 were smaller than the "American White" values on both the right and left sides of the face. Point 17 was greater than the "American White" value on

the right side of the face, but smaller on the left. Point 13 was smaller than the "American White" value on the right side of the face, but greater on the left. Midline point 5 was smaller than the "American White" mean tissue depth value, while midline point 2 was the same mean depth as the "American White" value (Table 4.6).

Male First Nations Nova Scotians, aged 35-45 years, had greater mean facial soft tissue depths (Table 4.6) at all but five of the 19 points reported by Manhein et al. (2000:57). Points 15, 18, and 19 were smaller than the "American White" values on both the right and left sides of the face. Point 17 was smaller than the "American White" value on the right side of the face, but greater on the left. Midline point 6 was also smaller in First Nations Nova Scotian adult males in this age group when compared to "American White" adult males of the same age.

Male First Nations Nova Scotians, aged 45-55 years, had greater mean facial soft tissue depths (Table 4.6) at all but five of the 19 points reported by Manhein et al. (2000:56). Points 11, 16, and 19 were greater than the "American White" values on the right side of the face but smaller on the left. Point 18 was smaller than the "American White" value on the right side of the face, but greater on the left. Midline point 2 was also smaller in First Nations Nova Scotian adult males in this age group when compared to "American White" adult males of the same age (Table 4.6). Comparisons of First Nations Nova Scotian adult data to "American White" adult data for males aged 56 years and above were not completed as data for males in this age range could not be collected in the current study.

4.3 Testing data for normality

Prior to examining the statistical significance of the differences between male and female facial soft tissue thickness in this population, the data was tested to determine if it was normally distributed. Determining how the data are distributed is an important step in deciding which statistical tests should be used in subsequent analyses. In order to test whether the data are normally distributed, probability plots were created for each of the 31 points using Minitab 15 Statistical Software. The *Kolmogorov-Smirnov* test for normality was used to produce the probability plots. These plots indicate that a distribution is normal when the p-value is above 0.05 (Figure 4.1).

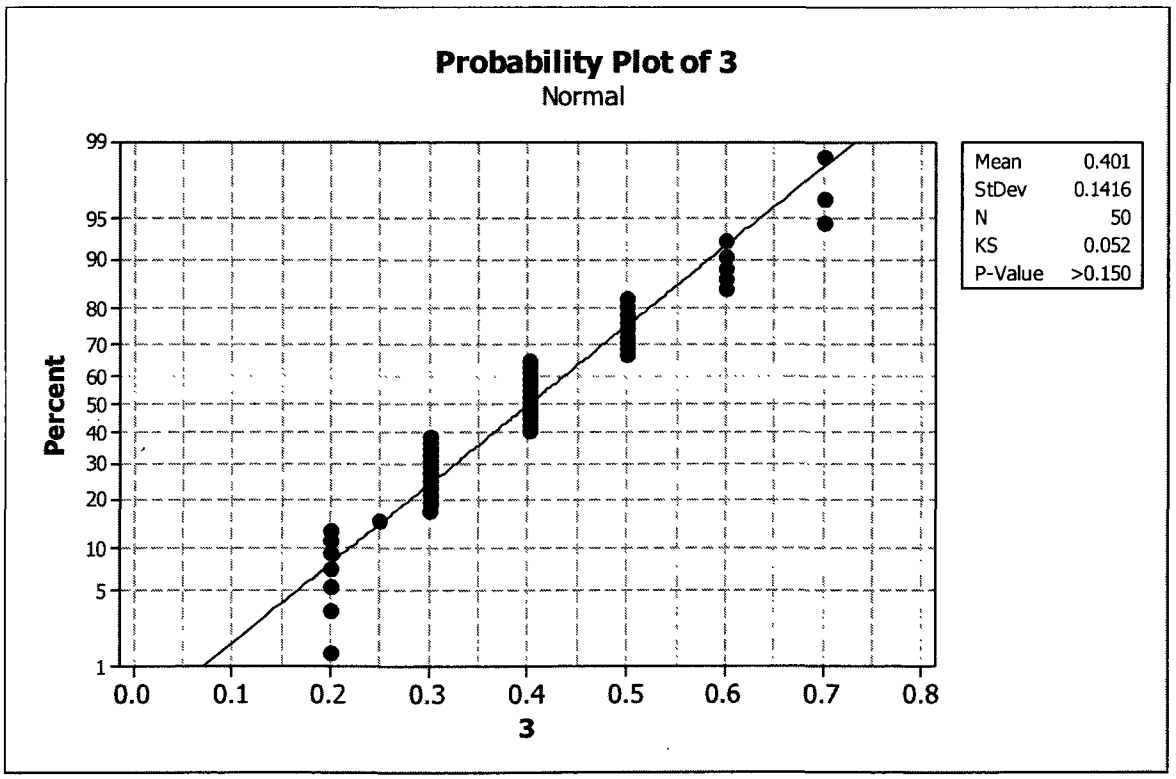

Figure 4.1. Frequency of facial soft tissue depth measurements for point 3 (end of nasals) calculated using Minitab 15 statistical software.

Using the *Kolmogorov-Smirnov* test for normality it was found that 10 (10 R, 11 R, 16 R, 17 R, 18 R, 11 L, 15 L, 16 L, 17 L, and 18 L) of the 31 points were not normally distributed across the entire study population. An additional test, the *Ryan-Joiner* test, was also performed to test the normality of the data from each of the points measured. The probability plots, produced using the *Ryan-Joiner* test, indicated that 20 (1, 6, 7, 8, 4 R, 10 R, 11 R, 12 R, 15 R, 16 R, 17 R, 18 R, 4 L, 10 L, 11 L, 15 L, 16 L, 17 L, 18 L, and 19L) of the 31 points were not normally distributed across the entire study population. The *Ryan-Joiner* test was also used to test the male and female facial soft tissue depth data separately in order to examine whether the non-normal distribution of these points was due to the pooling of male and female data. These probability plots indicated that, for males, nine (11 R, 14 R, 16 R, 18 R, 14 L, 16 L, 17 L, 18 L, and 19 L) of the 31 points were not normally distributed and, for females, 19 (5, 6, 7, 8, 4 R, 9 R, 10 R, 11 R, 15 R, 16 R, 17 R, 18 R, 4 L, 10 L, 11 L, 15 L, 17 L, 18 L, and 19 L) of the 31 points were not normally distributed. Because of the number of points that exhibited distributions that were not normal, subsequent statistical testing was performed using tests that were appropriate for nonparametric, or skewed, data.

4.4 Correlation of age with tissue depth

Because the facial soft tissue depth data for many of the points measured from this population are skewed, with a distribution that is not normal, nonparametric statistics were used in order to analyze relationships within the data (Heiman 2006:221). The *Spearman* correlation was employed to analyze the relationship between age and facial soft tissue depth as it is a nonparametric statistical test that can be used to analyze data with a skewed distribution (Heiman 2006: np). *Spearman's* correlations were calculated

for both males and females using SPSS Statistics 17.0 and were reported separately for each sex. Male data from all age groups were pooled together, as were female data, in order to examine how facial tissue depths change from the younger age ranges to the older age ranges. The only significant relationships between age and soft tissue thickness, for males across all age groups, were found at point 2 on the midline of the face (Table 4.7) and points 10 and 15 of the left side of the face (Table 4.7). The data indicate that age has an effect on the soft tissue thickness at these points at the 0.05 level of significance. No significant relationships were found between age and soft tissue thickness at points on the right side (points 4 R, 9 R, 10 R, 11 R, 12 R, 13 R, 14 R, 15 R, 16 R, 17 R, 18 R, and 19 R) of the face for males (Table 4.7).

Table 4.7 - Spearman's Correlation between facial soft tissue thickness and age of First Nations Nova Scotian male adults (N=11).

Point numbers and descriptions		P-value	Spearman's correlation
1	Glabella	0.553	0.201
2	Nasion	0.030	0.650*
3	End of nasals	0.476	0.241
5	Mid-philthrum	0.730	-0.118
6	Chin lip fold	0.257	0.374
7	Mental eminence	0.074	0.559
8	Beneath chin	0.544	0.206
4 L	Left lateral nostril	0.535	0.210
9 L	Left supraorbital	0.102	0.518
10 L	Left suborbital	0.022	0.677*
11 L	Left supracanine	0.222	-0.401
12 L	Left subcanine	0.305	0.341
13 L	Left posterior maxilla	0.061	0.581
14 L	Left superior mid mandible	0.349	0.313
15 L	Left inferior mid mandible	0.044	0.615*
16 L	Left lateral eye orbit	0.654	0.153
17 L	Left anterior zygoma	0.182	0.434
18 L	Left gonion	0.075	0.557
19 L	Left root of zygoma	0.703	0.130
4 R	Right lateral nostril	0.866	-0.058
9 R	Right supraorbital	0.328	0.326
10 R	Right suborbital	0.209	0.411
11 R	Right supracanine	0.167	-0.448
12 R	Right subcanine	0.741	-0.113
13 R	Right posterior maxilla	0.213	0.408
14 R	Right superior mid mandible	0.437	0.262
15 R	Right inferior mid mandible	0.475	0.241
16 R	Right lateral eye orbit	0.175	0.440
17 R	Right anterior zygoma	0.834	-0.072
18 R	Right gonion	0.259	0.373
19 R	Right root of zygoma	0.639	0.160

* = Correlation is significant at the 0.05 level (2-tailed)

The only significant relationship between age and soft tissue thickness for females, when all age groups are combined, was found at point 5 on the midline of the face (Table 4.8). The data indicate that age does have an effect on the soft tissue thickness at this point at the 0.05 level of significance. No significant relationships were found between age and soft tissue thickness at points on the left side of the face or points on the right side of the face for females (Table 4.8).

Table 4.8 - Spearman's Correlation between facial soft tissue thickness and age of First Nations Nova Scotian female adults (N=39).

Point numbers and descriptions		P-value	Spearman's correlation
1	Glabella	0.695	-0.065
2	Nasion	0.597	-0.087
3	End of nasals	0.323	0.163
5	Mid-philthrum	0.040	-0.330*
6	Chin lip fold	0.163	0.228
7	Mental eminence	0.578	0.092
8	Beneath chin	0.990	-0.002
4 L	Left lateral nostril	0.858	-0.030
9 L	Left supraorbital	0.718	-0.060
10 L	Left suborbital	0.519	0.106
11 L	Left supracanine	0.180	-0.219
12 L	Left subcanine	0.705	0.063
13 L	Left posterior maxilla	0.463	-0.121
14 L	Left superior mid mandible	0.235	0.194
15 L	Left inferior mid mandible	0.489	0.114
16 L	Left lateral eye orbit	0.777	-0.047
17 L	Left anterior zygoma	0.939	-0.013
18 L	Left gonion	0.685	0.067
19 L	Left root of zygoma	0.680	-0.068
4 R	Right lateral nostril	0.387	-0.143
9 R	Right supraorbital	0.994	-0.001
10 R	Right suborbital	0.720	-0.059
11 R	Right supracanine	0.197	-0.211
12 R	Right subcanine	0.325	-0.162
13 R	Right posterior maxilla	0.267	-0.182
14 R	Right superior mid mandible	0.579	-0.092
15 R	Right inferior mid mandible	0.835	0.034
16 R	Right lateral eye orbit	0.412	-0.135
17 R	Right anterior zygoma	0.611	-0.084
18 R	Right gonion	0.687	0.067
19 R	Right root of zygoma	0.310	-0.167

* = Correlation is significant at the 0.05 level (2-tailed)

An additional analysis of the relationship between age and facial soft tissue depths was performed on data from the entire study population, including males and females from all age groups (Table 4.9). As with the analysis of female data, the only significant relationship between age and soft tissue thickness was found at point 5 on the midline of the face (Table 4.9). The data indicate that age does have an effect on the soft tissue thickness at this point at the 0.05 level of significance. No significant relationships were

found between age and soft tissue thickness at points on the left side of the face or points on the right side of the face when male and female data was combined.

Table 4.9 - Spearman's Correlation between facial soft tissue thickness and age of First Nations Nova Scotian male and female adults (N=50).

Point numbers and descriptions		P-value	Spearman's correlation
1	Glabella	0.258	-0.163
2	Nasion	0.771	-0.042
3	End of nasals	0.155	0.204
5	Mid-philthrum	0.019	-0.331*
6	Chin lip fold	0.421	0.116
7	Mental eminence	0.693	0.057
8	Beneath chin	0.770	-0.042
4 L	Left lateral nostril	0.988	0.002
9 L	Left supraorbital	0.828	-0.032
10 L	Left suborbital	0.675	0.061
11 L	Left supracanine	0.136	-0.214
12 L	Left subcanine	0.919	-0.015
13 L	Left posterior maxilla	0.434	-0.113
14 L	Left superior mid mandible	0.181	0.192
15 L	Left inferior mid mandible	0.333	0.140
16 L	Left lateral eye orbit	0.965	-0.006
17 L	Left anterior zygoma	0.941	0.011
18 L	Left gonion	0.471	0.104
19 L	Left root of zygoma	0.480	0.102
4 R	Right lateral nostril	0.670	-0.062
9 R	Right supraorbital	0.841	0.029
10 R	Right suborbital	0.780	-0.040
11 R	Right supracanine	0.069	-0.259
12 R	Right subcanine	0.190	-0.188
13 R	Right posterior maxilla	0.493	-0.099
14 R	Right superior mid mandible	0.769	-0.037
15 R	Right inferior mid mandible	0.911	0.016
16 R	Right lateral eye orbit	0.602	-0.076
17 R	Right anterior zygoma	0.363	-0.131
18 R	Right gonion	0.386	0.125
19 R	Right root of zygoma	0.500	-0.098

* = Correlation is significant at the 0.05 level (2-tailed)

4.5 Comparing males and females

Although differences exist in the mean tissue depths between males and females at many of the points measured, there does not appear to be a pattern of one sex having thicker facial soft tissue than the other within the Nova Scotia First Nations population. This was evident when examining the mean facial soft tissue depths within each age group (Table 4.1). In the youngest age group, 19 to 34 years old, females had thicker mean facial soft tissue depths at 24 of the 31 points (including points 1, 2, 3, 6, 7, 8, 4 R, 9 R, 10 R, 13 R, 14 R, 15 R, 16 R, 17 R, 18 R, 4 L, 9 L, 10 L, 14 L, 15 L, 16 L, 17 L, 18 L, and 19 L) while males had thicker mean facial soft tissue depths at six of the 31 points measured (including points 5, 11 R, 19 R, 11 L, 12 L, and 13 L). The remaining point (12 R) was of equal mean thickness for males and females in this age group (Table 4.1).

In the 35 to 45 year old age group, males had thicker mean facial soft tissue depths at 15 out of 31 points measured (including points 2, 5, 9 R, 12 R, 16 R, 18 R, 9 L, 10 L, 11 L, 12 L, 13 L, 15 L, 16 L, 17 L, and 19 L) whereas females had thicker mean facial soft tissue depths at 15 out of 31 points (including points 3, 6, 7, 8, 4 R, 10 R, 11 R, 13 R, 14 R, 15 R, 17 R, 19 R, 4 L, 14 L, and 18 L). The remaining point (1) was of equal mean thickness for males and females (Table 4.1).

In the 46 to 55 year old age group, males displayed thicker mean facial soft tissue depths at 21 out of the 31 points measured (including points 1, 2, 3, 5, 6, 4 R, 9 R, 11 R, 13 R, 14 R, 15 R, 16 R, 18 R, 19 R, 9 L, 10 L, 11 L, 13 L, 15 L, 17 L, and 18 L), while females had thicker mean facial soft tissue depths at nine out of the 31 points (including points 7, 8, 10 R, 12 R, 17 R, 12 L, 14 L, 16 L, and 19 L). The remaining point (4 L) was of equal mean thickness for males and females (Table 4.1).

A similar trend was seen in the median tissue depths for the same age groups of males and females (Table 4.2). In the youngest age group, 19 to 34 years old, females had thicker median facial soft tissue depths at 17 out of the 31 points measured (including points 3, 7, 8, 4 R, 9 R, 10 R, 13 R, 15 R, 16 R, 18 R, 4 L, 9 L, 10 L, 15 L, 16 L, 18 L, and 19 L) while males had thicker median facial soft tissue depths at only six out of the 31 points (including points 5, 12 R, 14 R, 17 R, 11 L, and 14 L). The remaining eight points (1, 2, 6, 11 R, 19 R, 12 L, 13 L, 17 L) were of equal median tissue thickness for males and females (Table 4.2).

In the 35 to 45 year old age group, males had thicker median facial soft tissue depths at 16 out of 31 points measured (including points 2, 5, 9 R, 12 R, 16 R, 18 R, 19 R, 9 L, 10 L, 11 L, 12 L, 13 L, 14 L, 15 L 16 L, and 19 L), whereas females had thicker median facial soft tissue depths at 13 out of the 31 points (including points 3, 6, 7, 8, 4 R, 10 R, 11 R, 13 R, 14 R, 15 R, 17 R, 4 L, and 17 L). The remaining two points (1 and 18 L) were of equal median tissue thickness for males and females (Table 4.2).

In the 46 to 55 year old age group, males displayed thicker median facial soft tissue depths at 23 out of the 31 points measured (including points 2, 3, 5, 8, 4 R, 9 R, 10 R, 11 R, 13 R, 14 R, 15 R, 16 R, 18 R, 19 R, 4 L, 9 L, 10 L, 11 L, 13 L, 15 L, 17 L, 18 L, and 19 L), while females had thicker median facial soft tissue depths at only six of the 31 points (including points 7, 12 R, 17 R, 12 L, 14 L, and 16 L) and the remaining two points (1 and 6) were of equal median thickness for males and females (Table 4.2).

The current facial soft tissue depth data was not normally distributed for many of the points measured. Because of the lack of normal distribution, it was determined that a *Mann-Whitney* U test would be used to analyze the relationship between male and female

facial soft tissue depth measurements. The *Mann-Whitney* U test can be used to compare two independent samples of nonparametric data (Heiman 2006:np). As this data was not normally distributed, it was appropriate to use nonparametric testing techniques for the statistical analyses (Heiman 2006:221). Minitab 15 Statistical Software was used to test the difference between the male facial soft tissue depth measurements and the female facial soft tissue depth measurements. The *Mann-Whitney* U test indicated that a significant difference existed between males and females at only one point (point 5, mid-philthrum) (Table 4.10). The p-value for point 5 was 0.0027. As the p-value for this point was less than 0.05, a significant difference existed between the male and female facial soft tissue depths at the mid-philthrum point. None of the other 30 points were found to be significantly different between male and female First Nations Nova Scotians.

Table 4.10 - Mann-Whitney test comparing measurements of facial soft tissue depth from adult male and female aboriginal Nova Scotians

Point numbers and descriptions		Male Medians (N=11)	Female Medians (N=39)	W statistic	P-value
1	Glabella	6.000	6.000	299.0	0.6640
2	Nasion	7.000	6.000	316.0	0.4020
3	End of nasals	4.000	4.000	257.5	0.5906
5	Mid-philthrum	12.000	9.000	408.0	0.0027*
6	Chin lip fold	12.000	13.000	245.0	0.4045
7	Mental eminence	14.000	14.500	217.0	0.1382
8	Beneath chin	9.000	10.000	242.5	0.3771
4 R	Right lateral nostril	22.000	23.000	218.0	0.1451
9 R	Right supraorbital	8.000	8.000	272.0	0.8500
10 R	Right suborbital	8.000	9.000	212.0	0.1096
11 R	Right supracanine	12.000	12.000	306.5	0.5484
12 R	Right subcanine	14.000	13.000	301.0	0.6369
13 R	Right posterior maxilla	28.000	31.000	240.0	0.3482
14 R	Right superior mid mandible	29.000	27.000	284.5	0.9345
15 R	Right inferior mid mandible	11.000	12.000	258.0	0.6057
16 R	Right lateral eye orbit	5.000	5.000	251.5	0.4950
17 R	Right anterior zygoma	7.000	7.500	250.5	0.4861
18 R	Right gonion	8.000	11.000	227.0	0.2132
19 R	Right root of zygoma	5.000	4.500	334.0	0.1996
4 L	Left lateral nostril	20.000	22.500	216.0	0.1324
9 L	Left supraorbital	9.000	7.500	351.5	0.0953
10 L	Left suborbital	9.000	10.000	256.0	0.5729
11 L	Left supracanine	12.000	11.000	344.5	0.1333
12 L	Left subcanine	13.000	12.000	294.0	0.7588
13 L	Left posterior maxilla	30.000	28.000	331.5	0.2360
14 L	Left superior mid mandible	25.000	27.000	252.0	0.5114
15 L	Left inferior mid mandible	11.000	10.000	287.5	0.8786
16 L	Left lateral eye orbit	5.000	6.000	302.5	0.6048
17 L	Left anterior zygoma	7.000	7.000	255.5	0.5627
18 L	Left gonion	8.000	9.000	258.5	0.6135
19 L	Left root of zygoma	5.000	4.500	289.0	0.8478

* = Difference is significant at the 0.05 level (2-tailed)

4.6 Estimation of error rate

Intra-observer error was assessed by estimating the error rate associated with repeated measurements by the same person. Five of the study participants were measured twice with the author repeating all 31 measurements on each individuals face. These measurements were then complied in an Excel spreadsheet and the differences between each set of measurements, for each participant, were calculated (Table 4.11).

Table 4.11 – Mean differences between repeated measurements (mm) of five participants.

	Participant ID#				
	012	048	049	050	052
Mean difference between repeated measurements	4.1	2.8	1.4	1.4	1.1

A total mean difference between the first and second set of measurements, for all five participants, was calculated to be 2.2 mm. The standard deviation associated with this mean error rate was calculated to be 3.5 mm. Therefore, the error rate associated with measuring was estimated by the author as being 5.7 mm, the sum of 2.2 mm and 3.5 mm (Table 4.12).

Table 4.12 - Estimate of measurement error.

Total mean difference	2.2 mm
Standard Deviation	3.5 mm
Estimate of error	5.7 mm

The author used this estimate of error in a general assessment of facial soft tissue depth asymmetry, as the standard deviation of repeated measurements can be used to estimate measurement error (Bland and Altman 1996:744). If a difference between left and right measurements was more than 5.7 mm than an asymmetry was identified at that point for the individual being measured. If a difference between left and right

measurements was equal to or less than 5.7 mm, than an asymmetry was not identified, as it falls within a standard deviation of the mean. It should be noted that this approach was only used to estimate the general trends in asymmetry in this population, and that a statistical analysis of asymmetry was also performed.

4.7 Analysis of asymmetry

Bi-lateral measurements (points 4, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19) from each participant were compared and the differences were calculated for each point. As a general assessment of asymmetry, differences were attributed to asymmetry when they exceeded the estimated error rate of 5.7 mm. This was because differences below this amount could be attributed to measurement error, as they fall below the estimated error rate (Table 4.13).

Table 4.13 - Comparison of bi-lateral measurements for participant #024.

ID#	Point numbers and location	Right (mm)	Left (mm)	Difference (mm)	Thicker Side	Difference greater than error?
024	**4** Lateral nostril	30	29	1	R	No
	9 Supraorbital	12	9	3	R	No
	10 Suborbital	20	15	5	R	No
	11 Supracanine	17	10	7	R	Yes
	12 Subcanine	20	13	7	R	Yes
	13 Posterior maxilla	31	30	1	R	No
	14 Superior mid mandible	29	32	3	L	No
	15 Inferior mid mandible	23	10	13	R	Yes
	16 Lateral eye orbit	7	6	1	R	No
	17 Anterior zygoma	21	18	3	R	No
	18 Gonion	21	9	12	R	Yes
	19 Root of zygoma	7	7	0		No

Only six of the participants displayed more than three points that were significantly different. Of the six participants that did display more than two or three significant differences between bilateral measurements, only one (#024) displayed a

marked pattern of asymmetry. There did not appear to be a clearly dominant, or thicker, side of the face for the rest of the participants. Even when several points displayed a bi-lateral difference in a single individual, the thicker points were rarely all from one side. One of the best examples of asymmetry observed in this study was exhibited by participant #024 who displayed a significant difference at four (11, 12, 15, and 18) of the twelve bilateral points. All four of the points were thicker on the right side of her face (Table 4.13). Four participants (#007, #017, #037, and #041) also displayed significant differences at four of the twelve bi-lateral points with some points being thicker on the left side and some points thicker on the right side of the face (Table 4.14).

Table 4.14 - Comparison of bi-lateral measurements for participants #007,#017,#037, and #041.

ID#	Point numbers and location	Right (mm)	Left (mm)	Difference (mm)	Thicker Side	Difference greater than error?
007	**4** Lateral nostril	22	22	0		No
	9 *Supraorbital*	7	5	2	R	No
	10 Suborbital	7	10	3	L	No
	11 Supracanine	18	24	6	L	Yes
	12 Subcanine	12	12	0		No
	13 Posterior maxilla	36	27	9	R	Yes
	14 Superior mid mandible	34	24	10	R	Yes
	15 Inferior mid mandible	24	10	14	R	Yes
	16 Lateral eye orbit	5	5	0		No
	17 Anterior zygoma	10	8	2	R	No
	18 Gonion	7	8	1	L	No
	19 Root of zygoma	8	5	3	R	No
017	**4** Lateral nostril	28	35	7	L	Yes
	9 Supraorbital	7	6	1	R	No
	10 Suborbital	16	15	1	R	No
	11 Supracanine	12	11	1	R	No
	12 Subcanine	13	15	2	L	No
	13 Posterior maxilla	42	28	14	R	Yes
	14 Superior mid mandible	38	38	0		No
	15 Inferior mid mandible	21	6	15	R	Yes
	16 Lateral eye orbit	6	7	1	L	No
	17 Anterior zygoma	7	15	8	L	Yes
	18 Gonion	8	6	2	R	No
	19 Root of zygoma	6	6	0		No
037	**4** Lateral nostril	24	23	1	R	No
	9 Supraorbital	9	10	1	L	No
	10 Suborbital	15	9	6	R	Yes
	11 Supracanine	10	10	0		No
	12 Subcanine	16	13	3	R	No
	13 Posterior maxilla	32	16	16	R	Yes
	14 Superior mid mandible	24	22	2	R	No
	15 Inferior mid mandible	18	10	8	R	Yes
	16 Lateral eye orbit	5	6	1	L	No
	17 Anterior zygoma	7	7	0		No
	18 Gonion	7	17	10	L	Yes
	19 Root of zygoma	6	5	1	R	No
041	**4** Lateral nostril	17	18	1	L	No
	9 Supraorbital	8	8	0		No
	10 Suborbital	13	6	7	R	Yes
	11 Supracanine	28	9	19	R	Yes
	12 Subcanine	13	12	1	R	No
	13 Posterior maxilla	23	40	17	L	Yes
	14 Superior mid mandible	20	22	2	L	No
	15 Inferior mid mandible	12	16	4	L	No
	16 Lateral eye orbit	4	4	0		No
	17 Anterior zygoma	12	6	6	R	Yes
	18 Gonion	24	20	4	R	No
	19 Root of zygoma	3	3	0		No

One participant (#001) also displayed a significant difference at five (4, 13, 16, 17, and 18) of the twelve points. Some of these points were thicker on the left side and some points were thicker on the right side of the face (Table 4.15).

Table 4.15 - Comparison of bi-lateral measurements for participant #001.

ID#	Point numbers and location	Right (mm)	Left (mm)	Difference (mm)	Thicker Side	Difference greater than error?
001	**4** Lateral nostril	15	23	8	L	Yes
	9 Supraorbital	13	12	1	R	No
	10 Suborbital	13	13	0		No
	11 Supracanine	11	15	4	L	No
	12 Subcanine	14	15	1	L	No
	13 Posterior maxilla	12	30	18	L	Yes
	14 Superior mid mandible	25	24	1	R	No
	15 Inferior mid mandible	19	22	3	L	No
	16 Lateral eye orbit	4	28	24	L	Yes
	17 Anterior zygoma	13	26	13	L	Yes
	18 Gonion	21	9	12	R	Yes
	19 Root of zygoma	5	9	4	L	No

Before statistically analyzing the differences between the left and right facial soft tissue depth measurements, an additional test for normality was performed on the values of the differences between the left and right measurements for each participant. For each bilateral point (4, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19), of each volunteer, the left measurement was subtracted from the right measurement. The differences between the left and right measurements were then tested for normality using Minitab 15 Statistical Software. A *Ryan-Joiner* test for normality indicated that the differences between left and right measurements from eight (4, 9, 11, 15, 16, 17, 18, and 19) of the 12 bilateral points (4, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19), did not have a normal distribution.

The nonparametric *Wilcoxon* paired signed rank test was used to compare the left and right measurements, as it is a nonparametric statistic that can be used to compare two related samples of data that are not normally distributed (Heiman 2006: np). This analysis was performed using data from all participants and combining data from both sexes and all age groups. The statistical analysis revealed that a significant difference existed between the left side and right side measurements, in First Nations Nova Scotians, at only two points out of the 12 bi-lateral points measured (Table 4.16). Point 15 (inferior mid

mandible), with a p-value of 0.042, and point 18 (Gonion), with a p-value of 0.037, are significantly different in terms of left and right side measurements in this population.

Table 4.16 - Wilcoxon paired signed rank test analysis of differences between right and left measurements of facial soft tissue depth from adult male and female Aboriginal Nova Scotians (N=50).

Point numbers and descriptions		Wilcoxon Statistic	P-value	Estimated median	Significant Difference?
4	Lateral nostril	518.5	0.406	0.05	no
9	Supraorbital	409.5	0.124	0.05	no
10	Suborbital	421.5	0.712	0.00	no
11	Supracanine	561.0	0.291	0.05	no
12	Subcanine	544.5	0.141	0.05	no
13	Posterior maxilla	646.5	0.249	0.10	no
14	Superior mid mandible	577.0	0.342	0.05	no
15	Inferior mid mandible	669.5	0.042	0.10	yes
16	Lateral eye orbit	342.0	0.894	0.00	no
17	Anterior zygoma	443.5	0.460	0.05	no
18	Gonion	674.5	0.037	0.10	yes
19	Root of zygoma	311.5	0.741	0.00	no

In addition to performing the statistical analyses of asymmetry, a review of the pooled mean facial soft tissue depth data from the entire study population, including all males and females from all age groups (Table 4.3), revealed that the differences between the mean values of left and right measurements were minimal (4 lateral nostril = 0.2 mm, 9 supraorbital = 0.5 mm, 10 suborbital = 0.1 mm, 11 supracanine = 0.9 mm, 12 subcanine = 0.5 mm, 13 posterior maxilla = 1.3 mm, 14 superior mid mandible = 0.5 mm, 15 inferior mid mandible = 1.7 mm, 16 lateral eye orbit = 0.2 mm, 17 anterior zygoma = 0.1 mm, 18 gonion = 0.8 mm, and 19 root of zygoma = 0.1 mm).

A similar trend was seen when examining the pooled median facial soft tissue depth data from the entire study population, including all males and females from all age groups (Table 4.4). The median values for only one (9 supraorbital) of the 12 bilateral landmarks were identical on the right and left side. The differences between the left and right side median values for the other 11 landmarks were minimal (4 lateral nostril = 1.0

mm, 10 suborbital = 1.0 mm, 11 supracanine = 1.0 mm, 12 subcanine = 1.0 mm, 13 posterior maxilla = 0.5 mm, 14 superior mid mandible = 0.2 mm, 15 inferior mid mandible = 2.0 mm, 16 lateral eye orbit = 0.5 mm, 17 anterior zygoma = 0.3 mm, 18 gonion = 0.3 mm, and 19 root of zygoma = 0.2 mm).

Chapter 5: Discussion

5.1 The context for the current project

Forensic 3-D facial reconstruction has proven to be a useful tool in identification of skeletal remains when other methods, such as dental comparisons and DNA analysis, are not feasible (De Greef et al. 2006:S126; Starbuck and Ward 2007:130). Reconstructions are made available to the public who may be able to help identify the individual. While "they are not sufficient evidence of a positive identification for use in a court of law" (Tyrell et al. 1997:653), forensic 3-D facial reconstructions can help narrow the focus of an investigation. Potential leads may then be ruled out, or a positive identification may be made, using ante-mortem data (Snow et al. 1970:226; Tyrrell et al. 1997).

More than a century of research has lead to the collection of facial soft tissue depth data for a number of modern population groups around the world (Codinha 2009; De Greef et al. 2006; Domaracki and Stephan 2006; El-Mehallawi and Soliman 2001; Manhein et al. 2000; Phillips and Smuts 1996; Sahni et al. 2008). Initial methods involved the measurement of tissues from cadavers (Tyrrell et al. 1997), and while this method is still used by some researchers (Codinha 2009; Domaracki and Stephan 2006; Rhine and Campbell 1980; Rhine and Moore 1984), others point out that in-vivo measurements are more appropriate for this type of data collection as the aim is to recreate the face of an unknown individual as they appeared in life (Aulsebrook et al. 1996:83-84; Galdames et al. 2008; Garlie and Saunders 1999:61; Phillips and Smuts 1996:52; Prag and Neave 1997:18-19; Starbuck and Ward 2007:131; Tyrrell et al. 1997; Wilkinson 2004:129).

The current study provides in-vivo facial soft tissue depth data collected from First Nations Nova Scotian adults. Although many researchers indicate that asymmetry of the face is minimal, no such analysis exists for Canadian First Nations peoples. Facial soft tissue depth databases are generally created using data from only one side of the face since facial asymmetry has been deemed minimal by some researchers (De Greef et al. 2006; Manhein et al. 2000). The current study, in measuring seven mid-line points and 12 bi-lateral points on the faces of 50 adult participants, investigates whether measuring only one side of the face is sufficient for use in forensic 3-D facial reconstructions. This provides useful data for a population group that is not represented in the current literature.

Stephan and Simpson (2008:1266) offer a set of guidelines for improving the quality of facial soft tissue depth research. An effort was made to follow these guidelines throughout this study. This was accomplished by avoiding the selection of participants based on specific body mass index categories, reporting the median values of facial soft tissue depth as well as the mean values, reporting an estimate of error associated with the measurement technique, using a set of data points already tested and reported in previous studies (Manhein et al. 2000), and storing raw data for possible use in future studies.

5.2 Reporting First Nations Nova Scotian adult data

The current facial soft tissue depth data was reported in separate age and sex groupings, according to the protocol outline by Manhein et al. (2000). The data was also presented with sex and age groups collapsed to provide insight into trends within the population as a whole. In an effort to ensure that the current data could be compared, the

mean tissue depth values were reported for the same age and sex groupings as reported by Manhein et al. (2000) (Table 4.1). In addition, a collapsed group containing data from all participants, i.e. males and females and all age groups, was also reported (Table 4.3) as some research suggests that facial soft tissue depth data should be reported as broadly as possible (Stephan and Simpson 2008:1266). Median values were calculated for males and females as well as collapsed data which includes all males and females from all age groups; previous studies indicate that facial soft tissue depth data often has a skewed distribution and should be reported with descriptive statistics other than mean values alone (Domaracki and Stephan 2006:9; Stephan and Simpson 2008:1266). This also fulfilled the second provision of Stephan and Simpson (2008:1266) which outlines the need for more descriptive statistics of facial soft tissue depth measurements.

Body mass index (BMI) is used in some studies to further subcategorize data (Codinha 2009; De Greef et al. 2006). A study by Deurenderg et al. (1998) explains that BMI indices do not translate well from one population group to another. The first provision outlined by Stephan and Simpson (2008:1266) recommends that "individuals should not be excluded according to their body build". In keeping with this provision, data was reported for all participants measured in the present study, and no participants were denied participation based on body build. The BMI of each participant was, however, calculated in order to assess the general BMI range of the study population. The body mass index for each participant in the current study was calculated according to Health Canada guidelines for body weight classification in adults. However, as stated in this study, the "population studies used to develop the body weight classification system were derived from predominantly Caucasian populations from the USA and Europe"

(Health Canada guidelines for body weight classification in adults, n.d.). The results of the BMI calculation for the current population (Appendix B) demonstrated that 41 out of 50 participants were either overweight or obese. However, studies have reported that "First Nations Canadians have a greater incidence of obesity, diabetes and related metabolic disorders than the general population" (Katzmarzyk and Malina 1998:1130). It is therefore not surprising to find that the BMI values are quite high in this study group, as the calculation is based on a system derived from populations known to have lower BMI in general. What is 'normal' for First Nations populations would not translate to what is 'normal' for the Caucasian populations on which the system was based.

The same can be said for the populations participating in the study by Manhein et al. (2000). Although Manhein et al. (2000) selected participants that were deemed to fall within a 'normal' BMI range (Manhein et al. 2000:49), the determination of who was within the 'normal' BMI range was based on a visual assessment (Manhein et al. 2000:49). Just as First Nations Canadians have been shown to have higher obesity rates than the general Canadian population (Katzmarzyk and Malina 1998:1130), populations in the Southern United States have higher obesity rates than the general American population (Menifield et al. 2008:83). What might be considered 'normal' body morphology in this area of the United States would not translate to typical BMI standards. Manehin et al. (2000) collected data from individuals in the Southern state of Louisiana, and a 'normal' BMI in this area would not reflect a 'normal' BMI from other populations.

The comparison of facial soft tissue depth data between First Nations Nova Scotians and the Amercian "Black" and "Caucasian" populations from Manhein et al.

(2000) is warranted based on similar trends in body mass within these population groups. Additionally, when data from the 2004 Canadian Community Health Survey was compared to data from the United States from 1999-2002, obesity rates in adults (aged 18 years and older) were found to be significantly higher in the United States (Tjepkema 2005:4). Although Data collection for the Canadian Community Health Survey did not include individuals on First Nations reserves, it did include a total of 1528 Aboriginal Canadians who lived off reserve (Canadian Community Health Survey Cycle 2.2, 2004). This further supports the notion that the 'normal' participants selected for in Manhein et al. (2000) would be higher on a BMI scale than the general Canadian population, as would First Nation Canadians, as previously shown (Katzmarzyk and Malina 1998:1130). It was because of the similar BMI trends in these populations, as well as the use of the same measurement protocol, that it was deemed appropriate by the author to compare data from First Nations Nova Scotians with data from Amercian "Black" and "Caucasian" populations collected by Manhein et al. (2000).

It is helpful to compare facial soft tissue depth data between population groups in order to better understand how soft tissue depths differ between different populations. Stephan and Simpson (2008:1266) stated that the differences were small between population groups examined in their study. The current study represents the first opportunity to compare facial soft tissue depth data from First Nations Nova Scotian adults to data from other geographically separate population groups.

5.3 Comparison with other population groups

Rhine (1983) recorded facial soft tissue depth measurements for a Southwestern American First Nations population group. This facial soft tissue depth data is likely the most closely related, of all population data currently available, to the current First Nations Nova Scotian data. However, in collecting this data, Rhine used techniques very different from those in the current study. Cadavers were measured instead of living subjects (personal communication July 8, 2010), using the needle puncture method to record the depth to which a needle inserted into the soft tissue would travel before striking the underlying bone. Only adults were measured in this study, but no categorization by age was undertaken (personal communication July 8, 2010). Due to the differences in data organization between the current study and the data recorded by Rhine (1983), and the differences in measurement techniques used to collect the data, facial soft tissue depths for these population groups were not compared. The author instead focused on comparing data from population groups that had been collected using the same methodology. Data from the current study was compared to data from "American Black" adults and "American White" adults collected by Manhein et al (2000:56-57).

As raw data from the Manhein et al. (2000) study was unavailable, statistical analyses were not possible. However, comparisons were made between the mean values reported by Manhein et al. (2000) and those reported in the current study (Tables 4.5 and 4.6). Manhein et al. (2000:50) report that the locations with the greatest standard deviations and ranges for facial soft tissue depth were points 13 (posterior maxilla), 14 (superior mid mandible), 15 (inferior mid mandible), and 18 (gonion). This was true for both "American Black" adults and "American White" adults. The same was true for the

current study (Table 4.3). These four points (on both the right and left side of the face) had the greatest standard deviations (7.16 mm and above) and ranges (28 mm and above). Point 4 (lateral nostril), with a standard deviation of 5.44 mm on the right side and 4.89 mm on the left side, as well as a range of 32 mm on the right side and 28 mm on this left side, also displayed high variability in facial soft tissue depth within First Nations Nova Scotians. Points 4, 13, and 14 were within the fleshy cheek region of the face and displayed larger mean and median values (Tables 4.3 and 4.4). Points 15 and 18 were not in particularly fleshy areas and had smaller mean and median values (Tables 4.3 and 4.4).

When comparing mean facial soft tissue depths from the two American groups (Manhein 2000:56-57) and the First Nations Nova Scotian group (Tables 4.5 and 4.6), the points that displayed the greatest differences in tissue depth were points 4, 14 and 18. Mean tissue depth values at point 4 differed by as much as 15.9 mm between First Nations Nova Scotian adult females and "American Black" adult females with First Nations Nova Scotian females exhibiting thicker soft tissue (Table 4.5). Mean tissue depth values at point 4 differed by as much as 12 mm between First Nations Nova Scotian adult males and "American Black" adult males with First Nations Nova Scotian males exhibiting thicker soft tissue (Table 4.6).

Mean tissue depth values at point 14 differed by as much as 9.1 mm between First Nations Nova Scotian adult females and "American Black" adult females with First Nations Nova Scotian females exhibiting thicker soft tissue (Table 4.5). Mean tissue depth values at point 14 differed by as much as 4.8 mm between First Nations Nova Scotian adult males and "American Black" adult males with First Nations Nova Scotian males exhibiting thicker soft tissue (Table 4.6).

Mean tissue depth values at point 18 differed by as much as 5.1 mm between First Nations Nova Scotian adult females and "American Black" adult females with "American Black" females exhibiting thicker soft tissue (Table 4.5). Mean tissue depth values at point 18 differed by as much as 14.7 mm between First Nations Nova Scotian adult males and "American Black" adult males with "American Black" males exhibiting thicker soft tissue (Table 4.6).

Mean tissue depth values at point 4 differed by as much as 16.2 mm between First Nations Nova Scotian adult females and "American White" adult females with First Nations Nova Scotian females exhibiting thicker soft tissue (Table 4.5). Mean tissue depth values at point 4 differed by as much as 13.7 mm between First Nations Nova Scotian adult males and "American White" adult males with First Nations Nova Scotian adults exhibiting thicker soft tissue (Table 4.6).

Mean tissue depth values at point 14 differed by as much as 9.4 mm between First Nations Nova Scotian adult females and "American White" adult females with First Nations Nova Scotian females exhibiting thicker soft tissue (Table 4.5). Mean tissue depth values at point 14 differed by as much as 7.4 mm between First Nations Nova Scotian adult males and "American White" adult males with First Nations Nova Scotian males exhibiting thicker soft tissue (Table 4.6).

Mean tissue depth values at point 18 differed by as much as 5.5 mm between First Nations Nova Scotian adult females and "American White" adult females with "American White" females exhibiting thicker soft tissue (Table 4.5). Mean tissue depth values at point 18 differed by as much as 13.6 mm between First Nations Nova Scotian

adult males and "American White" adult males with "American White" males exhibiting thicker soft tissue (Table 4.6).

Stephan and Simpson (2008) report that mean facial soft tissue depth values do not differ by a significant amount between population groups. However, the comparison between First Nations Nova Scotian adult data and "American Black" adult and "American White" adult data, published by Manhein et al. (2000), revealed that differences do in fact exist between these populations. The general trend seen in this comparison is that facial soft tissue is thicker in First Nations Nova Scotians than in both American populations. Some of the more pronounced differences between these populations are seen at point 4 (lateral nostril), which was thicker in First Nations Nova Scotians than in both American populations, as well as point 14 (superior mid-mandible) to a lesser degree. These differences indicate that the region of the face from beside the nose to the mid-cheek region, tends to be thicker in First Nations Nova Scotians.

Conversely, facial soft tissue at point 18 (gonion) was thinner in First Nations Nova Scotians than in both American populations, although this trend appears to be more pronounced in males than in females. This is important information for forensic artists, who depend on population specific data to create representative 3-D facial reconstructions. Ongoing data collection for First Nations groups will serve to clarify the differences that exist between this population and other populations worldwide.

5.4 Correlation of age with tissue depth

Stephan and Simpson (2008:1266) recommend that facial soft tissue depth data be reported as broadly as possible with no subcategorization by age. In their analysis of facial soft tissue depth data, Manhein et al. (2000:55) report that a significant relationship exists between age and tissue depth at five of the 19 points measured for "American Black" adults aged 19-55 (male and female data combined) and at eight of the 19 points for "American White" adults aged 19-55 (male and female data combined). This suggests that subcategorization of data by age groups is warranted, as there are age related differences in facial soft tissue depth for these populations. An analysis of age related changes of facial soft tissue depth in First Nations Nova Scotians, with male and female data combined, showed that a significant relationship exists between age and tissue thickness at only one of the 31 points measured (Table 4.9). According to this analsyis, point 5 (mid-philthrum; p-value 0.019; *Spearman's* correlation -0.331), with a negative *Spearman's* correlation value, decreases in facial soft tissue depth with age for males and females in this population.

An analysis of facial tissue depth data from First Nations Nova Scotian male and female adults (analyzed separately) showed that a significant relationship exists between age and tissue thickness at only three of the 31 points measured for males (Table 4.7) and at only one of the 31 points for females (Table 4.8). The three tissue depth points that display a significant relationship with age, for males, include point 2 (nasion; p-value 0.030; *Spearman's* correlation 0.650), point 10 L (left suborbital; p-value 0.022; *Spearman's* correlation 0.677), and point 15 L (left inferior mid mandible; p-value 0.044; *Spearman's* correlation 0.615). The positive *Spearman's* correlation values indicate that

facial soft tissue depths, at these points, tend to increase with age. The point that displays a significant relationship with age, for females, is point 5 (mid-philthrum; p-value 0.040; *Spearman's* correlation -0.330). The negative *Spearman's* correlation value indicates that the facial soft tissue depth at this point tends to decrease with age. The remaining p-values indicate that there is no significant relationship between facial soft tissue thickness and age at any other points measured for males and females.

With only one point exhibiting a significant relationship with age for the entire study population (with male and female data combined), and only three points and one point exhibiting a significant relationship with age for separate male and female data respectively, there is support for the data being reported without subcategorization by age (Stephan and Simpson 2008:1266). When separated into age groups, many of the male and female First Nations Nova Scotian adult age categories have a very small number of participants (Table 4.1) which weakens the reliability of statistical tests. The strength of statistical testing is increased when the data is collapsed as it increases the sample size. For example, collapsing data into male and female groups with no age categories creates a group with 11 individuals (males) and 39 individuals (females) as opposed to the much smaller age specific groups (Table 4.1).

It should also be noted that Manhein et al. (2000:55) use the Pearson's correlation to analyze the relationship between facial soft tissue thickness and age. This statistical test is more suited to the analysis of parametric or normally distributed data (Heiman 2006:np). Previous studies demonstrate that facial soft tissue depth data is often nonparametric with distributions that are skewed or not normal (Domaracki and Stephan 2006:9; Stephan and Simpson 2008:1266). Tests for normality indicate that facial soft

tissue depth for First Nations Nova Scotian adults is in fact not normally distributed, therefore the more appropriate nonparametric *Spearman's* correlation is calculated in order to analyze the relationship between facial soft tissue thickness and age.

5.5 Comparing males and females

A comparison of male and female facial soft tissue depth in a population of adult Egyptians reveals sexual dimorphism in the thickness of facial soft tissues with females exhibiting greater soft tissue thickness than males in the eye, check, lip, chin and jaw regions (El-Mahallawi and Soliman 2001:106) . Codinha (2009:80.e3) found that adult Portuguese males have significantly thicker facial soft tissue than adult Portuguese females around the mouth and chin regions. Domaracki and Stephan (2006:9), in a study of Australian adults, conclude that males and females differ in facial soft tissue depth at several points but that none of these differences are statistically significant. The varied reports of sexual dimorphism in different population groups suggests that a statistical evaluation of the relationship between sex and facial soft tissue depth is warranted for populations that have not previously been studied.

A comparison of adult male and female First Nations Nova Scotian mean data (Table 4.1) revealed that males had thicker facial soft tissue at points 5 (mid-philthrum), 11 L (left supracanine), and 13 L (left posterior maxilla) in every age grouping while females had thicker facial soft tissue at points 8 (beneath chin) and 14 L (left superior mid mandible) in every age grouping. A comparison of adult male and female First Nations Nova Scotian median data (Table 4.2) revealed that males had thicker facial soft tissue at points 5 (mid-philthrum) and 11 L (left supracanine) in every age grouping while

females had thicker facial soft tissue at point 7 (beneath chin) in every age grouping. Comparing male and female data from the individual age groupings, however, is problematic due to the small number of participants within some of the groups (Tables 4.1 and 4.2). For this reason, and because the *Spearman's* correlation analysis revealed that few points display a significant relationship between facial soft tissue thickness and age, the statistical analysis of the relationships between male and female facial soft tissue thickness was reported using data that is collapsed, with no subcategorization by age.

Stephan and Simpson (2008:1265-1266) report that facial soft tissue depth data can be skewed and that this affects the way in which the data should be reported. The statistical analysis of skewed data, which is not normally distributed, requires the use of statistical tests that do not make the assumption of normality. The *Mann-Whitney* U test is used in the current study to analyze the relationship between male and female facial soft tissue depth values. Normality tests indicate that the facial soft tissue depth data is skewed with a distribution that is not normal. The *Mann-Whitney* U test is used based on its ability to compare two independent samples of nonparametric data (Heiman 2006:np).

The *Mann-Whitney* U test, performed on the collapsed age data for First Nations Nova Scotian males and females, indicated that a significant difference existed between males and females at point 5 (mid-philthrum) only (Table 4.10). Manhein et al. (2000:58), using the ANOVA statistical test, also found a significant difference between males and females at this point for both the "American Black" and "American White" populations. These populations, however, displayed a great deal more variability between the sexes than the First Nations Nova Scotian population. The "American Black" population displayed a significant difference between male and female facial soft tissue

depth values at 10 of the 19 points measured (Manhein et al. 2000:58). The "American White" population displayed a significant difference between male and female facial soft tissue depth values at 11 of the 19 points measured (Manhein et al. 2000:58). The recommendation by Stephan and Simpson (2008:1266) that facial soft tissue depth data be reported as broadly as possible is supported, for First Nations Nova Scotians, by the fact that there is very little affect by age and sex on facial soft tissue depth.

5.6 Measurement error

The third provision outlined by Stephan and Simpson (2008:1266) highlights the importance of calculating error rates for facial soft tissue depth measurement techniques. An estimate of error for the ultrasonic measurement technique used in this study was calculated using the standard deviation of repeated measurements as an estimate of measurement error (Bland and Altman 1996:744). Although the error rate was estimated by the author to be 5.7 mm (Table 4.12), the repeated measurement of five individuals demonstrates that measurement error is random. Repeated measurements occasionally read slightly larger than the first measurements of the same point, and occasionally slightly smaller. The errors therefore average out over the course of measuring multiple participants and when calculating mean and median values for facial soft tissue depth.

Minimizing the intra-observer error associated with this ultrasonic measurement technique can be achieved by practicing landmark location and by following the descriptions provided by Manhein et al (2000) for locating the correct anatomical points to be measured. Inter-observer error can be minimized, or eliminated, by ensuring that the same individual operates the measuring equipment throughout a study. The current study

does not report any estimate of the inter-observer error rate, as the same individual was responsible for measuring participants throughout the study.

5.7 Analysis of asymmetry

In order to assess facial soft tissue asymmetry in First Nations Nova Scotian adults, all participants were measured on both the right and left side of the face at 12 points (4, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19). An examination of the differences between the right and left measurements revealed that the majority of participants displayed asymmetry at three or fewer points with only six individuals displaying asymmetry at more than three points (Tables 4.13, 4.14, and 4.15). A study by Shah and Joshi (1978:146) suggests that certain activities, such as preferential mastication on one side of the face, can lead to increased skeletal development on that side. This increased skeletal development would be compensated for by the soft tissue (Shah and Joshi 1978:146; Shaner et al. 2000:145) and so a marked difference would be expected in soft tissue depth between the right and left measurements. Of the First Nations Nova Scotian adults displaying asymmetry at more than three points, only one individual had thicker facial soft tissue on only one side of their face (Table 4.13). This shows that there is not a strong tendency for one side of the face to be thicker than the other in this population group.

Taking into account the lack of a significant relationship between age and facial soft tissue depth for First Nations Nova Scotian adults (Tables 4.7, 4.8, and 4.9), as well as the lack of a significant relationship between sex and facial soft tissue depth for First Nations Nova Scotian adults (4.10), the statistical analysis of asymmetry was performed

on collapsed data with no subcategorization by age or sex. This analysis revealed that a significant difference exists at only two of the 12 bilateral points measured (Table 4.16). Point 15 (inferior mid mandible), with a p-value of 0.042 and a *Wilcoxon* statistic of 669.5, and point 18 (gonion), with a p-value of 0.037 and a *Wilcoxon* statistic of 674.5, both display significant asymmetry in this population group.

In their study of Australian adults, Domaracki and Stephan (2006:7) found that no significant difference exists between right and left tissue depths at the bi-lateral points measured. This is based, however, on data from only three bi-lateral points (mid-supraorbital, mid-infraorbital, and temporal muscle point). Domaracki and Stephan (2006) also fail to describe how the relationship between the left and right measurements was examined. There was no point measured in the current study that is comparable to the temporal muscle point, however points 9 (Supraorbital) and 10 (Suborbital) from the current study are comparable to the mid-supraorbital and mid-infraorbital points measured by Domaracki and Stephan (2006). Analysis of points 9 and 10 from First Nations Nova Scotians reveal that, as in Australian adults, there is no significant difference between right and left facial soft tissue depths (Table 4.16).

Chan (2007:44) examines facial soft tissue depth asymmetry in a study of Chinese-American adults, however, only two participants had both sides of their faces measured and there was no statistical analysis of the relationship between the left and right sides. These studies lack the statistical strength needed to demonstrate conclusively that facial soft tissue asymmetry is minimal, as they suggest.

A thorough examination of facial soft tissue depth asymmetry is reported by De Greef et al. (2006:S129-S130) in their study of "Caucasian" adults. A subset of 588

participants were measured bi-laterally. The right side and left side were compared using a paired t-test, a *Wilcoxon* paired signed rank test, and by comparing the medians of the differences for each point to the confidence intervals using a bootstrapping technique (De Greef et al. 2006:S129-S130). Although they claim that the differences between right and left measurements are probably small, in terms of their effect on creating 3-D facial reconstructions, they do report that 12 of the 21 bilateral points measured are significantly different from right to left (De Greef et al. 2006:S136). These 12 points are not clearly identified by De Greef et al. (2006), so no direct comaprison between findings from First Nation Nova Scotians is possible.

A study of Northwest Indian adults reveals that facial soft tissue tends to be thicker on the left side than on the right side (Sahni et al. 2008:143) indicating a pattern of facial soft tissue asymmetry within the study population. This was not the case in First Nation Nova Scotians. The varied results from these studies emphasize the need for an assessment of asymmetry in facial soft tissue depth research. In developing a protocol for the collection of facial soft tissue depth measurements from a new population group, researchers need to be aware that in measuring only one side of the face they may be missing valuable data.

The results of this analysis indicate that asymmetry of facial soft tissue in First Nations Nova Scotian adults is minimal. This result shows that measuring one side of the face would be sufficient in collecting facial soft tissue depth data from First Nations Nova Scotian adults. The minimal amount of asymmetry that does exist does not reflect a trend of soft tissue being thicker on one side of the face over the other. Because the nature of the existing asymmetry appears to be random in this respect, there would be

little to no affect on data that is pooled from a large study population where only one side of the face was measured.

Chapter 6: Conclusion

An investigation of facial asymmetry in First Nations Nova Scotian adults was employed in order to answer the question of whether the current technique of measuring only one side of the face, when using ultrasonic methods, is sufficient for collecting data for forensic 3-D facial reconstructions. Forensic 3-D facial reconstruction is an important tool in the investigation of unidentified human remains. The technique is employed by forensic artists to recreate the living face of an unidentified skull in an effort to have that person recognized and identified (Byers 2005:406). This involves building up the soft tissues of the face, using clay, to depths calculated from population specific data. The objectives of this study included the collection of data for First Nations Nova Scotians, a comparison of this data to other contemporary population data, an analysis of First Nations Nova Scotian data to determine the relationships between facial soft tissue depth and variables such as age and sex, as well as an analysis of facial asymmetry for this population.

Previous studies of facial soft tissue depth data report that age, sex, and the geographic population of participants, all strongly influence tissue depth measurements (El-Mehallawi and Soliman 2001; Manhein et al. 2000). Stephan and Simpson (2008:1266) argue that this is not always true and that this data would be more useful if it were reported as broadly as possible with no sub categorization by sex or age. The current study supports the findings of Stephan and Simpson (2008:1266) in that few significant relationships were found either between age and facial soft tissue depth or between sex and facial soft tissue depth in First Nations Nova Scotian adults.

An analysis of the effects of age on facial soft tissue depth revealed that, when the data for the whole study population was examined (male and female data from all age groups combined), only one point (5- mid philthrum) demonstrated a statistically significant change with age. Examining the data separately, there were three points (2- nasion, 10 L- left suborbital, and 15 L- left inferior mid mandible) that changed with age in males and only one (5- mid philthrum) that changed with age in females. Although there appears to be slightly more variability in age related changes when the data is considered separately in terms of sex, an examination of differences between male and female data revealed that there is a significant difference between male and female soft tissue depth at only one point (5- mid philthrum). It may therefore, be more appropriate to consider the analysis of combined data (male and female data combined) when assessing age related changes in soft tissue depth.

Although no statistical analysis could be performed comparing First Nations Nova Scotian adult data to other populations, a general comparison with "American White" adult data and "American Black" data (Manhein et al. 2000) reveals that the populations do differ in facial tissue depth data at many points on the face. First Nations Nova Scotians tend to have thicker facial soft tissue than the two American populations at the majority of points on the face, particularly in the area directly adjacent to the nostrils and extending to the middle cheek. The lower jaw area (point 18- gonion) was thinner in First Nations Nova Scotians than in the American populations. These differences emphasize the need for population specific facial soft tissue depth data. Forensic artists can use this data to produce forensic 3-D facial reconstructions that will more accurately resemble the face of an unknown individual when their population of origin is known to investigators.

Having determined that the effects of age and sex on facial soft tissue depth were minimal within First Nations Nova Scotians, an analysis of asymmetry was performed on data from the entire study population (male and female data from all age groups). A high degree of marked facial asymmetry, in this population, would indicate that valuable data would be missed if only one side of the face were measured and subsequent 3-D facial reconstructions would be less representative of the living individual. An analysis of asymmetry revealed that very little statistical difference exists between the right and left sides of the face in this population group. Only two points (15- inferior mid mandible, and 18- gonion) exhibited significant asymmetry in this population. The minimal amount of significant differences between right and left measurements, and the fact that asymmetries do not occur with one side of the face being consistently thicker than the other, supports the method of only measuring one side of the face for data collection for this population group. Investigations of asymmetry may be warranted in future endeavours to collect facial soft tissue depth data from other populations. The differences between First Nations Nova Scotians and the American populations from Manhein et al (2000) highlight the need for population specific data, however, the degree of asymmetry that exists in different populations may vary and should be considered when collecting data.

Future data collection projects should take the provisions outlined by Stephan and Simpson (2008:1266) into account in order to ensure that data is collected, reported, and used effectively. Reporting data for all body types within a population will provide a more realistic measure of the population as a whole, as what may be considered 'normal' body mass index for one population may not be 'normal' for other populations.

Descriptive statistics, such as medians and modes, should be reported in order to provide a more accurate picture of data that is not normally distributed. The reporting of measurement error is extremely important to qualify the accuracy of any facial soft tissue depth data. Continued efforts should focus on minimizing these errors for all methods of facial soft tissue depth data collection. A universally agreed upon set of data points would facilitate statistical comparisons between population groups, as well as help to increase the accuracy of locating and measuring anatomical points on the face. Finally, raw data, which can be used to statistically test facial soft tissue depth measurements and compare them with other studies, should be stored and made available to other researchers. Incorporating these recommendations into future research will lead to a better understanding of facial soft tissue and how it can help to identify individuals using 3-D facial reconstruction.

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Appendix A: Participant data sheet and consent form

SAINT MARY'S UNIVERSITY
3-D FACIAL RECONSTRUCTION RESEARCH
PARTICIPANT DATA SHEET

ID NUMBER _____

Please provide **all** of the information requested below. The data collected on each participant will be kept confidential and will be used only by researchers.

PLEASE PRINT CLEARLY

NAME _____
last first middle

BIRTH DATE _____
day month year

SEX ☐ MALE ☐ FEMALE

AGE _____

HEIGHT _____

WEIGHT _____

PARTICIPANT'S ANCESTRY
WHITE EUROPEAN ☐
BLACK AFRICAN ☐
ASIAN ☐
FIRST NATIONS ☐
OTHER ☐

FATHER'S ANCESTRY
WHITE EUROPEAN ☐
BLACK AFRICAN ☐
ASIAN ☐
FIRST NATIONS ☐
OTHER ☐

MOTHER'S ANCESTRY
WHITE EUROPEAN ☐
BLACK AFRICAN ☐
ASIAN ☐
FIRST NATIONS ☐
OTHER ☐

PLEASE CHECK ONE OR MORE OF THE FOLLOWING CATEGORIES THAT DESCRIBES YOUR ETHNIC BACKGROUND.

☐ FIRST NATIONS (NORTH AMERICAN) 01
(PLEASE SPECIFY)_____
☐ INDIGENOUS (SOUTH AMERICAN) 02
☐ WHITE EUROPEAN 03
☐ VIETNAMESE 04
☐ CHINESE 05
☐ JAPANESE 06
☐ KOREAN 07
☐ AFRICAN AMERICAN 08
☐ MEXICAN 09
☐ CUBAN 10
☐ PUERTO RICAN 11
☐ HISPANIC (S. AMERICA) 12
☐ EASTERN INDIAN 13
☐ OTHER (PLEASE SPECIFY) _____
_____

SAINT MARY'S UNIVERSITY
CONSENT FORM

1. PROJECT TITLE: Asymmetry in forensic 3-D facial reconstruction: An assessment of facial asymmetry in adult First Nations Nova Scotian facial soft tissue depth data.

2. PROJECT LOCATION:

3. NAMES AND TELEPHONE NUMBERS OF INVESTIGATORS:

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4. PURPOSE OF THE STUDY:

A. This is a research study.

B. Participants, of both sexes and all ages above 18 years, who are capable of remaining in a motionless position for a period of 3 to 5 minutes will volunteer for the study.

C. This study is designed to expand what we know now about the depth of the skin and muscle in particular areas of the faces of children and adults in Nova Scotian Aboriginal communities.

5. WHO CAN PARTICIPATE IN THIS PROJECT? Any individual who gives written consent, regardless of age, sex, or ancestry, will be included in the study if he/she can remain in a motionless position for a period of 3 to 5 minutes.

6. WHO CAN NOT PARTICIPATE IN THIS PROJECT? An individual will be excluded from the study only if he/she does not have the capacity to or does not desire to remain motionless for a period of 3 to 5 minutes

7. DESCRIPTION OF THE STUDY: The study will involve at least 100 subjects and will measure skin and muscle depth of particular points of the faces of children and adults. Measurements will be taken by using an ultrasound machine. Ultrasound is completely painless and has no harmful effects. The participant will be asked to rest his/her head on a stand (similar to one used in an eye doctor's office). A small amount of non-allergenic gel will be placed on several points of the face. The ultrasound will be placed on the gelled points and activated. While the machine is scanning the points it will be necessary for the participant to stay motionless. The gel will be removed with a sanitary wipe. The entire procedure will take 3 to 5 minutes.

To document this research procedure, still or video pictures may be taken while measurements are in progress. Any participant wishing to view pictures or video tape may contact one of the investigators listed above. Any pictures or video taken will not be used either in future research projects having to do with facial growth patterns, the aging face, or in publishing the results of this research, unless otherwise indicated by the participant or guardian. Publication of the results will be in scientific journals and lectures.

8. BENEFITS TO COMMUNITY: This project will aid in positive identifications for peoples of indigenous ancestry. For the police, who are searching for a missing child, employing this new data may help a family reunite with their lost child. The project will also provide unique training and research opportunities for Canadian Aboriginal students.

9. RISKS TO PARTICIPANTS: The ultrasound method of measuring presents no harm, present or long-range, to the participant.

10. INDIVIDUAL'S RIGHT TO REFUSE TO PARTICIPATE OR WITHDRAW: Study participants may refuse to participate or withdraw from the study at anytime. They may withdraw from the ultrasound sessions at any point. Participants may remove their personal data from the archive at a later date.

11. PARTICIPANT'S RIGHT TO PRIVACY: The results of the study may be released to the funding agency. The results of the study may be published. The privacy of participants will be protected and they will not be identified in any way.

12. RELEASE OF INFORMATION: The personal data, except for the volunteer's name, related to the study are available only to researchers and forensic artists. The participant may request to view their own personal data but not the data of any other individual participating in the study.

13. OTHER INFORMATION
   A. The costs of any study related and unforeseen complications must be met by the participant
   B. Individuals will not be paid for participation, but will receive a "thank you" gift.

14. SIGNATURES: The study has been discussed with me and my questions have been answered. I understand that additional questions regarding the study should be directed to investigators listed on page 1 of this consent form. I agree with the terms above and acknowledge I have been given a copy of the consent form.

☐ I give my permission to use photos of my face in presentations and/or publications based on this project (no personal information will be presented, only anonymous photos).

Signature of Participant Date

Signature of Witness

Appendix B: Body mass index data

Table B.1 - Body mass index calculated for First Nations Nova Scotian participants (continued on next page).

ID #	Sex	Age	height (cm)	weight (Kg)	BMI	BMI category
001	M	40	177.5	111.8	35.5	obese
002	M	20	188.5	109.1	30.7	obese
003	F	57	160	60.0	23.4	normal
004	F	34	160	70.0	27.3	overweight
005	F	23	160	52.3	20.4	normal
006	M	27	173	97.3	32.5	obese
007	F	40	161	93.2	35.9	obese
008	F	36	160	86.4	33.7	obese
009	F	39	161	60.0	23.1	normal
010	F	24	170	84.5	29.3	overweight
011	F	50	172	99.1	33.5	obese
012	F	74	152	73.6	31.9	obese
013	F	39	167.5	65.5	23.3	normal
014	F	29	165	95.9	35.2	obese
015	M	36	188	105.5	29.8	overweight
016	M	25	177	82.3	26.3	overweight
017	F	38	156	145.5	59.8	obese
018	F	34	169	105.5	36.9	obese
019	F	27	165	83.6	30.7	obese
020	F	37	157.5	91.4	36.8	obese
021	M	40	168.5	76.8	27.1	overweight
022	M	48	178	82.7	26.1	overweight
023	M	37	174	90.9	30.0	obese
024	F	31	176	143.2	46.2	obese
025	F	42	163.5	119.1	44.5	obese

Table B.1 (continued) - Body mass index calculated for First Nations Nova Scotian participants.

ID #	Sex	Age	height (cm)	weight (Kg)	BMI	BMI category
026	F	31	170	134.1	46.4	obese
027	M	31	178	100.0	31.6	obese
028	F	49	158	54.1	21.7	normal
029	F	28	171	113.6	38.9	obese
030	F	63	168.5	101.4	35.7	obese
031	F	26	158.5	80.9	32.2	obese
033	F	62	155	63.2	26.3	overweight
034	F	38	153.5	145.5	61.7	obese
035	F	32	177	65.0	20.7	normal
036	F	34	165	75.0	27.5	overweight
037	F	27	163	79.5	29.9	overweight
038	F	27	168.5	147.7	52.0	obese
039	M	48	181	123.2	37.6	obese
040	F	41	156	84.1	34.6	obese
041	F	43	161.5	75.0	28.8	overweight
042	F	46	161	97.7	37.7	obese
043	F	27	156.5	60.0	24.5	normal
044	F	43	168.5	116.4	41.0	obese
045	F	77	155	59.1	24.6	normal
046	M	30	180	89.1	27.5	overweight
047	F	34	156	70.5	29.0	overweight
048	F	42	158	106.8	42.8	obese
049	F	34	161	70.5	27.2	overweight
050	F	37	160	81.8	32.0	obese
052	F	27	162	64.1	24.4	normal

Appendix C: Raw data for all participants

Table C.1 - Raw facial soft tissue depth measurement data (in mm) from all participants (continued on next page).

		ID number, sex, and age of participant									
		001	002	003	004	005	006	007	008	009	010
		M	M	F	F	F	M	F	F	F	F
Point numbers and descriptions		40	20	57	34	23	27	40	36	39	24
1	Glabella	8	8	7	6	7	5	7	8	6	6
2	Nasion	10	6	7	6	8	7	7	8	6	7
3	End of nasals	2	5	3	4	3	2	5	3	2	4
5	Mid-philthrum	14	16	8	9	10	12	10	11	5	12
6	Chin lip fold	13	11	14	14	11	16	14	16	11	12
7	Mental eminence	17	9	17	15	11	16	15	20	10	12
8	Beneath chin	12	9	12	14	5	10	13	14	6	7
4 R	Right lateral nostril	15	17	21	27	21	22	22	40	20	22
9 R	Right supraorbital	13	11	12	8	4	5	7	5	7	5
10 R	Right suborbital	13	6	8	13	4	5	7	6	5	12
11 R	Right supracanine	11	15	12	17	9	23	18	11	8	11
12 R	Right subcanine	14	11	13	16	4	16	12	16	9	13
13 R	Right posterior maxilla	12	29	27	30	23	20	36	35	30	33
14 R	Right superior mid mandible	25	9	32	25	13	31	34	27	19	25
15 R	Right inferior mid mandible	19	11	12	12	8	21	24	10	13	13
16 R	Right lateral eye orbit	4	4	5	5	5	4	5	5	4	9
17 R	Right anterior zygoma	13	12	5	5	6	7	10	15	10	13
18 R	Right gonion	21	7	6	9	11	8	7	11	14	19
19 R	Right root of zygoma	5	5	8	4	5	7	8	5	8	4
4 L	Left lateral nostril	23	11	23	24	21	19	22	24	21	20
9 L	Left supraorbital	12	10	5	7	5	7	5	5	5	9
10 L	Left suborbital	13	7	10	11	5	6	10	9	6	7
11 L	Left supracanine	15	13	8	16	7	12	24	15	10	12
12 L	Left subcanine	15	12	12	12	8	11	12	15	11	9
13 L	Left posterior maxilla	30	30	10	19	6	32	27	21	12	28
14 L	Left superior mid mandible	24	9	32	27	8	29	24	27	21	22
15 L	Left inferior mid mandible	22	11	11	20	8	9	10	8	12	10
16 L	Left lateral eye orbit	28	6	6	6	4	5	5	6	4	9
17 L	Left anterior zygoma	26	7	7	5	5	7	8	8	12	12
18 L	Left gonion	9	9	9	8	4	7	8	9	16	10
19 L	Left root of zygoma	9	4	11	4	6	5	5	6	5	10

Table C.1 (continued) - Raw facial soft tissue depth measurement data (in mm) from all participants (continued on next page).

Point numbers and descriptions		ID number, sex, and age of participant									
		011	012*	013	014	015	016	017	018	019	020
		F	F	F	F	M	M	F	F	F	F
		50	74	39	29	36	25	38	34	27	37
1	Glabella	8	6	5	6	6	6	7	7	7	5
2	Nasion	9	6	5	6	8	5	7	8	6	6
3	End of nasals	6	5	3	3	3	3	3	4	2	5
5	Mid-philthrum	9	8	9	11	12	11	9	13	8	10
6	Chin lip fold	13	14	12	12	12	12	13	12	15	13
7	Mental eminence	16	14	11	14	10	9	16	14	17	14
8	Beneath chin	14	8	8	11	10	7	12	10	13	10
4 R	Right lateral nostril	25	25	20	23	24	25	28	32	23	25
9 R	Right supraorbital	10	7	8	8	8	4	7	5	8	9
10 R	Right suborbital	9	6	6	8	8	12	16	20	12	8
11 R	Right supracanine	9	7	12	15	11	12	12	17	11	18
12 R	Right subcanine	16	14	12	14	13	11	13	15	11	12
13 R	Right posterior maxilla	36	23	30	36	27	28	42	18	45	25
14 R	Right superior mid mandible	24	23	27	33	27	29	38	35	30	40
15 R	Right inferior mid mandible	18	15	10	10	6	11	21	13	9	7
16 R	Right lateral eye orbit	6	7	5	6	6	6	6	8	27	5
17 R	Right anterior zygoma	15	9	5	7	6	10	7	9	7	6
18 R	Right gonion	20	15	9	8	6	5	8	9	8	5
19 R	Right root of zygoma	5	4	4	5	5	4	6	5	6	5
4 L	Left lateral nostril	25	23	21	23	20	25	35	30	21	27
9 L	Left supraorbital	8	7	7	10	8	5	6	4	7	4
10 L	Left suborbital	8	7	9	8	9	8	15	13	10	6
11 L	Left supracanine	9	9	11	9	12	17	11	12	11	9
12 L	Left subcanine	16	11	12	12	10	10	15	13	7	8
13 L	Left posterior maxilla	33	26	29	31	26	25	28	35	25	37
14 L	Left superior mid mandible	32	27	29	34	28	24	38	30	23	44
15 L	Left inferior mid mandible	21	12	9	11	9	5	6	12	8	8
16 L	Left lateral eye orbit	7	6	5	6	6	5	7	6	6	6
17 L	Left anterior zygoma	19	9	10	9	6	6	15	7	6	5
18 L	Left gonion	17	12	5	9	8	5	6	8	7	6
19 L	Left root of zygoma	7	6	4	5	6	5	6	5	4	5

Table C.1 (continued) - Raw facial soft tissue depth measurement data (in mm) from all participants (continued on next page).

		ID number, sex, and age of participant									
		021	022	023	024	025	026	027	028	029	030
		M	M	M	F	F	F	M	F	F	F
Point numbers and descriptions		40	48	37	31	42	31	31	49	28	63
1	Glabella	6	7	6	6	6	10	6	5	5	8
2	Nasion	8	7	7	6	8	10	6	5	6	10
3	End of nasals	4	4	5	6	5	6	3	5	4	2
5	Mid-philthrum	11	9	12	11	11	15	7	9	8	10
6	Chin lip fold	14	12	12	14	13	21	11	14	12	15
7	Mental eminence	14	14	12	22	15	29	14	14	9	17
8	Beneath chin	10	9	8	15	12	22	7	8	9	11
4 R	Right lateral nostril	22	24	10	30	22	42	19	21	28	24
9 R	Right supraorbital	3	10	10	12	8	16	6	7	10	10
10 R	Right suborbital	8	11	9	20	13	23	4	12	10	12
11 R	Right supracanine	11	9	16	17	12	13	10	9	8	9
12 R	Right subcanine	14	10	14	20	13	23	16	13	12	11
13 R	Right posterior maxilla	40	35	33	31	36	43	14	20	24	23
14 R	Right superior mid mandible	30	25	32	29	30	40	29	19	21	38
15 R	Right inferior mid mandible	7	14	15	23	7	38	6	12	15	20
16 R	Right lateral eye orbit	6	8	26	7	4	7	4	7	6	4
17 R	Right anterior zygoma	6	5	5	21	13	16	10	6	6	8
18 R	Right gonion	8	5	23	21	17	19	8	9	20	22
19 R	Right root of zygoma	5	5	4	7	4	6	8	4	5	4
4 L	Left lateral nostril	19	17	24	29	19	39	20	21	19	27
9 L	Left supraorbital	9	9	13	9	9	11	8	7	9	10
10 L	Left suborbital	12	11	13	15	10	23	4	11	10	11
11 L	Left supracanine	16	8	11	10	9	24	11	9	7	9
12 L	Left subcanine	14	11	15	13	12	20	16	13	8	15
13 L	Left posterior maxilla	40	34	35	30	35	50	30	20	23	28
14 L	Left superior mid mandible	29	20	33	32	24	39	25	23	24	36
15 L	Left inferior mid mandible	7	18	11	10	7	40	13	11	7	23
16 L	Left lateral eye orbit	6	5	28	6	6	8	4	6	3	4
17 L	Left anterior zygoma	6	10	5	18	12	15	9	5	6	9
18 L	Left gonion	6	20	23	9	6	44	7	10	24	22
19 L	Left root of zygoma	4	4	5	7	6	6	4	3	4	9

Table C.1 (continued) - Raw facial soft tissue depth measurement data (in mm) from all participants (continued on next page).

		ID number, sex, and age of participant									
		031	033	034	035	036	037	038	039	040	041
		F	F	F	F	F	F	F	M	F	F
Point numbers and descriptions		26	62	38	32	34	27	27	48	41	43
1	Glabella	7	5	6	5	5	6	11	7	6	6
2	Nasion	8	5	8	5	4	6	10	7	6	5
3	End of nasals	2	3	4	3	2	6	7	7	4	4
5	Mid-philthrum	10	5	9	8	8	9	15	15	8	7
6	Chin lip fold	14	13	17	11	13	13	17	16	13	13
7	Mental eminence	15	14	19	13	12	17	20	15	17	13
8	Beneath chin	11	9	13	8	6	10	14	9	13	7
4 R	Right lateral nostril	26	21	28	18	16	24	26	22	19	17
9 R	Right supraorbital	9	7	14	7	8	9	11	11	9	8
10 R	Right suborbital	9	9	19	9	6	15	14	8	9	13
11 R	Right supracanine	16	9	25	9	8	10	24	13	13	28
12 R	Right subcanine	17	12	14	9	12	16	18	12	11	13
13 R	Right posterior maxilla	35	24	39	30	16	32	24	35	33	23
14 R	Right superior mid mandible	39	13	34	27	24	24	41	32	28	20
15 R	Right inferior mid mandible	14	9	16	16	17	18	12	21	26	12
16 R	Right lateral eye orbit	5	4	7	6	4	5	6	5	7	4
17 R	Right anterior zygoma	15	5	21	10	9	7	11	14	8	12
18 R	Right gonion	10	16	32	16	19	7	13	26	27	24
19 R	Right root of zygoma	6	4	4	3	3	6	5	6	5	3
4 L	Left lateral nostril	33	18	26	20	16	23	25	27	21	18
9 L	Left supraorbital	9	9	12	7	8	10	10	10	9	8
10 L	Left suborbital	13	11	17	5	6	9	18	12	14	6
11 L	Left supracanine	11	9	22	12	9	10	17	11	8	9
12 L	Left subcanine	15	12	15	9	12	13	16	14	9	12
13 L	Left posterior maxilla	35	23	32	32	20	16	37	32	32	40
14 L	Left superior mid mandible	42	25	35	18	20	22	36	30	26	22
15 L	Left inferior mid mandible	12	11	12	10	13	10	16	24	21	16
16 L	Left lateral eye orbit	8	5	5	4	4	6	7	5	5	4
17 L	Left anterior zygoma	17	7	18	5	11	7	10	14	5	6
18 L	Left gonion	10	14	29	16	14	17	12	24	24	20
19 L	Left root of zygoma	4	4	4	5	2	5	7	5	4	3

Table C.1 (continued) - Raw facial soft tissue depth measurement data (in mm) from all participants.

		ID number, sex, and age of participant									
		042	043	044	045	046	047	048*	049*	050*	052*
		F	F	F	F	M	F	F	F	F	F
Point numbers and descriptions		46	27	43	77	30	34	42	34	37	27
1	Glabella	7	5	8	4	7	9	8	6	7	6
2	Nasion	6	6	7	4	6	7	9	5	7	5
3	End of nasals	5	3	5	7	4	6	4	3	4	4
5	Mid-philthrum	10	10	10	9	13	8	11	9	9	10
6	Chin lip fold	14	10	14	12	13	12	14	10	14	12
7	Mental eminence	15	13	18	12	13	11	15	10	16	13
8	Beneath chin	7	8	12	7	10	8	13	5	9	9
4 R	Right lateral nostril	19	17	23	21	23	23	27	21	23	19
9 R	Right supraorbital	8	8	8	5	7	9	10	9	9	7
10 R	Right suborbital	9	4	11	8	4	6	18	8	7	10
11 R	Right supracanine	8	10	12	10	12	14	13	10	9	14
12 R	Right subcanine	8	11	13	8	14	12	14	10	14	13
13 R	Right posterior maxilla	31	31	33	29	27	28	34	30	32	32
14 R	Right superior mid mandible	27	24	30	25	25	22	29	27	28	27
15 R	Right inferior mid mandible	11	8	13	7	8	8	10	11	10	8
16 R	Right lateral eye orbit	5	4	5	5	4	7	17	4	7	3
17 R	Right anterior zygoma	11	7	7	6	5	7	8	6	7	6
18 R	Right gonion	5	6	16	4	6	12	10	6	8	7
19 R	Right root of zygoma	5	3	4	4	4	3	3	4	5	4
4 L	Left lateral nostril	20	18	24	20	20	26	30	19	24	19
9 L	Left supraorbital	8	4	8	5	7	6	10	8	7	6
10 L	Left suborbital	11	5	18	8	5	7	17	7	9	11
11 L	Left supracanine	9	16	11	12	11	14	15	12	11	9
12 L	Left subcanine	15	12	14	7	13	17	15	12	14	14
13 L	Left posterior maxilla	26	30	23	22	26	28	37	31	28	33
14 L	Left superior mid mandible	36	20	29	26	25	27	34	17	28	25
15 L	Left inferior mid mandible	7	7	8	6	6	8	10	7	12	8
16 L	Left lateral eye orbit	5	3	7	5	5	5	5	4	6	4
17 L	Left anterior zygoma	7	7	10	5	4	7	7	6	7	7
18 L	Left gonion	6	6	7	5	4	5	9	6	9	7
19 L	Left root of zygoma	4	3	4	3	4	4	5	4	4	5

* = Participant was measured twice, so the mean of the two measurements is reported.

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