Biomechanical Effects of Cesarean Section Scars on Second Trimester Pregnant Anatomy

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Introduction

Etiology of Maternal Trauma

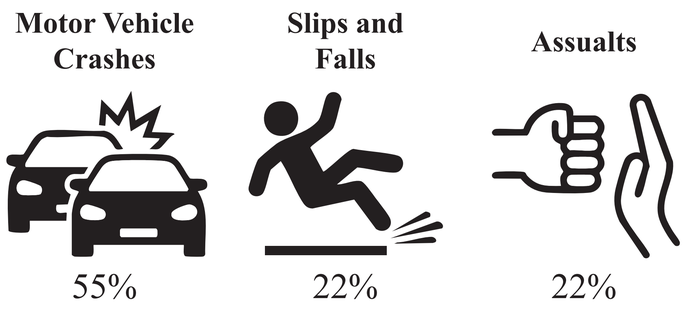


Figure 1: It is estimated that 1 in 12 pregnancies is complicated by traumatic injury. The leading causes of maternal injury during pregnancy are domenstic violence, motor vehicle crashes, and slips and falls [1]. The etiology of fetal injury death attributes 82% to motor vehicle crahses, with fetal loss more likely with more severe trauma [1].

Incidence of Cesarean Section

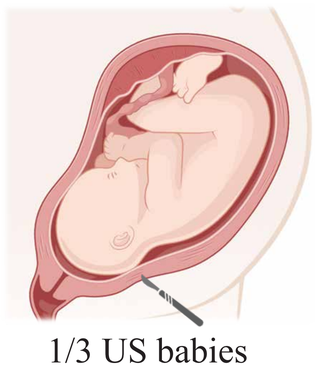


Figure 2: Approximately 1 out of every 3 babies in the United States is born via Cesarean Section [2]. Previous Cesarean Section increases the risk of uterine rupture and preterm birth in subsequent pregnancies [2,3].

Background

NEED: quantify maternal anatomy for injury modeling

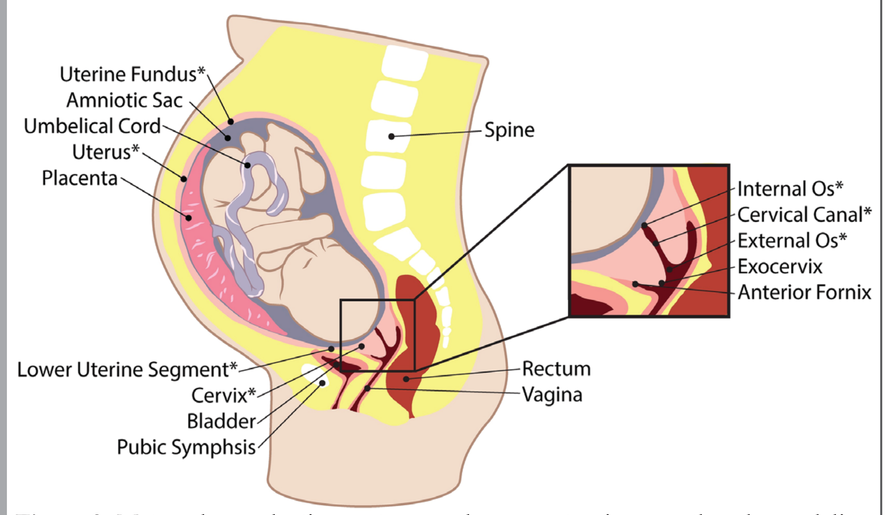


Figure 3: Maternal reproductive anatomy undergoes extensive growth and remodeling during pregnancy [4]. In order to quantify these changes, a widely implementable method to measure and model these tissues across gestation is necessary.

Methods

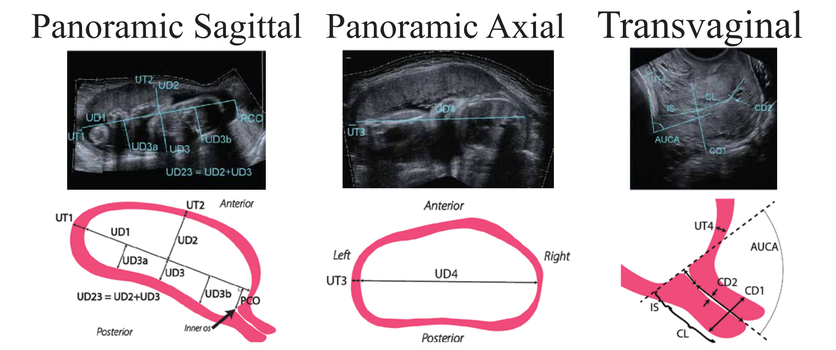


Figure 4: Dimension measurements from 2-dimensional ultrasound images capture the overall uterine and cervical shape and size [4]. Ultrasound is very common in prenatal care, and can be implemented in various positions and gestational ages.

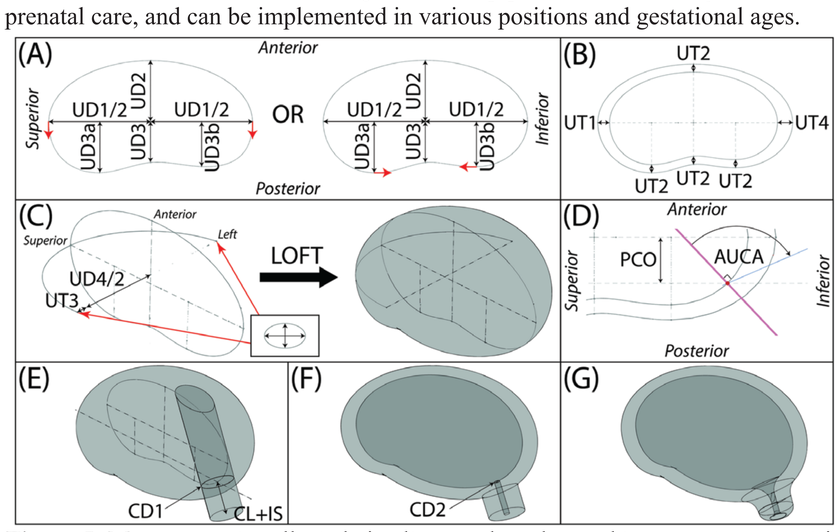
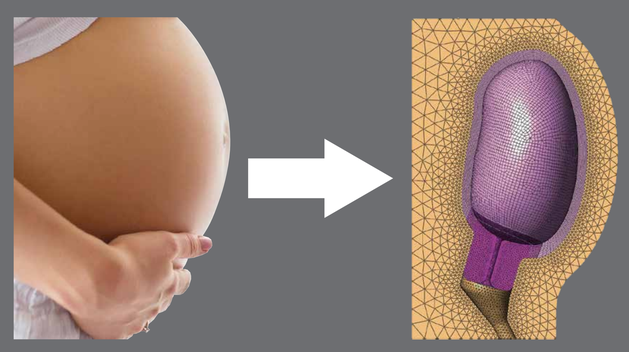


Figure 5: Measurements collected via ultrasound can be used to generate parametric patient-specific models of maternal anatomy. Using the *Design Table* feature in SolidWorks, geometries can be automatically built from maternal measurements [4].

Parametric in-silico modeling advances research on maternal, fetal, and placental injuries



Results

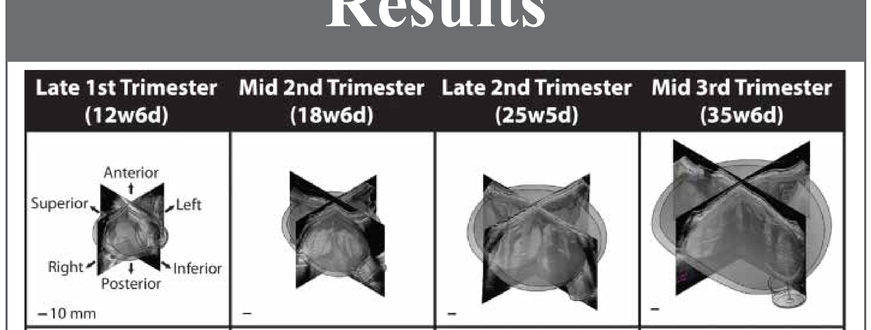


Figure 6: Models of the pregnant uterus and cervix for one participant from the late 1st to middle 3rd trimester, with the source ultrasound overlayed [5].

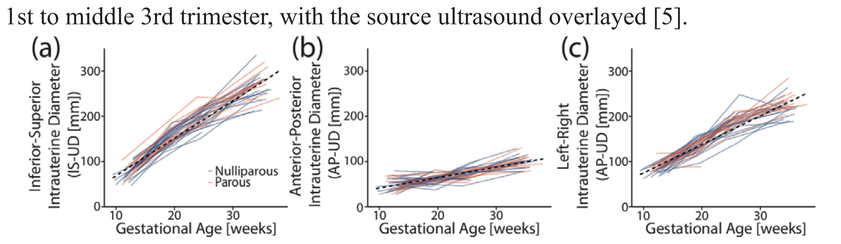


Figure 7: Intrauterine diameters in the (a) inferior-superior, (b) anterior-posterior, and (c) left-right direction increase steadily with gestational age [5].

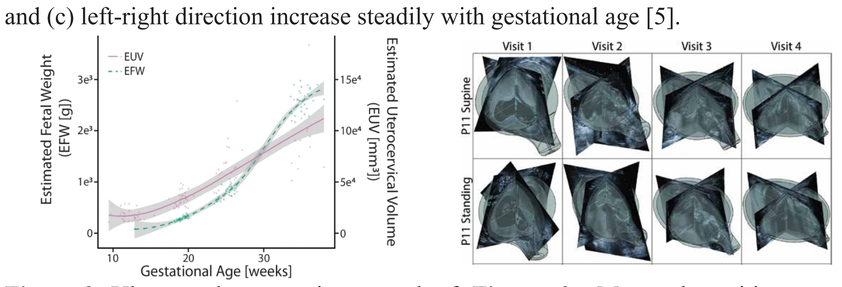


Figure 8: Ultrasound can monitor growth of maternal and fetal anatomy concurrently [5].

Figure 9: Maternal position can affect the shape of the anatomy [4].

Discussion

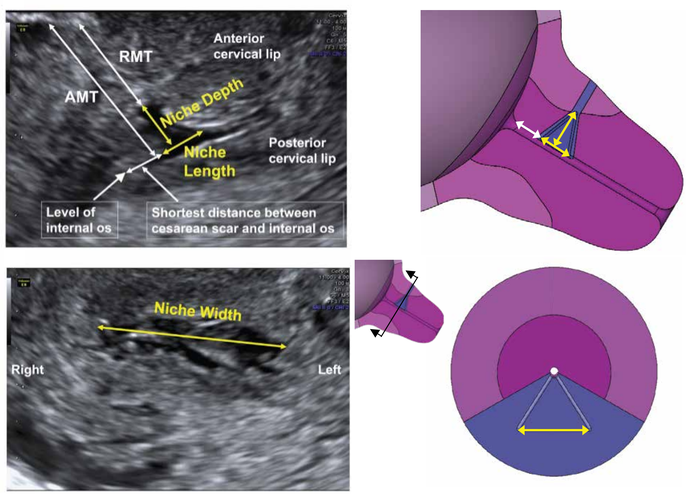


Figure 10: Parametric approaches can also be used to quantify cesarean section scars and their defects (niches). Clinical studies have found scar location to affect subsequent risk of preterm birth [6].

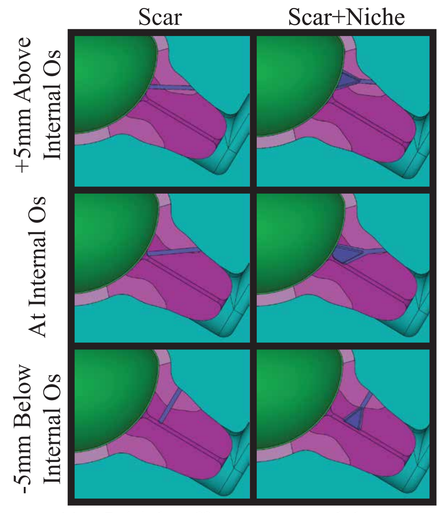


Figure 11: Initial efforts to model cesarean section scar location and niche size, which can be used to study anatomic mechanical response.

Outlook

Cesarean Section Scar and Uterine Rupture Risk

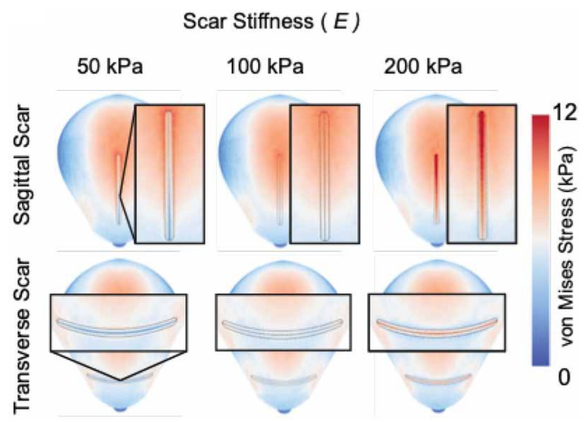


Figure 12: Finite element models could be used to assist risk of uterine rupture in the at-term uterus [7]. They can also be used to investigate the effects of scar stiffness and location.

Placental Abruption

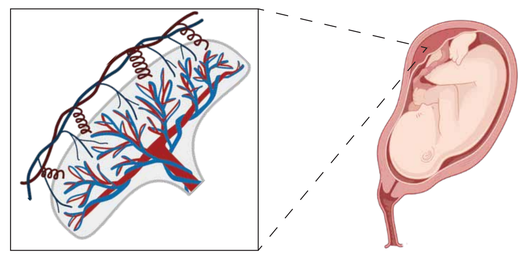


Figure 13: Maternal injury increases risk of placental aburption, which can lead to hemorrhage. Future work will thus include the placenta in the models. This will include making the size, shape, and position of the placenta parameterizable, as these are patient-specific. Additionally, models of placental abruption will incorpate existing fracture mechanics theory on strain energy mediated fracture [8].

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