Sex Differences in Common Hip Disorders and Preservation Procedures among Pediatric and Young Adult Patients: A Natural Language Processing Analysis of 8,328 Patients

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Disclosures: N. Tavabi: None. T. Williamson: None. A. Weiss: None. Y. M. Yen, None. T. Matheny: None., M. Millis: None. Y.J. Kim: 4; Cytex, Imagen. 3C; Orthopediatrics. 8; Journal of Hip Preservation Surgery, Orthopedics Review, Osteoarthritis and Cartilage. E.N. Novais: None. A.M. Kiapour: 3B; MIACH Orthopaedics: 8; BMC Musculoskeletal Disorders and American Journal of Sports Medicine.

INTRODUCTION: Hip injuries are among the most common joint injuries in children and young adults. Despite their high prevalence and the growing interest in hip preservation surgeries, there is limited understanding of sex differences in the diagnosis and treatment of these conditions. This knowledge gap largely stems from the absence of large-scale registries, which traditionally require extensive resources, such as manual chart reviews. In this study, we utilized an advanced natural language processing (NLP) pipeline to create a comprehensive hip preservation registry, spanning 23 years of clinical practice at a high-volume tertiary-care children's hospital.

METHODS: Following IRB approval, operative notes from patients with at least one encounter at our Orthopedic Surgery and Sports Medicine clinics within 2000 – 2023 were acquired (>321,000 notes from, 180,990 unique patients). A subset of 1,000 operative notes was manually annotated by medically trained experts to train a custom NLP pipeline. This pipeline was designed to accurately identify hip preservation surgeries (Accuracy: 99.1%, Sensitivity 99.2%, Specificity: 99.1%) along with their associated diagnoses, procedures, and laterality (Accuracy: 99.7%, Sensitivity 99.8%, Specificity: 95.3%). Chi-square test was used to compare the prevalence of hip diagnoses and procedures between males and females.

RESULTS: Within the studied 23 years, the model identified 11,241 hip surgeries from 8,328 unique patients (62% females; age: 15.6±8.8 years). Female patients (16.3±9.3 years) were significantly older than males (14.3±7.6 years) at the time of first operation (P<0.001). The majority of procedures (87.7%) were performed on a single hip (45.9% on the right hip, 41.8% on the left), with female patients less likely to undergo bilateral surgery compared to males (11.5% vs. 13.5%, P<0.001). Among the patients, 26.3% had undergone multiple hip surgeries including 28.6% of females and 22.8% of males affected (P<0.001). The distribution of these patients is as follows: 10.6% had 2 hip surgeries but one on each hip, 9.9% had 2 surgeries on the same hip, 4.2% had 3, 1.2% had 4, and 0.6% had more than 4 surgeries overall. The most common diagnoses and procedures (>100 cases) for each sex are in Figure 1. Compared to males, females had lower prevalence of FAI (29.9% vs 35.2%; P<0.001), SCFE (7.3% vs 16.8%; P<0.001), Perthes (1.8% vs 9.5%, P<0.001) and AVN (2.3% vs 3.9%, P<0.001), but higher rates of labral injuries (33.9% vs 23.3%; P<0.001), acetabular dysplasia (35.7% vs 15.0%, P<0.001), and hip instability (13.0% vs 9.8%; P<0.001). While there were no sex-specific differences in prevalence of pincer-FAI (P=0.925), females had lower prevalence of cam-FAI (14.7% vs 18.2%, P<0.001). There were significant sex-differences in most common hip preservation procedures with higher prevalence of femoral head/neck osteochondroplasty in males (31.1% vs 28.3%; P<0.001) and higher prevalence of PAO in females (20.1 % vs 7.4%%; P<0.001)-Figure 1.

DISCUSSION: Using an innovative NLP pipeline, we generated the largest hip preservation registry of more than 11,000 hip surgeries over 23 years. Current findings highlight significant sex differences in prevalence of hip disorders and preservation treatments among children and young adults. Females, who tend to be older at their first operation, are less likely to undergo bilateral procedures. Females were more likely to have hip dysplasia and instability, requiring acetabular osteotomies (e.g., PAO), compared to males who were more prone to FAI, requiring osteoplasty. A major limitation of this is that the data is from a single site, resulting in potential bias, in particular in treatment choice. Yet, the registry offers a unique opportunity to develop risk prediction and treatment selection algorithms leading to improved outcomes, which can then be validated in multi-site settings.

SIGNIFICANCE: This study highlights the potential of NLP for building large-scale registries, which is currently missing in the field of hip preservation. Such databases enable high-quality research to better understand the pathomechanisms of a range of hip disorders to improve clinical care. We are currently expanding this registry to include treatment outcomes to develop prediction models to assist with treatment planning.

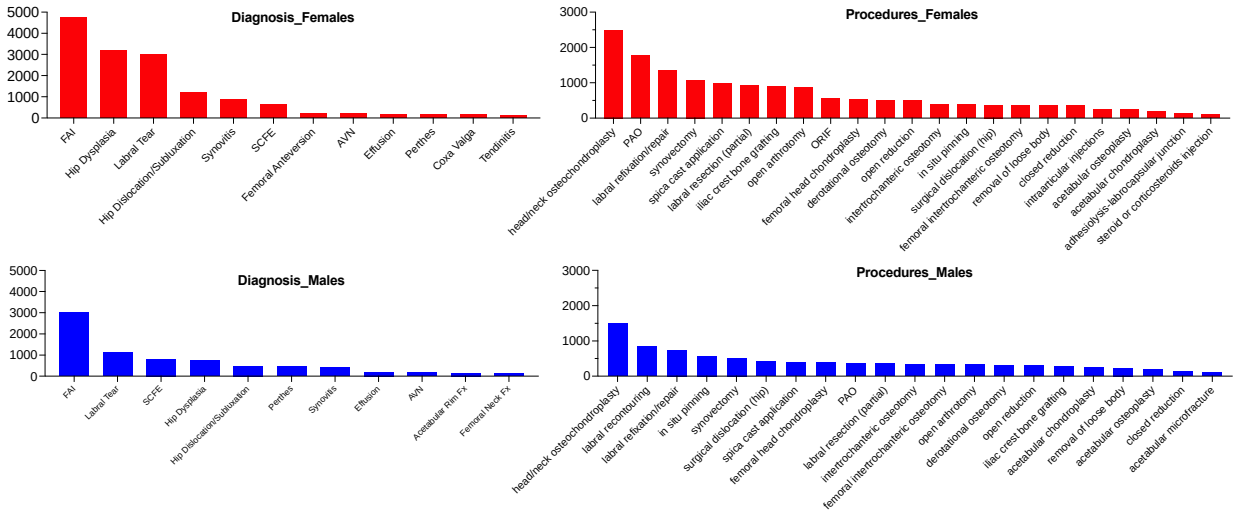

Figure 1: Most common hip diagnoses and preservation procedures (females: red, males: blue).