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Intergluteal fold depth has no influence on pilonidal sinus disease development

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ABSTRACT

Objective: The etiology of primary pilonidal sinus disease (PSD) remains unclear. Prior investigations suggest that sharp fragments from the occiput contribute to the formation of PSD. In 2009 a correlation between PSD and a deeper natal cleft was reported. We investigated the association between intergluteal fold (IGF) depth and PSD risk using a standardized five-step measuring protocol.

Material and Methods: Our clinical prospective study included 95 PSD patients and 105 non-PSD individuals, and measurements were taken from the glabella sacralis to the anus in a northern German population.

Results: The mean (± standard deviation) intergluteal depth progressively increased from the intergluteal opening from the sacral glabella at 9.1 (±3.4) mm to a maximum of 62.6 (±10.4) mm. Notably, the deepest point was consistently observed at the anus, where PSD occurrence is rare. No significant difference in IGF depth between PSD and non-PSD patients was found. Additionally, PSD predominantly developed in the proximal (cranial) third of the IGF, despite the maximum depth being in the distal region.

Conclusion: These findings suggest that IGF depth is not a risk factor for PSD.

Keywords: Intergluteal fold depth, natal cleft, pilonidal sinus, mechanism of disease, PSD

INTRODUCTION

The mechanism of primary pilonidal sinus disease (PSD) is unknown. Numerous theories about risk factors and prevention have emerged due to PSD's midline appearance in the lumbar region, glabella sacralis, and cranial opening of the intergluteal fold (IGF). Embryologic origins, such as remnants of the preen gland (1), residual human tail (2), neuro-cutaneous traction (3), faulty ectodermal closure (4), and gluteal muscle involvement (5), have been discussed and eventually dismissed. When more than 17,000 soldiers were taken out of action by PSD during World War II, Buie proposed that the disease was acquired from driving in hard seats on bumpy roads, coining the term "Jeeps disease" (6). Subsequent research disproved this theory (7).

This resulted in speculations about the acquired reasons for PSD: Higher body mass index (BMI), faulty hygiene, enhanced sweating and hormonal imbalances (8) have not been definitively proven. The folliculitis theory (9), in growing gluteal hair theory, or ruptured hair from other body regions piercing into the skin had to be discarded due to lack of supporting evidence. Recent studies by our group suggest that sharp hair fragments constitute the primary component of the pilonidal sinus nest (10), particularly from the occiput (11). Electron microscopy images (12) have captured hair strands erecting themselves and piercing the skin of the upper (cranial) IGF when a sharp edge is in proximity and hair scales point away from the skin. A hairy IGF seems to hold hair longer into position, suggesting that hairy individuals appear to have a higher susceptibility to PSD. We understand that many pilonidal sinuses

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are not found to contain hair, and a successful description of the complete PSD etiology must ultimately also address this issue.

In 2009, Akinci et al. (13) reported a correlation between PSD and deeper natal clefts after measuring the IGF depth, suggesting that surgical procedures to flatten the natal cleft, such as the Karydakis procedure, might reduce the risk of recurrence.

Understanding that a steeper upper natal cleft would cause hair to stand more upright, we wondered why a deeper natal cleft could significantly increase the risk of PSD. To investigate further, we developed a standardized measuring protocol to assess natal cleft depth in both PSD and non-PSD individuals.

Our study aims to address the key questions: the most reliable method for measuring the IGF depth, the presence of one or multiple "deepest points" within the IGF, and potential differences in maximum IGF depth between genders and PSD status. Ultimately, our goal is to determine if IGF depth is an independent risk factor in PSD. Our null hypothesis: There is no association between IGF depth and PSD risk, and IGF depth does not serve as an independent risk factor for PSD.

MATERIAL and METHODS

Patients

A total of 200 participants from a normal population in northern Germany were included in this study. The size of the study population was set, with the objective of creating a cohort double the size of the preceding study.

The PSD patients (95 individuals, 47.5%) were consecutively enrolled from the procto-surgery department who were from St. Marienhospital Vechta (no patient declined participation). One hundred-five (52.5%) non-PSD-patients were recruited from hospital workers, medical students, and patients with non-PSD-associated and non-inflammatory-related diagnoses (mainly traumatology). Participants were required to provide informed consent before being included in this study.

Measuring Tool

First, we tried to measure the depth of the intergluteal (natal) cleft without any mechanical influence of these soft tissues with laser light frame projection (14), but it was not possible. Despite being accurate down to 1/10 of mm, the intergluteal depth was not properly measured by this method due to buttock contact blurring the view of the sacral skin. Thus, we opted for mechanical measurement, modifying the method of Akinci et al. (13). To avoid the compression of the buttocks by heavy instrumentation and consequently lower IGF measurements, an electronic measurement tool from carbon fibre was procured (Kynup, digital caliper, Shenzeng Keyungu Network, Shenzen, China), and a lightweight aluminium plate (with a contact area of 20×3 cm) fixed below by our technical crew (with a total weight of 118 g). Upon calibration, the measuring device showed a deviation of no more than one millimeter across twenty measurements on a hard surface.

Measuring Procedure

To gauge IGF depth, the distance from the upper opening of the IGF (with a sub-3 mm diameter) to the IGF's end at the anus was evaluated. This span was split into four equal parts, resulting in five measuring points marked using a water-soluble pen. Measurements were taken at positions "a" (IGF opening), position "e" (anus), at the midpoint between a and e ("c", mid IGF), and at the midpoints between a and c ("b", 1/4), and c and e ("d", 3/4) (Figure 1). The procedure involved gently placing the tool's thin alloy plate over both buttocks without pressure as patients lay prone. The plastic lever was gently lowered until the midline's IGF depth was visually identified.

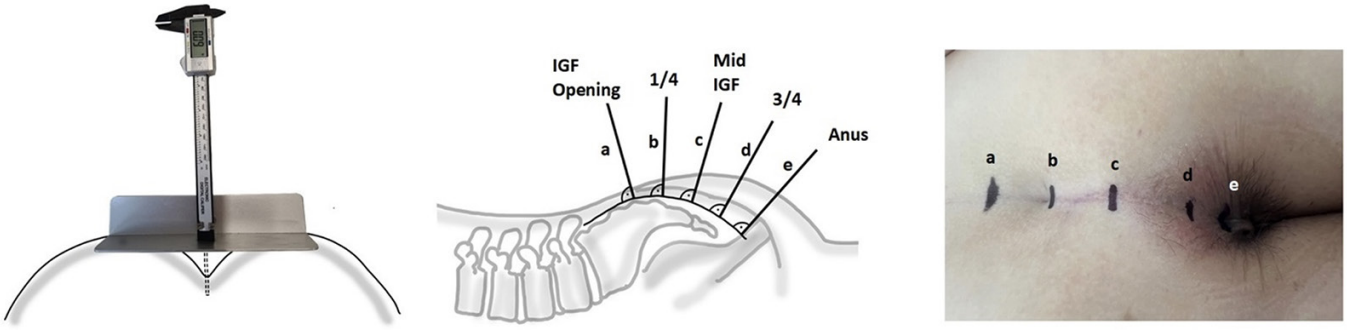

Figure 1. The left side of the figure shows a photo of the lightweight measuring tool used in the study. Please note that the numbers on the tool in the illustration are not correct and are for illustrative purposes only.

On the right side of the figure, there is an illustration demonstrating the measuring points. The measuring tool was positioned at a 90-degree angle to the sacral bone. The distance from the upper opening of the intergluteal fold (point A, with a diameter of less than 3 mm) to the end of the intergluteal fold at the anus (point E) was measured. This length was then divided into four equal parts, resulting in the identification of three additional points: B, C, and D.

IGF: Intergluteal fold

Measuring Protocol

All measurements were consistently conducted by the same investigator (LB) to avoid interobserver variability. For precision, each IGF depth at positions "a" to "e" underwent five measurements (with a variability of 1-3 mm per measurement). These measurements were recorded and the mean was used for analysis. The instrument was always positioned perpendicular to the sacral bone to measure skin-to-midline distance, as depicted in Figure 1.

Statistical Analysis

The study data were recorded in an Excel sheet (Excel 2016, Microsoft Corporation, Redmond, WA, USA). Continuous variables are presented as mean ± standard deviation (SD). Categorical variables are expressed as proportions and analyzed using Fisher's t-test. To assess differences between group means, we conducted an ANOVA. Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

Ethics: The study received approval from the Ethics Committee of Saarland (number: 59/22, date: 11.07.2022). The study was conducted in compliance with these guidelines and regulations, prioritizing the welfare and rights of the participants (15). The analysis done in this study did not contain any interventions that could potentially cause harm to human participants. Nevertheless, ethic approval was given by the Ethics Committee of the county Ethics chamber of the Saarland University Homburg/Saar 59/22 from 11th of July 2022 (Chair Prof. Dr. Grundmann) and by the Ethics Committee Hannover GRAE/151/2022 from 19th of August 2022 (Head Prof. Dr. Creutzig).

RESULTS

The study population consisted of 125 males (62.5%) and 75 females (37.5%). The age of the participants ranged from 16 to 81 years (PSD 16-77, non-PSD 16-81), with a mean (±SD) age of 37.7 (±15.5) years. The age and sex distribution between the PSD and non-PSD groups were not significantly different.

The participants' BMI had a mean (± SD) value of 27.2 (±5.1) kg/m^2. The range of BMI values was 17.8 to 50.6 kg/m^2.

The mean (± SD) length of the IGF from Glabella sacralis to anus was 16.3 (±2.5) cm in males and 15.3 (±2.5) cm in females. The mean IGF depth at different positions were as follows: 9.1 (±3.3) mm at the IGF opening (position a), 21.1 (±8.1) mm at ¼ (position b), 32.4 (±10.1) mm at mid IGF (position c), 45.6 (±10.0) mm at ¾ (position d), and 61.8 (±10.8) mm at the anus (position e). The largest IGF depth was observed between the gluteal muscles at the level of the anus. There were no statistically significant differences in IGF depth between males and females (p=0.816; t-test), or between PSD- and non-PSD patients (p=0.833; t-test; Figure 2).

A relationship between BMI and IGF depth was examined. There was a moderate increase in IGF depth with increasing BMI (slope 95% confidence interval: 0.01050 to 0.5088, R square =0.004163, p=0.041). The data indicate that the IGF depth moderately increases with BMI in our cohort at this time, measured with this method.

Age and its effect on body composition were found to affect BMI in the cohort, with a mean (± SD) increase in BMI over age, from the third decade of life (25.0±3.9 kg/m^2) to the ninth decade (28.5±5.3 kg/m^2).

The effect of age on IGF depth was analyzed between the third and ninth decades (Table 1). It was observed that IGF depth decreased at all five measuring points; with the largest decrease (by a factor of 1.7) observed in the mid region of the IGF (position c) (Table 1). This indicates a decrease in IGF depth with age at all measured points while BMI slightly increases, suggesting a less muscular contour effect.

Overall, these findings suggest that IGF depth is not significantly influenced by gender or the presence of PSD, but it shows a moderate association with BMI and a decrease with advancing age.

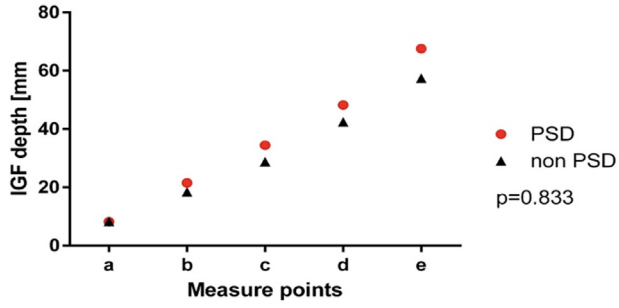

Figure 2. IGF depth for PSD versus non-PSD patients in predefined measuring points: (a) cranial opening of intergluteal fold (IGF opening), (b) proximal intergluteal fold, ¼ distance, (c) midpoint of the intergluteal fold (Mid IGF), (d) distal intergluteal fold, ¾ distance, (e) caudal end of intergluteal fold, anus.

IGF: Intergluteal fold, PSD: Pilonidal sinus disease

Table 1. Intergluteal fold depth [in mm] at five measuring points a-e, versus age decades 3-9

Age [decade]	a	b	c	d	e
20-29 [3]	1.55	2.91	4.27	5.73	7.00
30-39 [4]	1.48	2.78	4.03	5.55	7.10
40-49 [5]	1.33	2.82	3.98	5.20	7.00
50-59 [6]	1.21	2.33	3.29	4.75	6.42
60-69 [7]	1.28	2.64	3.56	5.04	6.40
70-79 [8]	1.05	1.89	3.00	4.42	6.16
80-89 [9]	1.00	2.25	2.50	3.50	5.75

Measuring points: (a) cranial opening of intergluteal fold; (b) proximal intergluteal fold; (c) mid intergluteal fold; (d) distal intergluteal fold; (e) caudal end of intergluteal fold close to anus

DISCUSSION

Although hair is not always found in pilonidal sinuses, the mechanism behind hair fragment insertion in PSD remains a key research subject. While factors such as increased axial hair force (positive) and sweating (negative) have been identified, further exploration is needed. After the 2009 publication suggested IGF depth as a potential risk factor, contrasting clinical findings led us to hypothesize that the IGF depth is not independently associated with PSD risk.

In our study, we conducted measurements using a standardized 5-point method with a lightweight tool in a larger cohort and found no significant difference in the depth of the natal cleft between PSD patients and the normal population. This raises doubts about the overall influence of IGF depth on the PSD development for several reasons. First, the maximum IGF depth occurs at the anus, where PSD is rare (16). Most PSD cases are found at the cranial opening of the IGF near the glabella sacralis (point A to B Figure 1), questioning the relevance of a region unaffected by PSD in the disease's genesis. Additionally, at the cranial opening, where PSD originates, IGF depth is minimal and seems unrelated to the disease's development. Prior studies have shown that sharp hair fragments tend to slide down the back and enter the skin at the cranial IGF opening. We assume that existing local hair helps hold the loose hair upright, allowing it to remain in position while gluteal muscle movement and the friction of the surrounding tissue drive it into the skin.

The differences between our findings and those of the previous Turkish study can be attributed to several factors. One potential explanation is the difference in populations. Our study focused on a northern German cohort, while the Turkish study involved a different population. Genetic, environmental, and lifestyle factors could affect the prevalence of PSD and its risk factors. Furthermore, the sample sizes in the two studies vary, which could impact the statistical power of the findings, with larger sample sizes generally producing more reliable results.

Methodological differences between the studies could also explain the inconsistent IGF depth measurements. Heavier measuring tools, for example, may compress the gluteal muscle and artificially reduce IGF depth. In our study, measurements in three of five positions exceeded the maximum depths recorded in the study by Akinci et al. (13). While body weight could theoretically explain this shallower IGF depth, we showed that reducing BMI from 50 to 20 kg/m^2, only decreases IGF depth by 25%. Therefore, the data suggest it's impossible for BMI to be a significant factor in reducing IGF depth by a factor of two in the Turkish cohort.

Age-related muscle atrophy is also unlikely to explain the discrepancy, as the Turkish cohort had a mean age of 27 years, while our cohort had a median age of 38 years, which suggests that IGF-related characteristics should have been more prominent in the younger Turkish population. Additionally, the Turkish study included 14% females, while our study had a much larger proportion of female participants (37.5%). While females in our study showed a trend toward lower BMI and smaller IGF depths, the smaller number of females in the Turkish study cannot fully explain the deviation in measurements. Given that differences in age, BMI, and gender composition do not account for lower IGF measurements, we propose that these discrepancies may be due to compression of the gluteal muscle during measurement, possibly caused by the use of a heavy tool or manual pressure. Such conditions may not provide accurate measurements of delicate soft tissues like the IGF.

Study Limitations

The study does acknowledge certain limitations. IGF depth was measured in prone patients, a position represents only one of the positions individuals adopt throughout the day. This prone position was necessary for comparison with the previous study. Additionally, the population cohort in our study focused on a northern German population, whose anatomical characteristics and predispositions may differ from those in other regions. This could limit the applicability of our findings to other populations. While our study suggests similarities in PSD genesis between developed countries like Germany and Türkiye, each region's unique contributing factors should be considered, and caution is needed when extrapolating findings to other populations.

The presence of migrants in the German cohort may also contribute to anatomical diversity, though the extent of this influence was not explicitly detailed. To validate and reconcile these findings, further research involving diverse populations, larger sample sizes, and rigorous methodologies will be necessary. Such studies could offer a clearer understanding of the potential link between IGF depth and PSD risk.

This study reveals that the deepest point of the IGF consistently is located distant from areas where PSD primarily occurs. Consequently, it can be inferred that IGF depth does not correlate with PSD development and does not impact PSD therapy. Given that most sharp hair fragments measure between 5 and 15 mm, any structure within this range could elevate hair fragments, causing the sharp end to potentially penetrate the skin irrespective of IGF's anatomical features.

Our study's findings provide evidence that IGF depth lacks an association with PSD risk. IGF depth does not emerge as an independent risk factor for PSD.

CONCLUSION

In conclusion, this study conducted on a northern German cohort offers compelling evidence that IGF depth is not linked to PSD development and does not act as an independent risk factor.

Ethics

Ethics Committee Approval: The analysis done in this study did not contain any interventions that could potentially cause harm to human participants. Nevertheless, Ethic approval was given by the Ethics Committee of the county Ethics chamber of the Saarland University Homburg/Saar 59/22 from 11th of July 2022 (Chair Prof. Dr. Grundmann) and by the Ethics Committee Hannover GRAE/151/2022 from 19th of August 2022 (Head Prof. Dr. Creutzig).

Informed Consent: Participants were required to provide informed consent before being included in this study.

Footnotes

Author Contributions

Concept - D.D.; Design - D.D.; Supervision - D.D.; Fundings - D.D.; Materials - D.D.; Data Collection or Processing - L.B., D.D.; Analysis or Interpretation - M.M., P.M., L.B., M.B-M., M.S., M.O., D.D.; Literature Search - M.M., P.M., L.B., M.B-M., M.S., M.O., D.D.; Critical Review - M.M., P.M., L.B., M.B-M., M.S., M.O., D.D.; Writing - M.M., P.M., L.B., M.B-M., M.S., M.O., D.D.

Conflict of Interest: No conflict of interest was declared by the authors.

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