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Differences in Stride Length, Stance Width and Modified Harris Hip Score between Patients with Mild Limb Lengthening and Those Without Limb Lengthening at Three Months After Total Hip Arthroplasty at Prof. Dr. I G. N. G. Ngoerah General Hospital Denpasar

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ABSTRACT

Background: Total hip arthroplasty (THA) is a surgical intervention to alleviate pain, restore joint function, and improve quality of life for patients with hip joint degeneration, often caused by osteoarthritis (OA). A common complication after THA is limb length discrepancy (LLD), which affects biomechanics and gait, leading to potential discomfort and reduced functional ability. Mild limb lengthening (MLL), a subtype of LLD, can significantly impact stride length, stance width, and overall recovery. Evaluating these parameters provides insight into the biomechanical effects of LLD and informs rehabilitation strategies aimed at optimizing post-operative outcomes.
Materials and Methods: This cross-sectional study assessed 40 patients who underwent THA at RSUP Prof. IGNG Ngoerah between November 2023 and May 2024. Patients were divided into two groups: those with MLL (≤2 cm) and those without LLD. Inclusion criteria included primary THA, three-month follow-up, and consent for participation. Patients with severe complications, such as polyethylene wear or muscle atrophy, were excluded. Gait parameters, including stride length and stance width, were measured, and functional outcomes were evaluated using the Modified Harris Hip Score (MHHS). Statistical analyses were conducted using SPSS version 26.0. The Shapiro-Wilk test assessed normality, while independent T-tests and Mann-Whitney U tests compared normally and non-normally distributed data, respectively.
Results: Significant differences were observed in stride length ($p = 0.022$) and stance width ($p = 0.033$) between patients with and without MLL. MHHS scores were lower in the MLL group ($p = 0.033$), indicating reduced functional recovery. However, no significant difference was found in the stride length of the non-THA limb ($p = 0.482$). These findings highlight the impact of MLL on gait and overall recovery.

Conclusion: Mild limb lengthening after THA significantly affects gait parameters and functional outcomes, as reflected in reduced stride length, altered stance width, and lower MHHS scores. Early identification and targeted rehabilitation strategies are critical for optimizing recovery. Future studies with larger cohorts and extended follow-up are recommended to explore long-term effects and refine intervention approaches.

Keywords: Total hip arthroplasty, limb length discrepancy, gait analysis, rehabilitation

INTRODUCTION

Total hip arthroplasty (THA), also known as hip replacement surgery, is a procedure used to replace a damaged hip joint, often due to degenerative conditions like osteoarthritis (OA). The goal of THA is to alleviate pain, restore joint function, and improve the quality of life for patients suffering from hip joint degeneration. As people age and the severity of OA progresses, the need for THA becomes more common, especially in elderly individuals. The prevalence of THA ranges from 0.9% to 1.5% in the general population, increasing to 5% to 10% among those aged 60 and older with OA (Thompson and Miller, 2016).

The success of THA largely depends on the accuracy of the surgical procedure, as biomechanical imbalances can lead to significant complications. One common complication associated with THA is limb length discrepancy (LLD), which occurs when there is a difference in length between the operated and non-operated leg. After THA, patients frequently experience leg lengthening more often than shortening, and even small differences can have a considerable impact on biomechanics. LLD can lead to pelvic imbalance, gait disturbances, and general discomfort. Severe LLD may result in significant disability, pain, and reduced functional ability, often necessitating additional medical interventions to correct the discrepancy. The effects of LLD are not confined to the lower limbs but can influence the entire body by affecting posture, weight distribution, and gait patterns. These imbalances result in uneven pressure distribution across joints, which increases the risk of chronic pain and musculoskeletal issues. (Azar et al., 2020; Thompson and Miller, 2016).

To compensate for LLD, patients often unconsciously adjust their posture and gait, which may impact pelvic stability and alter the biomechanics of the lower limbs. These compensatory adjustments can lead to changes in muscle tone and joint movement, ultimately reducing overall body function and mobility. As a result, gait efficiency is compromised, causing increased discomfort, challenges with mobility, and a decrease in the patient's quality of life. Rehabilitation plays a crucial role in the recovery process after THA, especially in managing issues related to LLD. Rehabilitation aims to help patients adapt to changes in limb length and their new prosthetic joints. Gait evaluation is an essential component of rehabilitation, involving the analysis of gait parameters such as stride length and stance width. These evaluations help assess the patient's walking ability, stability, and balance, allowing healthcare providers to tailor rehabilitation programs that address individual needs and optimize recovery outcomes. (Clement et al., 2016; McWilliams et al., 2013).

Stride length, the distance traveled by one leg during a complete walking cycle, is influenced by limb length and muscle strength. Abnormal stride length can indicate biomechanical issues, such as LLD or muscle weakness. Stance width, the distance between the feet when standing or walking, plays an important role in maintaining balance and stability. A wider stance can provide a stable base, reducing the risk of falls, but an excessively wide stance may indicate compensatory efforts to maintain balance, suggesting underlying biomechanical issues. By evaluating these parameters, medical professionals can identify specific biomechanical challenges and create effective rehabilitation strategies that enhance mobility and overall quality of life. Functional outcomes after THA are often assessed using tools like the Modified Harris Hip Score (MHHS), an adaptation of the Harris Hip Score (HHS). While HHS traditionally focuses on pain and general hip joint function, it has limitations when assessing younger, more active patients. MHHS addresses these limitations by incorporating a broader range of activities and placing less emphasis on pain, allowing for a more accurate evaluation of functional recovery in active patients. (Beard et al., 2008; PARVIZI et al., 2003).

This study focused on the effects of Mild Limb Lengthening (MLL) on stride length, stance width, and functional outcomes measured by the MHHS after THA. By assessing gait parameters like stride length and stance width, researchers sought to understand the biomechanical impact of LLD on patients' walking function. The findings of this study will also provide insights into the importance of post-surgery rehabilitation programs for improving gait patterns, restoring balance, and thus, enhancing quality of life.

MATERIALS AND METHODS

This study uses a cross-sectional design to determine differences in stride length, stance width, and MHHS assessments between patients with mild limb lengthening and those without limb lengthening at 3 months post-total hip arthroplasty. The population in this study were all hip osteoarthritis patients who underwent total hip arthroplasty in the period of November 2023 – May 2024 at RSUP Prof. I.G.N.G. Ngoerah. The sample size in this study was calculated using the formula for the size of the numerical comparative test sample size of two groups and from the calculation, the minimum number of samples for each group is 10 and the minimum total number of samples is 20 samples.

Inclusion and Exclusion Criteria

To ensure the validity of the study and control for potential confounding variables, strict inclusion and exclusion criteria were established. Inclusion criteria required patients to be undergoing primary total hip arthroplasty, to have a follow-up period of at least three months, and to provide post-operative hip X-ray results. Additionally, patients needed to consent to participate in the study and cooperate during examinations. Exclusion criteria eliminated patients with catastrophic polyethylene wear, abductor muscle atrophy, or nonunion of the greater trochanter. The analysis of mean and proportion differences in confounding variables indicated significant differences between the two groups, affirming their comparability for the stud. (Lai et al., 2001; McWilliams et al., 2013; Zhang et al., 2015).

STATISTICAL ANALYSIS

The data will be analyzed using the Statistical Package for Social Science (SPSS) version 26.0 program. To find out whether the data has a normal distribution or not, the data will be analyzed by the Shapiro-Wilk test because the number of samples < 50. The data has a normal distribution if the p value > 0.05 on the normality test. The normally distributed data were presented as averages ± standard deviations and analyzed using an independent T-Test. The data that are not normally distributed will be presented as the median (range) and analyzed using the Mann-Whitney U non-parametric test. In the hypothesis test, p <0.05 is considered statistically significant. The categorical variable is presented as a frequency and analyzed using Fisher's exact test.

RESULTS

General Characteristics of Research Subjects

Based on search results from the Prof Dr I G N G Ngoerah Denpasar General Hospital for the period November 2023 to May 2024, a total of 40 research subjects were found who met the inclusion and exclusion criteria, with the following general characteristics:

Table 1. General Characteristics of Research Subjects

General Variable Characteristic	Status		*p value*
	Subject with LLD < 2 cm (n = 20)	Subject with LLD > 2 cm (n = 20)	
Mean Age (year ± SD)	58.10 ± 7.60	60.45 ± 7.97	0.269
Jenis Kelamin	Man: 8 (40%) woman: 12 (60%)	Man: 4 (20%) Woman: 16 (80%)	0.841
Rerata Indeks Massa Tubuh (kgBB/m^2 ± SD)	27.38 ± 2.46	26.62 ± 3.29	0.132

Differences in Stride Length and Stance Width in Patients with Mild Limb Lengthening Compared to Without Limb Lengthening Three Months After THA

Before conducting statistical tests, a normality test was performed using the Shapiro-Wilk test for a sample size < 50. An independent T-test was conducted to determine the differences between mild limb lengthening and step length, stride length, and stance width, and significant results were obtained ($p < 0.05$). The results of the independent T-test using SPSS software can be seen in Table 2 and Table 3.

Table 2. Data Normality Test Results using the Shapiro-Wilk Test

Variable	p	Information
Stride Length	0.380	Normal distribution
Stance Width	0.151	Normal distribution
MHHS	0.080	Normal distribution

Table 3. Difference between Mild Limb Lengthening and quantity, Stride Length, dan Stance Width

Variable	Mean ± Std. Deviation		*p*
	With MLL (n=20)	**Without *Limb Lengthening* (n=20)**	
Stride Length	61.74±14.34	69.27±4.27	0.022
Stance Width	11.47±2.67	9.65±2.16	0.033

An independent T-test was carried out to determine the difference between mild limb lengthening and the modified Harris hip score and obtained significant results ($p<0.05$).

Table 4. Mild Limb Lengthening on Modified Harris Hip Score (MHHS)

Variable	Mean ± Std. Deviation		*p*
	With MLL (n=20)	With out *Limb Lengthening* (n=20)	
MHHS	68.41 ± 11.27	75.3±8.46	0.033

Differences in Stride Length in non-THA Limb Between Patients With Mild Limb Lengthening and Patients Without Limb Lengthening at 3 Months Post-THA.

An independent T-test was carried out to determine the difference between the stride length of the two legs in patients with mild limb lengthening, and the results were not significant ($p>0.05$).

Table 5. Stride length comparison 3 months following THA

Variable	Mean ± Std. Deviation		*p*
	Patient with *Mild Limb Lengthening* (n=20)	Patient without *Limb Lengthening* (n=20)	
Stride length	59.74±4.79	58.0±4.43	0.482

DISCUSSSION

Characteristics of Study Subjects

The study examined a cohort of 40 patients who underwent Total Hip Arthroplasty (THA) at RSUP Prof. IGNG Ngoerah, starting from November 2023. This cohort comprised two distinct groups: 20 patients with mild limb lengthening (up to 2 cm) and 20 patients without limb lengthening. Key demographic variables, such as age and gender, were recorded. A mean difference test was employed for numerical variables, while a proportion difference test was used for nominal variables like gender. The analysis revealed no statistically significant differences between the two groups regarding these demographic factors.

Three months following THA, significant differences were observed in stride length and stance width between the two patient groups. The independent t-test yielded significant results for stride length ($p = 0.011$) and stance width ($p = 0.015$) in patients with mild limb lengthening. These findings align with previous research by McWilliams et al., who highlighted that larger leg length discrepancies (LLD) were associated with shorter gait, particularly in patients with LLD ranging from 1 to 2 cm. Similar results were noted by Lai et al. and Zhang et al., who documented reduced walking speed and stride length in patients with greater than 10 mm LLD. (Lai et al., 2001; McWilliams et al., 2013; Zhang et al., 2015).

In addition, another study by Plaass et al. showed that limb lengthening in THA patients resulted in poorer walking and gait ability compared to patients without limb lengthening. Röder et al. also found that gait was significantly associated with limb lengthening but not with pain reduction in patients with an average limb lengthening of 1.5 cm. Conversely, pain was significantly associated with leg shortening but not with patient gait. The reasons for this phenomenon may include several factors. First, limb lengthening can cause biomechanical changes to the leg and joint, resulting in disruptions to the patient's natural walking pattern. Second, a difference in leg length after surgery can cause an imbalance in loading on other joints, such as the hip, knee, and spine, ultimately affecting patient stability and gait. Third, the body takes time to adjust to the new leg length, and during this adaptation period, patients may experience discomfort and altered gait patterns. Lastly, a significant leg length difference can also affect proprioception and muscle coordination, which are essential for maintaining balance and gait quality. (Plaass et al., 2011; Röder et al., 2012).

The gait pattern resulting from leg length discrepancy is characterized by reduced stance time on the shorter limb, decreased walking speed, increased stride length, and reduced step length on the shorter side. To compensate during walking, individuals may hold the shorter-side foot in an equinus position, tilt the pelvis by dropping it on the shorter side, and flex the contralateral knee. These compensatory mechanisms aim to equalize functional leg length and minimize displacement of the center of gravity, thereby reducing energy expenditure. Typically, patients adopt an equinus foot position and drop the pelvis on the shorter side, while contralateral knee flexion is more commonly employed for larger discrepancies. Other compensatory adjustments for small discrepancies include supination of the foot on the shorter side (to lengthen it) and pronation of the foot on the longer side (to shorten it) (Sato et al., 2020; Sayed-Noor and Sjödén, 2006).

Despite these compensations, leg length discrepancy often leads to an asymmetric gait, evidenced by differences in the vertical ground reaction force vectors between the shorter and longer limbs. In contrast, a normal gait is symmetrical, with similar ground reaction force vectors for both legs. Many individuals with normal gait may have a leg length discrepancy of up to eight millimeters, which is generally considered functionally insignificant, as it can be easily compensated for without causing a limp. Discrepancies of 1.2 to 2.5 centimeters have been linked to hip joint arthritis on the longer side. Using ground reaction force vector analysis, Kaufman et al. found that leg length discrepancies greater than two centimeters resulted in gait asymmetry between the longer and shorter limbs. They quantified this asymmetry by comparing stance time, vertical force peaks, and loading and unloading rates, observing greater levels of asymmetry compared to the general population, which tended to increase with larger discrepancies and varied based on individual functional adaptations. A discrepancy exceeding 5.5% led to increased mechanical work by the longer leg and greater vertical displacement of the body's center of gravity (Gordon and Davis, 2019; Kaufman et al., 1996; Schmidle et al., 2022b)

Modified Harris Hip Score (MHHS) Outcomes

There is a Significant Difference Between Mild Limb Lengthening and the Modified Harris Hip Score (MHHS) in patients 3 Months Post-THA. The study also assessed the Modified Harris Hip Score (MHHS) to evaluate functional outcomes at three months post-THA. An independent t-test indicated a significant difference in MHHS scores (p = 0.028) between patients with and without mild limb lengthening. Previous studies, including those by Beard et al., confirmed that functional scores decline with increasing limb length discrepancies, particularly in patients with more than 10 mm of lengthening. This decline can be attributed to changes in pelvic balance, tension on soft tissues, and biomechanical implications that affect walking, posture, and stability. While differences of less than 1 cm in leg length are often deemed acceptable, increasing discrepancies may lead to significant functional limitations and musculoskeletal disorders. The observed decrease in MHHS scores among patients with greater limb length discrepancies underscores the importance of addressing these changes in post-operative care. This also explains why the Modified Harris Hip Score in patients with limb length discrepancy (LLD) decreases with increasing LLD post-THA (Beard et al., 2008; Li et al., 2021b; Zhang et al., 2015).

Stride Length of the Non-THA Limb

In examining the stride length of the non-THA limb, the independent t-test revealed no significant difference (p = 0.482) between patients with mild limb lengthening and those without limb lengthening. However, patients with mild limb lengthening typically display a difference in stride length between limbs. This discrepancy in stride length can signal underlying biomechanical issues that compromise walking stability and efficiency. Mild limb lengthening, defined as an increase of less than 2 cm, often results from the placement of prosthetic components during THA. Although even minor changes in limb length can influence gait mechanics, patients frequently experience alterations in their walking patterns, including uneven stride lengths and load asymmetry. These changes may lead to increased discomfort or pain, particularly in joints that bear more weight during walking. (Zhang et al., 2015).

This study may have a limited sample size, which could affect the validity and reliability of the results. With a small sample size, the findings may not reflect the wider population, and sampling errors may have a greater impact on the results. A larger sample would improve data variability, allowing the results to be more generalizable and to have greater statistical power. Furthermore, the study is limited to a three-month period post-Total Hip Arthroplasty (THA). This short follow-up duration may not be sufficient to observe the long-term effects of limb lengthening in patients after THA. Long-term effects such as gait adaptation, biomechanical changes, and patient quality of life may take longer to become evident and be fully evaluated. Short-term results may not capture complications or side effects that could emerge after a longer follow-up period. Therefore, to fully understand the impact of limb lengthening on patients post-THA, a study with a longer follow-up period and a larger number of participants is needed to obtain a more comprehensive and accurate picture of the effects of this procedure. Long-term research would also help identify factors that may contribute to positive or negative outcomes, as well as aid in developing more effective intervention strategies to improve clinical outcomes for patients.

CONCLUSION

The findings of this study highlight significant differences in gait parameters and functional outcomes between patients with mild limb lengthening and those without, three months following total hip arthroplasty (THA). Specifically, differences in stride length, stance width, and the Modified Harris Hip Score indicate that mild limb lengthening can have a notable impact on post-operative recovery and functional performance. These results underscore the importance of monitoring and addressing limb length discrepancies in the early post-operative period to optimize rehabilitation strategies.

To enhance the robustness of future research, it is recommended to increase the sample size, which would improve data variability and the generalizability of findings. Additionally, conducting studies with a follow-up period extending beyond three months will allow for a more thorough evaluation of the long-term effects of mild limb lengthening on gait and overall quality of life in post-THA patients. This approach will contribute to the development of targeted interventions and better clinical outcomes for patients undergoing hip arthroplasty.

Declaration by Authors

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