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STUDY ON THE EFFECTS OF ANABOLIC STEROIDS ON POST-TOTAL KNEE ARTHROPLASTY RECOVERY: A DOUBLE-BLIND STUDY

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ABSTRACT

This pilot study aimed to investigate the effects of Nandrolone decanoate, an anabolic steroid, on post-total knee arthroplasty (TKA) recovery and muscle strength. The study also assessed the drug's safety in patients with multimorbidity. A double-blind randomized study design was employed, with patients receiving either Nandrolone decanoate or a saline placebo intramuscularly biweekly for six months. The steroid group consisted of patients with an average BMI of 40.9 and a mean age of 65.2. The control group comprised five participants with ages ranging from 55 to 70 and BMI ranging from 20.5 to 34.5, who received saline injections. Knee society scores (KSS) and functional tests (sit-to-stand, timed walking) were conducted at specified intervals, along with bone mineral density scans to measure changes before and after surgery. The steroid group consistently outperformed the control group in all functional tests based on analysis of variance (ANOVA). After 6, 18, and 24 months of postoperative recovery, the steroid group exhibited significant improvements in quadriceps muscle strength compared to the control group. Furthermore, significant differences in KSS scores were observed at six weeks, 6 months, and 24 months, indicating a better overall outcome in the steroid group. However, the steroid group did not show a statistically significant change in bone mineral density from pre- to post-surgery, despite reductions in lumbar spine and femur mineral density during the surgical procedure. This pilot study suggests that the use of Nandrolone decanoate following TKA may lead to improved functional outcomes and quadriceps muscle strength

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during postoperative recovery. Further research with a larger sample size is warranted to validate these findings and evaluate long-term safety considerations.

KEYWORDS: Post-total knee arthroplasty, Steroids, Nandrolone decanoate, Knee society scores

INTRODUCTION

Total knee replacement surgery is a highly effective treatment for end-stage osteoarthritis of the knee, a condition affecting approximately 10% of the population over the age of 55. Although long-term studies have reported high success rates, with survival rates ranging from 84% to 98% at 15 years based on distal endpoints like revision surgery, optimizing postoperative recovery and functional outcomes remains an ongoing goal [1]. Following total knee replacement, patients commonly experience improved overall health; however, pain and stiffness reduction in the initial three months post-surgery are significant. One area that often suffers is the quadriceps muscle, leading to a loss of strength [2]. Postoperative muscle strength plays a crucial role in functional performance, making it vital to explore interventions that can accelerate recovery and maximize the benefits of surgery [3].

Anabolic steroids, commonly used by athletes to enhance performance, can have profound effects on the musculoskeletal system. These substances can increase lean body mass, induce muscle fiber hypertrophy [4], and enhance muscle strength and mass. Given these potential benefits, there is a hypothesis that anabolic steroids may have advantageous effects on strengthening postoperative muscles in elderly patients undergoing knee replacement surgery, leading to improved mobility and faster recovery rates. Bone mineral density is another important factor to consider [5].

Anabolic steroids may influence bone health, and exploring their impact on bone mineral density after total knee replacement is relevant to assess their overall effects. To investigate the potential benefits of anabolic steroids in postoperative recovery [6], specifically muscle recovery, strength, and bone mineral density, we conducted a study administering small doses of Nandrolone decanoate, an anabolic steroid [7], to patients following total knee replacement surgery. A comparison was made between the group receiving the steroid injections and the control group receiving saline injections [8], with the aim of evaluating whether anabolic steroids can enhance recovery, muscle strength, and bone mineral density in this population.

Methodology

Study Design and Participants

This study employed a prospective double-blinded randomized trial design, conducted at a large regional academic teaching hospital. All subjects provided both verbal and written informed

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consent prior to participation. The study included individuals aged 50 to 70 years with monolateral primary osteoarthritis, while patients with rheumatoid arthritis were excluded to prevent confounding factors. Patients with specific medical conditions such as prostate hypertrophy, cardiac conditions with chronic ischemia or acute coronary syndrome, chronic liver disease, chronic kidney failure, hypertrophic benign and malignant prostates, and those taking antiepileptic medications were also excluded. Prior to enrollment, a specialist physician evaluated all patients. The sample size consisted of five patients in each group.

Randomization

To achieve maximum randomization, closed envelopes were used for randomization as soon as possible after surgery. An internet-based generator was employed to generate a block of ten envelopes, ensuring uninterrupted randomization even in cases of exclusions.

Surgical Procedure and Postoperative Care

During surgery, all patients received both regional and general anesthesia. Prior to anesthesia, a dose of 2 grams of cefazolin was administered. Cemented total knee replacements (Stryker® DuraconTM) were performed using a standard midline incision and a parapatellar median approach. Computer navigation systems (Stryker® Navigation) guided the surgery in all cases. Following surgery, patients were taken to the surgical ward, where continuous passive motion (CPM) machines and Cryo/Cuff (Arthrex) cold compression were used intermittently from the first postoperative day onwards. Patients were mobilized and allowed to bear full weight on the first day after surgery [9]. Intravenous antibiotics and subcutaneous Enoxiparine (Clexane®) were administered until discharge, which occurred once the patient demonstrated a safe gait, performed straight leg raises, and achieved flexion to 90 degrees. Suture removal was conducted by the general practitioner on day 12 following surgery. Patient progress was assessed at six weeks, three months, six months, and twelve months after surgery using functional tests, strength assessment, and bone mineral density (BMD) measurement.

Intervention

The research nurse visited the patients while they were still in the hospital to explain the procedures. Patients in the intervention group received intramuscular injections of Nandrolone decanoate at a dose of 50 mg, while the control group received normal saline injections. The injections were administered twice weekly for a duration of six months [10].

Outcome Measures

The outcome measures included functional tests, strength assessment, and bone mineral density (BMD) measurement. Functional tests comprised a sitting-to-standing test and a timed walking test. Knee function was evaluated using the Knee Society Score (KSS). Thigh muscle strength

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was measured using the BiodexTM Isokinetic Dynamometer. BMD was assessed using DEXA scans. Means and standard deviations were calculated for age, height, mass, knee society scores, and BMD values. Independent samples t-tests were conducted to compare subject groups, while repeated measures ANOVA was employed to compare test limbs and occasions. Posthoc comparisons of means were conducted using LSD tests.

Statistical Analysis

Data analysis was performed using version 12.0.1 of the Statistical Package for Social Sciences (SPSS). As an exploratory study involving multiple variables, there was a high risk of Type 1 errors. However, considering the minimal consequences of such errors in this

Table 1 Control group and study group demographics

	Study group	Control group
Height	170	170
Male/female	2/3	1/4
Weighing (kg)	89	92
Age (in years)	65.2	66.1
Body Mass Index	40.9	21.8

Results

Subject characteristics

There were ten patients in the study. Two males and three females made up the study group, while one male and four females made up the control group. Each participant's physical characteristics are presented in Table 1. It was found there were no significant differences between the subjects' ages, heights, weights, or body mass indexes. In light of this, it was determined that the primary physical variables were adequately matched in both groups.

Knee Society Score

Based on the KSS and function scores calculated for the steroid and control groups (mean standard deviation), respectively, is shown in Table 2 and 3. KSS function scores did not improve post-operatively in either nandrolone or control groups. In spite of a trend toward higher function scores in the nandrolone group, no significant differences were found between the nandrolone and placebo groups. At three months, no significant difference was observed except for a difference in KSS results between subject groups.

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Sit-to-stand

Using the limbs of the control and steroid groups, we calculated the difference between standing from a sitting to a standing position for the non-involved limb and the involved limb. No main effect or interaction was significant in sit-to-stand data. A near significant difference in speed was observed between the steroid and control groups at post-surgery.

Timed walk

Comparison of walking times between steroid and control limbs (mean + standard deviation)

Table 2: Scoring system for Knee Society

	Preoperative	Week -6	6m	12m	18m	24m
Study	44.6 (± 8.9)	55.5 (± 5.9)	80.1 (± 6.1)	84.3 (± 6.1)	91.4 (± 6.1)	92.6 (± 3.4)
Control	47.1 (± 5.6)	67.5 (± 22.3)	75.3 (± 8.3)	71.2 (± 50.3)	69.1(± 12.1)	80.5 (± 7.2)
Value of p	0.27	0.01	0.08	0.04	0.04	0.02

Table 3: Functional Scores for Knee Societies

	Pre-Op	6 weeks	6m	12m	18m	24m
Study	51± (13.2)	53± (12.1)	61± (9.2)	81± (16.4)	80± (10.2)	81± (12.0)
Control	49 ± (0.01)	49 ± (0.01)	65 ± (14.1)	79± (13.1)	63 ± (12.1)	76 ± (15.5)
p-value	0.41	0.39	1.4	0.24	0.28	0.17

Table 5 presents the groups. According to the statistical analysis of the walking data, there were no significant main effects or interactions. Nandrolone, however, showed steady improvements from 6 weeks to 6 months, compared to the control group that showed only minor improvements. Walking speeds for the nandrolone group, however, approximated those of the control group after 18 and 30 months.

Power in quadriceps and hamstrings

As shown in Table 6 and 7, the steroid and control groups reported mean strength values with standard deviations for the non-involved and involved quadriceps and hamstrings at 180•s-1 for both non-involved limbs. After six, twelve and two years were significant differences were found

between groups for the quadriceps. As far as hamstring strength was concerned, no significant differences were observed between groups based on the test interval interaction. A steady improvement in quadriceps and hamstring strength was observed in the nandrolone group throughout the follow-up period. Compared to the experimental group, the control group only showed minimal improvement for peak torque for the hamstrings.

Density of bone minerals

The two groups' mean and standard deviations of bone mineral density at the femur and spine are shown in Table 8. At no point during the study did any of the subjects show abnormal BMD values. Both groups showed decreased bone mineral density 6 months after surgery at the femur and spine. Both the femur and spine BMD of the nandrolone group decreased less significantly in percentage terms. Even so, no significant differences emerged between the groups based on statistical analysis.

Table 4: Stand up from sitting

	Pre - Op	6 weeks	6m	12m	18m	24m
Study	9.8 (± 2.6)	8.9 (± 1.5)	7.5 (± 1.5)	8.5 (± 3.9)	6.8 (± 1.2)	7.8 (± 1.8)
Control	10.5 (± 6.1)	12.1 (± 5.5)	10.5 (± 4.6)	10.6 (± 6.3)	9.9 (± 2.4)	9.5 (± 2.3)
p-value	0.10	0.85	0.17	0.64	0.18	0.61

Table 5: Test on time takes to walk (in seconds)

	Pre-Op	6 weeks	6 m	12m	18 m	24m
Study	20(± 2.5)	22.6 (± 8.5)	17.8 (± 3.6)	16.8 (± 3.2)	17.7 (± 2.9)	20 (± 6.1)
Control	22.5 (± 2.5)	22.8 (± 1.5)	22.8 (± 4.1)	21.9 (± 4.7)	22.3 (± 2.7)	21.4 (± 2.4)
*P**	0.10	0.81	0.17	0.14	0.16	0.60

Table 6: Strength of the quadriceps in NM at 180° seconds

	Pre-Op	6 wk	6m	12m	18m	24m
Study	51.9 (± 13.1)	44 (±10.5)	75.6 (± 20.8)	76.5 (± 23.4)	77.4 (± 33.1)	81.4 (± 33.5)
Control	48.7 (± 27.8)	38.4 (± 12.1)	46.8 (± 12.8)	54.2 (± 7.9)	62.4 (± 5.9)	54.1 (± 10.4)
Value - p	0.74	0.54	0.01	0.02	0.31	0.01

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Table 7 Hamstring strength determined by the isokinetic force of 180° sec^{1} in Nm

	Pre-Op	6week	6m	12m	18m	24m
Study	37.8 (± 21.4)	26.2 (± 13.6)	38 (± 17.4)	38.1 (± 11.1)	45.5 (± 25.4)	40.8 (± 22.7)
Control	24.4 (± 13.8)	11.8 (± 9.8)	14.8 (± 10.8)	20.7 (± 13.5)	26.4 (± 10.4)	22.8 (± 8.4)
Value p	0.18	0.21	0.2	0.11	0.19	0.14

Table 8 Pre-op and 6-month postoperative BMD of the femur and spine in g/cm^{2}

	Pre-surgery femur anatomy	Surgically repaired 6 m femur	Loss of bone percentage	Preoperative spinal surgery	Surgical recovery post-spine surgery	Loss of bone percentage
Study	0.8235	0.807	-0.61%	1.247	1.230	-1.15%
Control	0.8226	0.787	-2.70%	1.16	1.134	-1.86%
Value p	0.8	0.81		0.18	0.05	

DISCUSSION

The findings of this study suggest that the administration of Nandrolone decanoate, an anabolic steroid, following knee replacement surgery can lead to improvements in quadriceps muscle strength and functional outcomes. Quadriceps weakness is a common issue after knee surgery, and addressing this weakness is crucial for optimizing postoperative recovery and functional performance. Previous studies have shown that preoperative quadriceps strength significantly influences functional outcomes following knee replacement surgery [11]. Even years after surgery, muscle weakness can persist, highlighting the importance of addressing this issue to improve long-term outcomes [12]. While strength training interventions have shown positive results, the effects of such interventions are still limited. Anabolic steroids, known for their impact on protein and bone metabolism, have gained interest in medical applications, including muscle preservation in aging populations. These substances can positively influence muscle size, strength, and lean body mass [13]. In this study, the administration of Nandrolone decanoate resulted in increased peak torque of the quadriceps and improved isokinetic torque. The knee

society functional score, functional tests, and slower decline in bone mineral density further support the potential benefits of Nandrolone in promoting functional recovery. It is important to note that this study used a biweekly administration of 50 mg of Nandrolone decanoate, which demonstrated a trend towards improved function without observed side effects. However, the use of anabolic steroids after major joint surgery has not been extensively studied in a double-blind prospective manner. Some studies in knee replacement and hip fracture patients have shown positive effects on gait [14], muscle volume, and bone loss, but further research is needed to fully understand the long-term risks and benefits of anabolic steroid use in this context. It is worth mentioning that this study has certain limitations [15]. The small number of participants in each group and potential selection bias may have contributed to measurement errors. However, these errors were minimized through rigorous study design, including the double-blind approach. Random errors and placebo effects could affect both groups equally.

CONCLUSIONS

In this pilot study, the administration of Nandrolone decanoate after knee replacement surgery demonstrated significant improvements in quadriceps muscle strength and clinical outcomes, as assessed by the knee society score. These findings suggest that anabolic steroids may have a beneficial effect on postoperative recovery and functional outcomes in this context. However, due to the small sample size and exploratory nature of this study, further research with a larger study population is required to confirm these results and establish the general applicability of anabolic steroid use after joint replacement surgery. Future studies should also investigate the long-term risks and potential side effects associated with the use of anabolic steroids in this patient population.

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