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RESEARCH

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Analysis of the efficacy of different amounts of parathyroid grafts in the treatment of secondary hyperparathyroidism

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Abstract

Purpose This study compares the efficacy of two different ranges of parathyroid transplantation weights with the aim of determining a preferable range for transplantation weight.

Methods From May 2018 to June 2023, 79 patients underwent total parathyroidectomy with autotransplantation. Demographic data, symptoms, and pre- or postoperative biochemical indicators were compared between two different ranges of parathyroid transplantation weights.

Results All 79 surgeries were successful, with a total of 316 parathyroid glands reported among the patients. The patients were diagnosed with parathyroid hyperplasia. Postoperatively, itching, bone pain, and muscle weakness disappeared, while serum parathyroid hormone and phosphate levels significantly decreased. With an average follow-up of 12 months, no transplant-dependent recurrence was observed.

Conclusion Parathyroid transplantation with a weight of 30–50 mg is a feasible, safe, and effective surgical approach.

Keywords Secondary hyperparathyroidism, Chronic kidney disease, Total parathyroidectomy, Parathyroid hormone, Autotransplantation

Background

Secondary hyperparathyroidism (SHPT) is a frequent and severe complication in patients with chronic kidney disease undergoing long-term dialysis. It is commonly characterized by elevated levels of parathyroid hormone (iPTH) in the blood, hyperphosphatemia, and hypercalcemia, and is associated with mortality from cardiovascular disease in dialysis patients [1]. The elevated levels of parathyroid hormone (PTH) in SHPT are associated with various clinical issues, including renal bone disease, increased calcium burden, higher risk of ectopic calcification, abnormalities in lipid and glucose metabolism, uncontrolled bone pain, and anemia [2]. These complications may complicate the clinical management of patients and negatively affect their quality of life [3–5]. Early treatment of SHPT mainly involves internal medicine treatment methods, which can slow down the progression of the disease [1]. However, patients with secondary hyperparathyroidism (SHPT) will experience a decrease in the expression levels of calcium-sensitive receptors and vitamin D receptors. Many patients gradually develop resistance to treatment and ultimately require surgical intervention [6, 7]. Parathyroidectomy is the preferred treatment method for secondary hyperparathyroidism (SHPT), as it can increase the survival rate of

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dialysis patients by 15–57%, while also improving hypercalcemia, hyperphosphatemia, tissue calcification, renal osteodystrophy, and the quality of life of the patients [6, 8]. Considering the potential to increase postoperative hypocalcemia levels and reduce recurrence rates, total parathyroidectomy with autotransplantation (tPTX+AT) has become the most popular surgical option currently [9]. However, there is no unified standard to determine the amount of autotransplantation between 30 and 80 milligrams [10]. Therefore, this study adopts a retrospective research approach to investigate the postoperative efficacy of different autotransplantation methods.

Methods

A total of 170 uremic patients who underwent long-term hemodialysis and total parathyroidectomy with autotransplantation (tPTX+AT) at the Liaoyang Central Hospital of China Medical University from May 2018 to June 2023 were studied through electronic medical records. After excluding 91 individuals who did not meet the inclusion criteria, 79 participants remained. Among them, 79 patients underwent tPTX+AT surgery, with 36 receiving a dose of 30-50 mg and 43 receiving a dose of 51-80 mg. The retrospective study and grouping of the research are shown in Fig. 1. The diagnostic criteria for secondary hyperparathyroidism (SHPT) are as follows: CKD stage 3: iPTH>70pg/ml; CKD stage 4: iPTH>110pg/ml; CKD stage 5: iPTH>300pg/ml. Indications for PTX surgery: (1) Persistent iPTH>800pg/ml; (2) Refractory hyperphosphatemia and/or hypercalcemia not responsive to drug therapy; (3) Enlarged parathyroid gland detected by imaging (such as high-frequency color Doppler ultrasound showing enlarged parathyroid glands with a diameter exceeding 1 cm and rich blood flow); (4) History of use of active vitamin D and its analogs with the occurrence of drug resistance.

Inclusion criteria: (1) Patients diagnosed with secondary hyperparathyroidism and meeting the indications for PTX surgery; (2) Regular hemodialysis for more than 3 months; (3) Age between 18 and 75 years old.

Exclusion criteria: malignancy, severe malnutrition, infection or inflammatory conditions, clotting disorders, patients with serious cardiopulmonary diseases who cannot tolerate surgery, those unwilling to participate in the study, and lost to follow-up patients, Ectopic parathyroid glands, intraoperative exploration of fewer than four or more parathyroid glands.

There is no unified standard for the weight of transplantation, and the range of transplantation in China is typically between 30-80mg [10]. Therefore, after collecting the data from our hospital, this study found that patients could be divided into the following two groups: Group A: 30-50 mg, Group B: 51-80 mg. A comparison was made between the two groups in terms of postoperative serum levels of calcium, phosphorus, intact parathyroid hormone (iPTH), and alkaline phosphatase, as well as improvements in clinical symptoms. Successful tPTX+AT surgery is indicated by a rapid decrease in iPTH levels and relief from clinical symptoms [11].

Postoperatively, bedside electrocardiographic monitoring was performed to observe the patients' vital signs and any occurrences of speech difficulties, swallowing

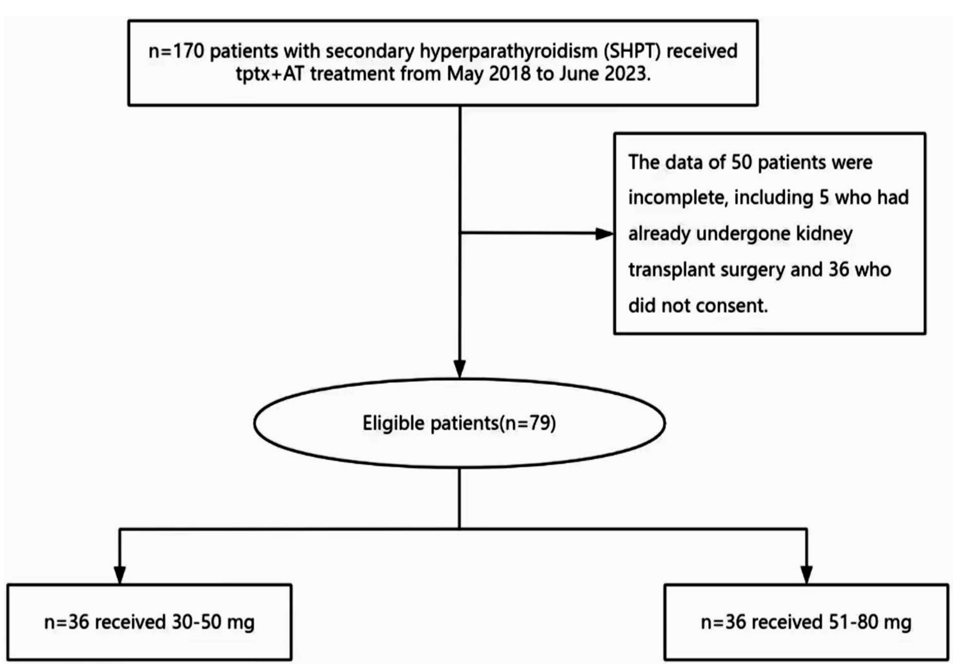

Fig. 1 Flowchart of the study's review and grouping process.3. Perioperative management

difficulties, incision bleeding, throat swelling, and numbness or convulsions in the mouth and limbs. Serum electrolyte levels were tested every 4 h, and if symptoms such as limb convulsions or numbness occurred, calcium supplementation was provided promptly. This could involve administering 3 g of 10% calcium gluconate mixed in 30 ml of normal saline via intravenous pump, along with oral calcium supplementation (such as calcitriol, calcium carbonate, or calcium acetate). Blood calcium levels should be monitored to remain between 1.8 and 2.2mmol/L.

Perioperative management

Transplantation method Identify the parathyroid glands that have been dissected, place them in 4 degree saline or tissue solution, cool for 30 min, and then physically separate them into tiny pieces, either by granulation or homogenization. Generally speaking, small tissues of about 1 mm are appropriate. 10–20 pieces of small tissue are more moderate in number. As long as the parathyroid tissue is dispersed into small pieces during transplantation, the success rate of transplantation is high.

During the operation, you can have an assistant help with blades and micro-syringes After the treatment is completed, choosing the appropriate graft site is key. Generally, the blood supply around the tissue is chosen to be rich and oxygen partial pressure supply is abundant. For example, within muscle tissue. The best graft site for thyroid surgery is the sternocleidomastoid muscle. No additional surgical incision or sterilization is required. Of course, other muscle sites are also suitable, such as deep in the muscle tissue of the extremities. Currently, subcutaneous adipose tissue under the abdominal wall as well as proximal subcutaneous adipose tissue in the extremities are also being studied, and there is no evidence as to whether grafting is more effective.

After the muscle was selected, multiple small cavities within the muscle were first bluntly separated, hemostasis was exact, and the chopped parathyroid tissue was filled into each small cavity in turn, and silk sutures were used to close the cavities. Placing more cavities can improve the survival rate of transplanted parathyroid glands. Homogenized parathyroid tissue tends to have a higher success rate because of its broader tissue graft contact surface.

Postoperatively, bedside electrocardiographic monitoring was performed to observe the patients' vital signs and any occurrences of speech difficulties, swallowing difficulties, incision bleeding, throat swelling, and numbness or convulsions in the mouth and limbs. Serum electrolyte levels were tested every 4 h, and if symptoms such as limb convulsions or numbness occurred, calcium supplementation was provided promptly. This could involve administering 3 g of 10% calcium gluconate in 30 ml normal saline via intravenous pump, along with oral calcium supplementation (such as calcitriol, calcium carbonate, or calcium acetate). Blood calcium levels should be monitored to remain between 1.8 and 2.2mmol/L.

Observation target

The baseline observational data in this study includes: ① General information: gender, age, duration of dialysis, body mass index, primary disease; ② Serum indicators: blood urea nitrogen, creatinine, calcium, phosphorus, potassium, sodium, chloride, albumin, alkaline phosphatase, PTH, 25-hydroxyvitamin D; ③ Incidence of complications: bone pain, itching, restless leg syndrome, and sleep disorders.

A total of 79 cases were included and divided into 2 groups according to the surgical methods: 36 cases in group A and 43 cases in group B. There was no difference in the baseline data between the 2 groups ($P > 0.05$), so there was no effect on the results and PSM (propensity score matching) was not needed. However, the differences in calcium, phosphorus, iPTH, hemoglobin, and alkaline phosphatase were significant ($P<0.05$), and there was selection bias and confounding variables. The propensity score matching (PSM) method was used to perform 1:1 matching with a tolerance of 0.2, and the matching variables were calcium, phosphorus, iPTH, hemoglobin, and alkaline phosphatase. The matching variables were calcium, phosphorus, iPTH, hemoglobin and alkaline phosphatase. 34 pairs of data were successfully matched.

Patients in our hospital's hemodialysis unit were followed up face-to-face and by reviewing medical records, while patients from other facilities were contacted via telephone follow-up with both the patients themselves and their respective hemodialysis center doctors to gather the following metrics: Serum indicators: calcium, phosphorus, PTH, and ALP at postoperative day 1, 1 month, and 6 months,12 months; Complication relief status: bone pain, skin itching, restless leg syndrome, and sleep disorders at 12 months post-surgery; The endpoint events include kidney transplantation, death, or the follow-up point at 12 months post-surgery for each patient.

Serological indicator collection

The timing for blood collection was chosen as the early morning of the second day after the patient's admission to the hospital. Venous blood was processed by centrifugation, and the supernatant was tested for various biochemical indicators: BUN, Cr, calcium, phosphorus, potassium, sodium, chloride, albumin, ALP, TC, and SI using a biochemical analyzer. The testing was completed by the Laboratory Department of Liaoyang Central Hospital of China Medical University.

Table 1 Baseline general information and clinical indicators of the two patient groups

Indicator	Group A	Group B	*P*-value
Age (years)	47.31 ± 11.93	45.51 ± 10.32	*p*>0.05
Gender (Male/Female)	15/21	20/23	*p*>0.05
Dialysis vintage (years)	6(4 8)	8(6 10)	*p*>0.05
BMI(kg/m2)	21.12(19.60 22.64)	21.76(19.21 24.32)	*p*>0.05
BUN(mmol/L)	19.37(15.54 23.2)	20.22(15.01 25.44)	*p*>0.05
Cr(umol/L)	916.13 ± 334.04	940.00 ± 307.21	*p*>0.05
K(mmol/L)	4.38(4.12 4.89)	4.45(4.10 5.00)	*p*>0.05
Na(mmol/L)	140.27(137.95 142.60)	141.55(139.10 144.00)	*p*>0.05
Cl(mmol/L)	98.31 ± 3.81	98.66 ± 4.14	*p*>0.05
25(OH)D3	19.05(9.70 28.43)	18.28(8.40 27.77)	*p*>0.05
TC(mmol/L)	4.95 ± 4.92	3.86 ± 0.92	*p*>0.05
SI(umol/L)	11.04(6.74 15.35)	12(7 17)	*p*>0.05

Note Group A represents TPTX+AT (30-50 mg), Group B represents TPTX+AT (51-80 mg). BMI stands for body mass index, BUN stands for blood urea nitrogen, Cr stands for creatinine, Na stands for sodium, Cl stands for chloride, Alb stands for albumin, ALP stands for alkaline phosphatase, PTH stands for parathyroid hormone, 25(OH)D stands for 25-hydroxyvitamin D, TC stands for total cholesterol, and SI stands for serum iron

Statistical methods

The statistical analysis was conducted using SPSS 26.0 software. Continuous variables that followed a normal distribution (age, Cr, Alb) were expressed as mean±standard deviation($\bar{x} \pm s$), and comparisons of individual time points before and after surgery within groups were conducted using paired sample t-tests. For comparisons involving three or more time points, repeated measures analysis of variance was utilized, while comparisons between groups at the same time points were done using independent sample t-tests. Skewed continuous data (BMI, BUN, calcium, phosphorus, ALP, PTH, 25(OH)D) were presented as median and interquartile range, and comparisons within groups for individual time points before and after surgery were performed using paired sample Mann-Whitney U tests. Comparisons involving three or more time points were conducted using K independent sample Mann-Whitney U tests, and comparisons between groups utilised double independent sample Mann-Whitney U tests. Gender, a categorical variable, was expressed as frequency (%), and comparisons were conducted using chi-square tests. Statistical significance was set at $P<0.05$.

Result

Basic information

This study is a single-center, retrospective clinical research. The most common primary disease in both groups is chronic glomerulonephritis. There were no statistically significant differences in the gender ratio, age, or other physiological indicators between the two groups ($P>0.05$). All patients underwent total parathyroidectomy combined with forearm autotransplantation. See Table 1.

Table 2 Changes in blood iPTH levels before and after surgery after PSM

	Group A	Group b	*P*-value
Pre-operation	1593.88(1276.88 1910.18)	1507.65(1201.78 2913.53)	*P*>0.05
Post-op 5 min	23.73(16.01 31.45)	48.55(28.08 68.47)	*P*<0.05
Post-op 10 min	15.83(11.10 20.57)	33.45(20.13 46.77)	*P*<0.05
Post-op 30 min	11.73(8.10 15.37)	25.05(13.36 34.74)	*P*<0.05
Post-op 1 week	1.46(0.55 2.37)	3.31(0.50 6.12)	*P*<0.05
Post-op 1 month	2.17(0.78 3.57)	3.57(1.44 9.57)	*P*<0.05
Post-op 3 months	2.68(1.35 5.77)	3.04(1.66 12.44)	*P*<0.05
Post-op 6 months	4.52(1.44 7.55)	5.99(2.36 15.77)	*P*<0.05
Post-op 12 months	5.22(2.45 23.57)	10.89(13.09 21.98)	*P*<0.05

Table 3 Changes in blood calcium levels before and after surgery after PSM

	A组	B组	P值
Pre-op Ca	5.37(4.36 6.39)	5.26(4.23 6.30)	*P*>0.05
Post-op day 1	2.03(1.83 2.24)	2.42(2.56 2.28)	*P*<0.05
Post-op 2 days	1.93(1.65 2.22)	2.15(1.81 2.22)	*P*<0.05
Post-op 3 days	2.05(1.89 2.12)	1.81(1.51 2.12)	*P*<0.05
Post-op 1 month	1.89(1.72 2.07)	1.87(1.68 2.06)	*P*<0.05
Post-op 3 months	1.84(1.66 2.03)	1.93(1.78 2.09)	*P*<0.05
Post-op 6 months	1.94(1.78 2.10)	241(2.07 2.76)	*P*<0.05

Table 4 Changes in blood phosphorus levels before and after surgery after PSM

	Group A	Group B	P值
Pre-op P	2.18 ± 0.46	2.18 ± 0.43	*P*>0.05
Post-op day 1	2.03 ± 0.37	2.05 ± 0.43	*P*<0.05
Post-op 2 days	1.82 ± 0.47	1.87 ± 0.40	*P*<0.05
Post-op 3 days	1.61 ± 0.50	1.69 ± 0.47	*P*<0.05
Post-op 1 month	1.41 ± 0.46	1.36 ± 0.36	*P*<0.05
Post-op 3 months	1.23 ± 0.37	1.19 ± 0.28	*P*<0.05
Post-op 6 months	1.25 ± 0.34	1.08 ± 0.23	*P*<0.05

Table 5 Changes in hemoglobin and alkaline phosphatase before and after surgery after PSM

	Hb(g/L)	ALP(U/L)
Preoperative	192.80 ± 21.8	267.81(119.40 416.23)
Post-op 1 month	107.47 ± 21.07	263.67(124.10 403.24)
Post-op 3 months	113.37 ± 21.07	96.18(66.22 122.14)*
Post-op 6 months	190.67 ± 15.68	89.05(63.00 116.00)*
Post-op 12 months	108.65 ± 17.73	87.90(65.4 110.40)*

Note * $P<0.05$ compared to preoperative values

Changes in serological indicators before and after surgery

Tables 2 and 3, and 4 show that postoperative levels of blood calcium, phosphorus, and PTH were significantly lower in both groups ($P<0.05$). As shown in Table 5, the hemoglobin levels at different time points postoperatively did not show any changes compared to preoperative levels and did not have statistical differences ($P>0.05$). Alkaline phosphatase levels also decreased compared to preoperative levels, but with statistical differences at 3, 6, and 12 months postoperatively ($P<0.05$).

Group A comprised 36 patients, while Group B had 43 patients

As shown in Fig. 2, there was a significant difference in iPTH levels between the two groups in the early postoperative period ($P<0.05$). However, As of December, this significant difference gradually diminished, but there still remained a notable distinction between the two groups ($P<0.05$).

As shown in Fig. 3, there was no difference in blood calcium levels between the two groups for a long time postoperatively. However, as time progressed, differences between the two groups could be observed at 6 and 12 months postoperatively ($P<0.05$).

As shown in Fig. 4, there was no difference in blood phosphorus levels between the two groups for a long time postoperatively. However, a difference can be observed at the 12-month postoperative mark ($P<0.05$).

5.2. In group A, there were 28 (82%) patients with preoperative bone pain, including 18 (52%) patients with mild pain, 9 (26%) patients with moderate pain, and 1 (2.9%) patient with severe pain. After 12 months of follow-up, all patients with mild bone pain had symptomatic relief; among those with moderate bone pain, 1 patient with severe bone pain was converted to mild bone pain.32 (94%) of patients with preoperative bone pain in group B, of whom 20 (58.8%) had mild pain, 10 (29.4%) had moderate pain, and 2 (5.8%) had severe pain. After 12 months of follow-up, the symptoms of those with mild bone pain were relieved; among those with moderate bone pain, 7 patients were relieved, 3 cases turned to mild pain, and among the 2 cases with severe bone pain, 1 case turned to mild pain and 1 case turned to moderate bone pain. The postoperative bone pain relieving rate in group A was 96.4% (27/28), and the postoperative bone pain relieving rate in group B was 84.3% (27/32), and there was no statistically significant difference in the comparison among the groups (P>0.05). 0.05). See Table 6. pruritus, sleep disorder, and restless leg syndrome were relieved to different degrees after surgery, and there was no statistically significant difference between the preoperative and postoperative incidence rates and postoperative relief rates of patients in the two groups ($P>0.05$).

Discussion

This single-center retrospective study collected clinical data from 68 SHPT patients who underwent tPTX+AT. The study results indicate that the use of excess parathyroid tissue of 51–80 micrograms (See Fig. 5 at the end of the text) as opposed to 30–50 micrograms (See Fig. 6 at the end of the text) can meet clinical needs. Changes in hemoglobin, alkaline phosphatase, iPTH, serum calcium, serum phosphorus levels, and improvements in clinical symptoms before and after surgery were analyzed. Observing the data mentioned above, it was found that there were significant statistical differences in iPTH, blood calcium, and blood phosphorus levels between patients at different time periods before and after surgery

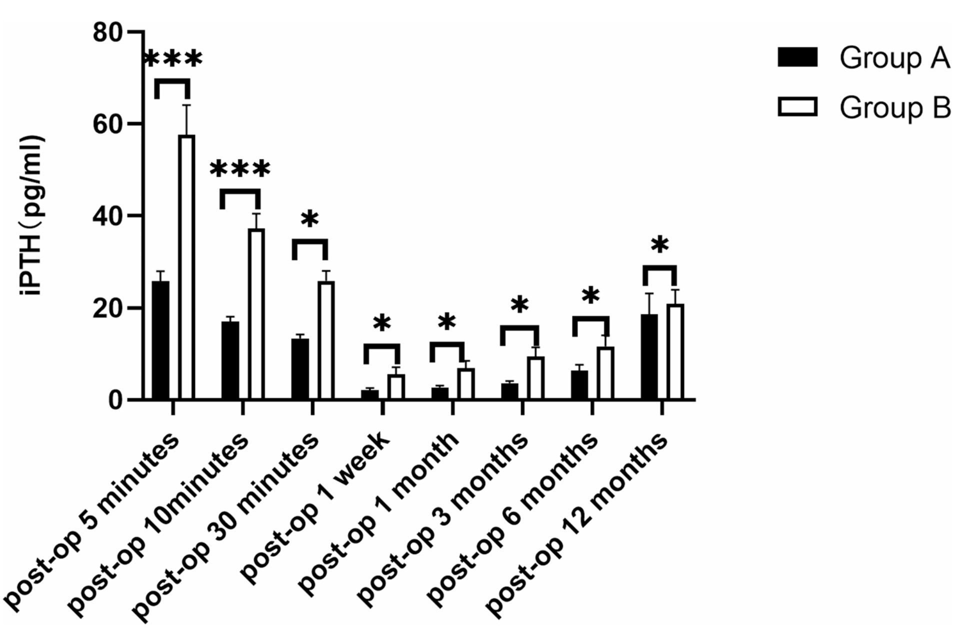

Fig. 2 Note * Comparison of different transplantation weights between the two groups, $P<0.05$

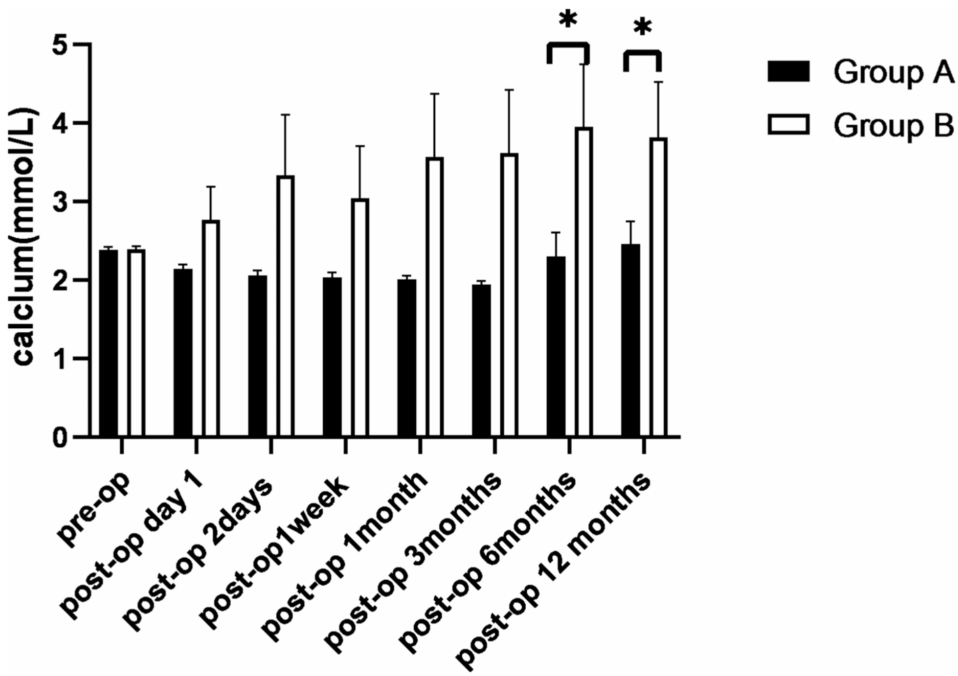

Fig. 3 Note * Comparison of different transplantation weights between the two groups, $P < 0.05$

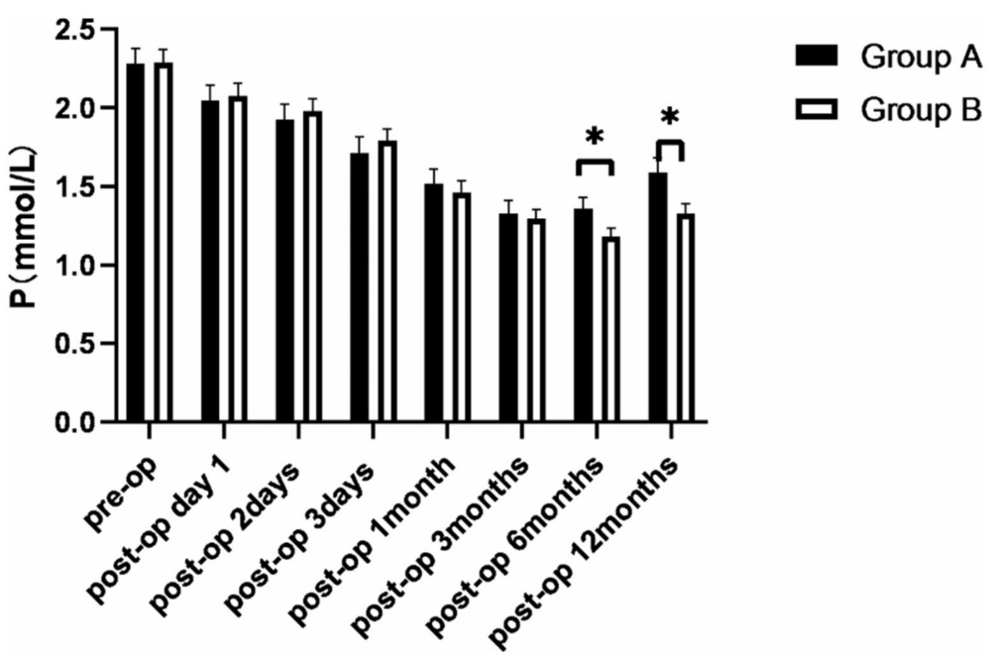

Fig. 4 Note * Comparison of different transplantation weights between the two groups, $P < 0.05$

in both groups. iPTH, blood calcium, and blood phosphorus levels in both groups significantly decreased compared to preoperative levels. The decrease in iPTH was more pronounced in group A compared to group B at 6 months. However, iPTH levels continued to rise with time after the first week postoperatively. The postoperative increase in iPTH may be related to the patient's dialysis time and regrowth of the transplanted tissue [12]. In Fig. 2, a significant reduction in differences between the two groups can be observed after one week postoperatively. This may also be related to the duration of dialysis and individual differences. Thus, it is clear that the efficacy of Group A is better than that of Group B. Successful tPTX+AT surgery is defined as a rapid decrease in iPTH levels and alleviation of clinical symptoms [13]. In Fig. 3, significant statistical differences between the two

Table 6 Improvement of clinical symptoms between preoperative and 12 months postoperative in both groups after PSM

Clinical symptoms	Group	Preoperative number of patients(%)	Postoperative number of patients(%)	*P*-value
Bone pain	Group A	28(82%)	1(2.9%)	<0.001
	Group B	32(94%)	5(14.7%)	<0.001
Skin itching	Group A	15(44.4%)	4(11.7%)	<0.01
	Group B	30(88.3%)	9(26.4%)	<0.01
Restlessleg syndrome	Group A	10(29.4%)	1(2.9%)	<0.01
	Group B	15(44.5%)	2(5.8%)	<0.01

Note Group A represents TPTX+AT (30-50 mg), and Group B represents TPTX+AT (51-80 mg)

Fig. 5 Weighed parathyroid tissue

groups were only observed at 6 and 12 months. Therefore, while there is not much difference between the two groups in the short term, over time, the rate of increase in calcium levels in Group A is slower than that in Group B. This indirectly reflects that the long-term efficacy of Group A is better than that of Group B. Similarly, when analyzing the comparison of phosphorus levels postoperatively between the two groups, statistical differences were only noted at 12 months, indicating that Group A has better long-term efficacy.

In this study, there were no significant changes in hemoglobin levels between the two groups of patients who underwent total parathyroidectomy combined with forearm autotransplantation compared to preoperative levels. This may be due to the patients having underlying kidney disease. Chronic kidney disease leads to irreversible damage to kidney parenchyma, resulting in a decrease in erythropoietin (EPO) secretion. The body lacks sufficient EPO to stimulate hematopoietic stem cells, which is why there was not much difference in hemoglobin levels compared to preoperative values. Alkaline phosphatase levels significantly decreased compared to preoperative levels, which better demonstrates the success of the surgery in both groups; however, there was no difference between the groups.

Fig. 6 Weighed parathyroid tissue

Chronic renal insufficiency significantly promotes the proliferation of parathyroid cells. With advancements in new technologies, the survival period of patients undergoing hemodialysis has been extended. A serious complication that occurs in patients with advanced chronic kidney disease (CKD) is secondary hyperparathyroidism (SHPT), which is characterized by widespread parathyroid hyperplasia and elevated levels of parathyroid hormone (PTH) in the serum [14, 15]. The main surgical PTX procedures include total parathyroidectomy (tPTX), subtotal parathyroidectomy (sPTX), and total parathyroidectomy with autotransplantation (tPTX-AT) [16]. Although all three types of surgery are in use, tPTX-AT has gradually become the mainstream procedure [17]. Currently, there are many studies comparing different surgical techniques, but there is limited research on the weight of transplants. Autotransplantation of 30–50 mg of parathyroid tissue is a safe and effective approach. Surgical failure may be attributed to inadequate preoperative localization, incomplete exploration, and the natural process of parathyroid tissue regrowth. Although it is not definitive which surgical approach has absolute superiority, thorough exploration of the neck can help improve the success rate of the surgery. For patients requiring long-term hemodialysis, ignoring the risk of recurrence is not advisable; to prevent HPT recurrence, all parathyroid tissues, including those in abnormal locations, must be completely excised. Most patients undergo dialysis treatment through bilateral forearm arteriovenous fistulas created via the antecubital approach. Removal of residual parathyroid tissue in the forearm is considered to be more feasible and safe in cases of recurrence compared to transplanting in the superior mediastinal region. Revision surgery for recurrent hyperparathyroidism due to autotransplantation is typically simpler because the surgical pathway in the forearm area is direct, does not require general anesthesia, and reduces the risk of major surgical complications.

Ideally, the completeness of the surgery can be biochemically confirmed using intraoperative PTH measurements. If the intraoperative PTH exceeds 400ng/L, it may indicate that there is residual parathyroid tissue that has not been completely excised. With the widespread use of intraoperative parathyroid hormone measurement as an auxiliary tool to guide surgical completeness, the controversy over whether further exploration for excess glands is necessary may diminish. The application of intraoperative parathyroid hormone monitoring could serve as a beneficial adjunctive measure to ensure that patients have undergone sufficient parathyroidectomy to treat secondary hyperparathyroidism during surgery [18–20].

The study indicated that in patients with renal osteodystrophy and normal liver function, ALP levels can serve as an indicator of osteoblast activity, which is positively correlated with the severity of preoperative renal bone disease. Additionally, patients with a condition known as "starvation bone syndrome" exhibited higher ALP levels preoperatively [21, 22]. In summary, this study indicates that total parathyroidectomy combined with forearm subcutaneous autotransplantation is a safe and effective method for treating secondary renal hyperparathyroidism. Regarding the amount of forearm transplantation, the 30-50 mg autotransplantation protocol appears to be superior to the 51-80 mg protocol, as it better improves the patients' primary clinical symptoms, such as bone pain, muscle pain, skin itching, and insomnia; however, it presents a higher recurrence rate in the short-term follow-up.

Conclusions

Parathyroid transplantation with a weight of 30–50 mg is a feasible, safe, and effective surgical approach. However, it has to be acknowledged that the present study was a single-center retrospective study and it was not possible to randomize the weight of tissue autografted from the patients, which could have caused a potential selection bias. The follow-up time of this study was 1 year. A longer follow-up period for patients may be better for assessing surgical efficacy.

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Author contributions
Ge zhou performed surgeries on all cases and conducted data analysis. Wentan chen participated in the study design and statistical analysis. Wentan chen assisted in surgeries. All authors read and approved the final manuscript. All the authors have read and approved the manuscript for submission. All authors reviewed the manuscript.

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Data availability
The data are not publicly available due to (restrictions e.g.,their containing information that could compromise the privacy of research participants).

Declarations

Ethics approval and consent to participate
The study was conducted following the principles stated in the Declaration of Helsinki. This study is an observational, retrospective research. Patients' written informed consent for using health data was obtained before operation. The experimental protocol approved by the ethics committee of Liaoyang Central Hospital (ethical number:2024080107).

Consent for publication
Not applicable.

Clinical trial number
Not applicable.

Competing interests
The authors declare no competing interests.

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