



Recovery of Bone Mineral Density in 126 Patients after Surgery for Primary Hyperparathyroidism

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Abstract. Primary hyperparathyroidism (pHPT) is associated with increased fracture risk and decreased bone mass. The recovery of bone mass after surgery varies; therefore tests that predict the increase in bone mass after parathyroidectomy would be desirable. Preoperatively and at 1 year after surgery bone mineral content (BMC) in the distal radius and bone mineral density (BMD) in the lumbar spine and hip, as well as biochemical variables, were measured in 126 pHPT patients (95 women, 31 men). The mean \pm SD age of the patients was 63 ± 15 years. The mean \pm SD serum calcium level was 2.78 ± 0.16 mmol/L. Altogether, 60% of the patients had a low oral calcium intake, and 18% had a 25-hydroxyvitamin D₃ deficiency. Preoperatively, postmenopausal women had lower Z-scores for BMD in the hip ($p < 0.001$) and lumbar spine ($p < 0.05$) than did premenopausal women. One year after surgery the bone density had increased in about 50% of the patients. The multiple logistic regression analysis showed that there was a weak association between the change in BMD in the hip, the serum 1,25-dihydroxyvitamin D₃ level ($p < 0.05$), and renal function ($p < 0.05$), respectively. We concluded that about 50% of patients have increased bone mass after pHPT surgery, but the increase in the bone density is difficult to predict for the individual patient. Because many pHPT patients have low oral calcium intake and a vitamin D deficiency, it would be of interest to evaluate the role of postoperative calcium/vitamin D supplements.

Historically and still in some developing countries, patients with primary hyperparathyroidism (pHPT) are characterized by an aggressive bone disease, osteitis fibrosa cystica [1, 2]. Although patients in the Western world nowadays mostly have a mild increase in their serum calcium levels, they do have bone involvement with increased remodeling activity [3, 4], decreased bone mineral density (BMD) [5–12], and an increased risk for bone fracture [13–17]. The demineralization is more pronounced in cortical bone than in cancellous bone [18–22].

Some reversibility of bone loss has been documented after pHPT surgery [23–25]. Several studies have revealed the greatest increase in BMD in trabecular bone [6, 19, 21], although some reversibility of BMD in cortical bone has been documented as well [10].

In addition, previous investigations have reported a correlation between the serum parathyroid hormone (PTH) levels, alkaline phosphatase levels, and cortical and trabecular bone loss [26–28].

Others have reported an association between the preoperative Z-score of the bone mineral content (BMC) in the distal radius and the postoperative increase in bone mass [29].

The aim of the present study was to describe bone involvement at various sites of the skeleton in patients with pHPT before and after parathyroidectomy. We also determined the preoperative clinical and biochemical variables that predict changes in bone density after surgery.

Patients and Methods

Patients

The study included 126 patients (95 women, 31 men) with clinical and biochemical signs of pHPT. The mean \pm SD age of patients was 63 ± 15 years, the mean \pm SD serum calcium level was 2.78 ± 0.16 mmol/L, and the mean \pm SD serum PTH level was 10.4 ± 9.1 pmol/L. The diagnosis of pHPT was histologically proved in each patient: 113 patients had a solitary parathyroid adenoma, and 13 patients had multiglandular disease. The mean \pm SD adenoma weight was 1.25 ± 1.46 g. Follow-up was performed 1 year postoperatively. None of the patients exhibited biochemical signs of persistent or recurrent disease during the follow-up period.

Biochemistry

Blood samples were obtained after an overnight fast the day before surgery. Serum ionized calcium concentrations were analyzed from blood samples normalized to pH 7.4 with the ion selective electrode ABL 505 (Radiometer, Copenhagen, Denmark). Serum PTH levels were analyzed by an assay for intact PTH (Incstar, Stillwater, Mn, USA) (reference range 1.0–5.0 pmol/L). Levels of total serum calcium (reference range 2.20–2.60 mmol/l) were measured by a routine laboratory analyzer. High-performance liquid chromatography was used to assess the serum 25-hydroxyvitamin D₃ [25(OH)D₃] level, and 1,25-dihydroxyvitamin D₃ [1,25(OH)₂D₃] was measured with a radioreceptor assay (Incstar). The serum concentrations of propeptide of type I procollagen (PICP) and C-terminal type I collagen telopeptide (ICTP) were determined with

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commercially available radioimmunoassay kits (Orion Diagnostica, Espoo, Finland). Serum concentrations of osteocalcin (bone gla protein) were measured with the commercially available Incstar Osteocalcin 125/RIA kit.

The glomerular filtration rate (GFR) was determined by a technique for measuring renal clearance of the contrast agent iohexol [30]. Using this method, the average value for young healthy subjects is 127 ml/min, with an expected reduction in subjects older than 55. Thus in 65-year-old subjects the expected GFR would be about 80 ml/min.

Bone Density

Bone mass in cortical bone was analyzed by single photon absorption (SPA) [31] and determined as BMC (i.e., bone mass divided by the one-dimensional length of the bone measured). The photon source used was americium-241 (^{241}Am), and measurements were made with a modified Gambro bone mineral detector (Gambro, Lund, Sweden) on both forearms one-fourth the distance from the styloid process to the olecranon. The technique has a precision of 1% to 2% (coefficient of variation) [31]. The BMC is expressed as grams per centimeter.

The BMD of the lumbar spine (L2–L4), the femoral neck, Ward's triangle, and the trochanter region were investigated by dual-energy x-ray absorptiometry (DEXA). To simplify presentation, the three measurements in the hip are reported as the total hip value in the Results section if not stated otherwise. Measurements were made with Lunar Expert XL equipment, software version 1.72 (Lunar, Madison, WI, USA). The technique has a precision of 1%. BMD is expressed as grams per square centimeter. In addition, the results of the BMC and BMD measurements are expressed as absolute values and as age- and gender-specific standard deviations (Z-scores).

Clinical Variables

The medical history of each patient was recorded before surgery and included symptoms and signs of pHPT, medications, and previous and ongoing diseases. Smoking habits, oral calcium intake, menopausal status, and a history of bone fractures were obtained from a standardized questionnaire.

Calcium intake was estimated from the reported intake of dairy products [32]. On the basis of the second Swedish National Nutritional Survey performed during 1997–1998 by the National Food Administration, it has been calculated that around 73% of the calcium intake in the Swedish population is consumed as milk and cheese. The recommended daily intake of calcium is 800 mg according to the Swedish National Food Administration [33]. It can thus be calculated that the intake of calcium from dairy products would be approximately 580 mg/day to fulfill this recommendation.

The body mass index (BMI) was calculated according to the formula: weight (kg)/(height (m))².

Statistics

The results are expressed as the mean \pm SD if not stated otherwise. For statistical evaluation of differences between groups, the Kruskal Wallis or Mann-Whitney U-test was used. For categorical data, statistical significance was analyzed by the χ^2 test and by Fish-

Table 1. Clinical characteristics of 126 patients with pHPT.

| Variable | Result |
|-------------------------------------|----------------|
| Age (years) | 63 \pm 15 |
| BMI (kg/m ²) | 26.0 \pm 4.6 |
| Male/female | 31/95 |
| Premenopausal/postmenopausal | 15/80 |
| Smoker (yes/no) | 19/107 |
| Calcium intake (mg/day) | 510 \pm 371 |
| Cardiovascular diseases (yes/no) | 58/68 |
| Gout (yes/no) | 5/121 |
| Rheumatoid arthritis (yes/no) | 3/123 |
| Corticosteroids (yes/no) | 10/116 |
| Estrogen treatment (yes/no) | 13/113 |
| Biphosphonate treatment (yes/no) | 5/119 |
| Levothyroxine (yes/no) | 6/120 |
| Bone fracture ^a (yes/no) | 9/117 |

pHPT: primary hyperparathyroidism; BMI: body mass index.

^aBone fracture during the 5-year period prior to surgery.

Table 2. Pre- and postoperative biochemical characteristics of 126 patients operated on for pHPT.

| Variables | Preoperative | Postoperative ^a | <i>p</i> | Reference range |
|-------------------------------------------------|-----------------|----------------------------|----------|-----------------|
| Total s-Ca (mmol/L) | 2.78 \pm 0.16 | 2.34 \pm 0.16 | < 0.001 | 2.20–2.60 |
| Intact s-PTH (pmol/L) | 10.4 \pm 9.1 | 5.3 \pm 6.6 | < 0.001 | 1.0–5.0 |
| s-Osteocalcin ($\mu\text{g/L}$) | 46 \pm 31 | 23 \pm 13 | < 0.001 | 10–37 |
| s-25(OH)D ₃ (nmol/L) | 54 \pm 19 | 53 \pm 23 | 0.78 | 20–100 |
| s-1,25(OH) ₂ D ₃ (pmol/L) | 90 \pm 31 | 57 \pm 29 | < 0.001 | 24–120 |
| s-PIPC ($\mu\text{g/L}$) | 124 \pm 46 | 113 \pm 46 | < 0.01 | 72–259 |
| s-ICTP ($\mu\text{g/L}$) | 5.6 \pm 5.9 | 5.5 \pm 6.5 | 0.73 | 1.9–6.7 |
| u-Ca (mmol/L) | 5.1 \pm 2.7 | 2.8 \pm 1.9 | < 0.001 | 2.5–8.0 |
| GFR (ml/min/1.73 m ²) | 77 \pm 22 | 77 \pm 23 | 0.43 | 80–127 |

s-Ca: serum calcium; s-PTH: serum parathyroid hormone; s-25(OH)D₃: serum 25-hydroxyvitamin D₃; s-1,25(OH)₂D₃: serum 1,25-dihydroxyvitamin D₃; PIPC: propeptide of type I procollagen; ICTP: type I collagen telopeptide; u-Ca: urinary calcium; GFR: glomerular filtration rate.

^aOne year after surgery.

er's exact test when expected frequencies were less than five. A stepwise linear regression model was used in the multivariate analyses. The final model included independent variables with *p* < 0.20. Results are given as parameter estimates (β coefficient) and standard errors for the regression coefficient [SE (β)]. To calculate a significant increase in BMD and BMC for the individual patient, the formula: $1.96 \times \sqrt{2} \times \text{CV}$ (coefficient of variance) was used. The formula generates the value that separates two independent samples with 95% confidence. Because the SPA and DEXA methods used in the present study both have a CV of 1%, it can thus be calculated that for an individual patient the BMC and BMD must increase by 2.8% to be significant.

Results

Patient Characteristics and Biochemical Characteristics

Preoperative clinical and biochemical characteristics are shown in Tables 1 and 2. Altogether, 4 patients (3%) had a preoperatively

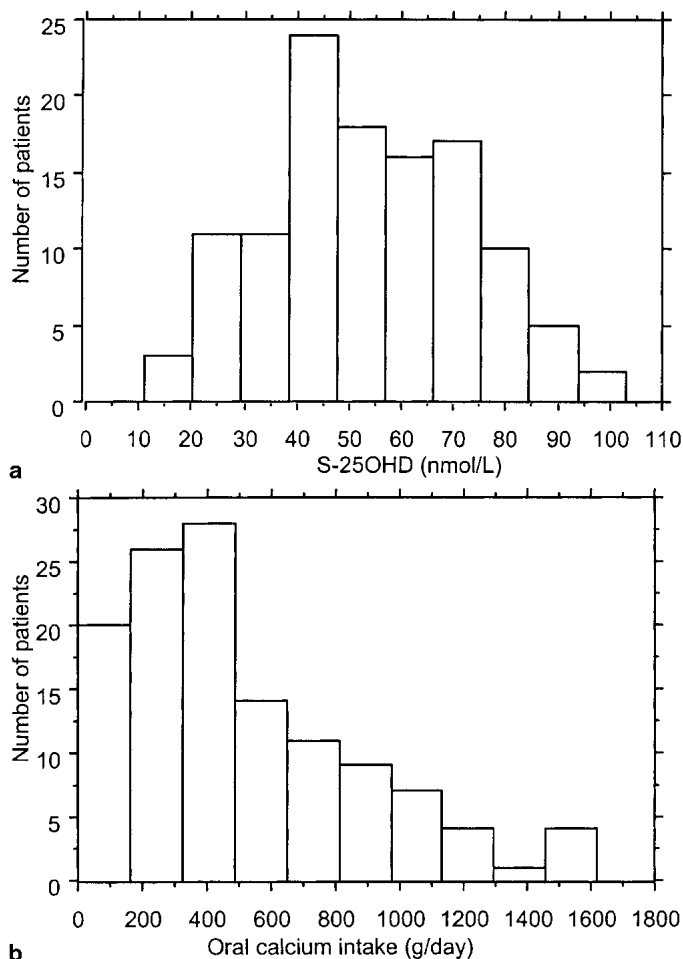


Fig. 1. a. Distribution of serum level of 25-hydroxyvitamin D (S-25OHD) in the 126 patients operated on for primary hyperparathyroidism. (Reference values are 20–100 nmol/L). b. Distribution of the daily calcium intake per day from dairy products in 126 patients operated on for primary hyperparathyroidism. (Recommended daily intake has been calculated to be 580 g/day.)

low serum 25(OH) D_3 level (Fig. 1a), and 77 patients (61%) had low calcium intake as estimated by the intake of dairy products (Fig. 1b). Furthermore, 14 patients (11%) had decreased renal function (GFR). At 1 year after surgery all patients were normocalcemic, and 90 patients (71%) had a normal serum PTH level.

Bone Mineral Measurements Preoperatively

Bone mass preoperatively and at 1 year after surgery is shown in Table 3. Preoperatively, the Z-score for BMD in the lumbar spine was higher than either the Z-score for BMC in the distal radius ($p = 0.03$) or the Z-score for BMD in the hip ($p < 0.05$). In men, there were no differences in the Z-score between various sites in the bone. In contrast, in women the Z-score for BMD in the lumbar spine was higher than the Z-score for BMC in the distal radius ($p = 0.03$). Preoperatively, women and men did not differ regarding Z-scores for the BMC and BMD at any measured site (Table 4). Preoperatively, however, postmenopausal women had lower Z-scores for the BMD in the hip ($p < 0.001$) and the lumbar spine ($p < 0.05$) than did premenopausal women (Table 4).

Preoperatively, patients with cardiovascular disease or impaired renal function had Z-scores for the BMC and BMD similar to those of patients with no cardiovascular disease and normal renal function. Furthermore, there were no preoperative differences in the Z-scores between smokers and nonsmokers, between patients with preoperatively normal and low serum levels of 25(OH) D_3 , or between patients with normal and low calcium intake.

The preoperative Z-scores for the BMC and BMD were no different in patients on corticosteroids or thyroxine from those in patients not taking those medications.

Bone Mineral Measurements Postoperatively

At 1 year after surgery the bone mass had increased at all sites measured (Table 3). The increase in BMC in the distal radius was less than the increase in BMD in the hip (femoral neck) ($p < 0.01$), trochanter region ($p < 0.01$), or lumbar spine ($p < 0.001$). This pattern was found in women, whereas in men the increased BMC was less only when compared to changes in the lumbar spine ($p < 0.05$).

Patients without cardiovascular disease had a larger increase of BMD in the hip [trochanter region 0.035 ± 0.049 vs. 0.010 ± 0.047 ($p < 0.01$) and in Wards triangle 0.023 ± 0.048 vs. -0.003 ± 0.050 ($p < 0.01$)] than did patients with no cardiovascular disease. The magnitude of the increases of BMC in the distal radius and of BMD at all sites was similar when patients with impaired versus normal renal function, patients with low versus normal calcium intake, or premenopausal versus postmenopausal women were compared.

Individual Measurements

At 1 year after surgery, the BMC in the distal radius had increased in 42% of the patients. Moreover, the BMD had increased in the lumbar spine in 54% and in the hip in 48% of the patients (Table 3).

Determinants of Changes in Bone Mass

The correlations between preoperative variables and changes in BMC in the distal radius and in BMD in the lumbar spine and in the hip, respectively, are shown in Table 5. In the multivariate analyses we included, in addition to gender and age, all variables with a p value of < 0.20 . In these analyses we found no variable that was independently associated with changes in the BMC in the distal radius and in the BMD in the lumbar spine, respectively. However 1,25(OH) $_2D_3$ (β coefficient = -0.04189 , SE (β) = 0.02087 , $p < 0.05$) and the GFR (β coefficient = -0.08464 , SE (β) = 0.03250 , $p < 0.05$) were significantly associated with the alteration in the BMD of the hip.

Discussion

In accordance with previous studies we demonstrated that patients with pHPT preoperatively display decreased bone density. Furthermore, we confirmed that sites with more cortical bone (distal radius) are more affected by pHPT than sites with cancellous bone (e.g., the lumbar spine) [5, 19–22]. In men, however, there were no significant differences in the preoperative Z-scores for various sites of the skeleton, although there was a trend to lower Z-scores in cortical bone.

Table 3. Bone density before and 1 year after surgery for pHPT in 126 patients.

| Variable | Preoperative | Postoperative ^a | <i>p</i> | Δ abs | Δ % |
|--------------------------------------|----------------|----------------------------|----------|---------------|--------------|
| BMC (g/cm) | 2.782 ± 0.981 | 2.804 ± 1.028 | 0.15 | 0.033 ± 0.205 | 1.93 ± 14.50 |
| Z-score | -0.66 ± 1.22 | -0.51 ± 1.30 | | | |
| BMD L2–L4 (g/cm ²) | 1.041 ± 0.230 | 1.082 ± 0.239 | < 0.001 | 0.039 ± 0.074 | 4.03 ± 7.32 |
| Z-score | -0.34 ± 1.52 | -0.02 ± 1.65 | | | |
| Femoral neck (g/cm ²) | 0.802 ± 0.163 | 0.878 ± 0.522 | < 0.001 | 0.078 ± 0.513 | 3.94 ± 7.24 |
| Z-score | -0.54 ± 0.94 | -0.27 ± 1.05 | | | |
| Trochanter (g/cm ²) | 0.690 ± 0.171 | 0.715 ± 0.174 | < 0.001 | 0.023 ± 0.049 | 3.82 ± 8.92 |
| Z-score | -0.64 ± 1.09 | -0.41 ± 1.16 | | | |
| Ward’s triangle (g/cm ²) | 0.627 ± 0.176 | 0.636 ± 0.175 | < 0.01 | 0.011 ± 0.050 | 2.62 ± 9.60 |
| Z-score | -0.71 ± 0.92 | -0.58 ± 0.98 | | | |
| Total hip (g/cm ²) | 0.844 ± 0.183 | 0.862 ± 0.198 | < 0.001 | 0.021 ± 0.052 | 2.40 ± 7.31 |
| Z-score | -0.550 ± 1.026 | -0.377 ± 1.149 | | | |

BMC: bone mineral content; BMD: bone mineral density.

^aOne year after surgery.

Table 4. Preoperative bone density in 126 patients operated on for pHPT.

| Variable | Men vs. women Men (<i>n</i> = 31) | Premenopausal vs. postmenopausal Women (<i>n</i> = 95) | <i>p</i> | Premenopausal women (<i>n</i> = 15) | Postmenopausal women (<i>n</i> = 80) | <i>p</i> |
|--------------------------------|---------------------------------------|---------------------------------------------------------------|----------|--------------------------------------------|---------------------------------------------|----------|
| BMC (g/cm) | 4.074 ± 0.639 | 2.380 ± 0.674 | < 0.001 | 3.164 ± 0.438 | 2.235 ± 0.609 | < 0.001 |
| Z-score | -0.607 ± 1.223 | -0.671 ± 1.229 | 0.94 | -0.084 ± 1.268 | -0.779 ± 1.198 | 0.10 |
| BMD L2–L4 (g/cm ²) | 1.172 ± 0.199 | 0.998 ± 0.224 | < 0.005 | 1.230 ± 0.175 | 0.954 ± 0.205 | < 0.001 |
| Z-score | -0.194 ± 1.557 | -0.385 ± 1.508 | 0.57 | 0.253 ± 1.281 | -0.506 ± 1.524 | < 0.05 |
| total hip (g/cm ²) | 0.952 ± 0.149 | 0.809 ± 0.181 | < 0.001 | 1.034 ± 0.099 | 0.756 ± 0.159 | < 0.001 |
| Z-score | -0.460 ± 1.030 | 0.578 ± 1.029 | 0.81 | 0.292 ± 0.816 | -0.750 ± 0.983 | < 0.001 |

Women and men did not have significantly different preoperative Z-scores at any site measured. However, preoperatively, postmenopausal women had lower Z-scores in the hip and the lumbar spine than did premenopausal women. Thus it seems that the pHPT disease affects postmenopausal women more adversely than premenopausal women. This finding suggests a need for early surgical treatment during the course of the disease.

At 1 year after surgery the BMC and BMD had significantly increased at all sites measured. The largest increase was seen in trabecular bone, a finding supported by previous studies [12, 19, 21].

Interestingly, we found that about 40% to 50% of the patients have improved bone density 1 year postoperatively. This finding is important because previous studies so far have described only the mean change in bone density. The largest improvement was seen in the lumbar spine (54%). Furthermore, for both men and women, the bone density increased more in trabecular bone than in cortical bone.

In an attempt to find variables that can predict the change in bone density after surgery, we first performed univariate analyses between preoperative clinical and biochemical variables and bone density, as well as changes in BMC in the distal radius and in BMD at various sites, respectively. Although we found some significant associations, multivariate analyses showed that none of the variables was independently associated with the increased bone density in the distal radius or the lumbar spine. In contrast, in the final multiple logistic regression analysis, the serum 1,25(OH)₂D₃ level and renal function (GFR) were independently associated with the increased BMD in the hip. 1,25(OH)₂D₃ affects the skeleton by stimulating osteoclastic activity and inhibiting the action of osteoblasts [34, 35]. Thus one can speculate that patients with high preoperative serum 1.25(OH)₂D₃ levels have a high bone turnover and thus have more to gain in bone mass from the operation. Although

Table 5. Correlations between the percent changes in BMC and BMD versus preoperative variables.

| Variables | r ² | <i>p</i> |
|----------------------------------------|----------------|----------|
| BMC | | |
| Gender | 0.009 | 0.99 |
| Age | 0.023 | 0.12 |
| s-1.25(OH) ₂ D ₃ | 0.020 | 0.17 |
| Z-score for BMC | 0.044 | 0.03 |
| Oral calcium intake | 0.023 | 0.13 |
| BMD L2–L4 | | |
| Gender | 0.003 | 0.77 |
| Age | 0.086 | 0.36 |
| s-Ca | 0.014 | 0.20 |
| s-25(OH)D ₃ | 0.024 | 0.12 |
| s-1.25(OH) ₂ D ₃ | 0.048 | 0.03 |
| u-Ca | 0.040 | < 0.05 |
| Z-score for BMD L2–L4 | 0.032 | 0.06 |
| BMD total hip | | |
| Gender | 0.004 | 0.50 |
| Age | 0.029 | 0.09 |
| s-1.25(OH) ₂ D ₃ | 0.109 | < 0.001 |
| GFR | 0.073 | < 0.01 |

these data are theoretically interesting, the association between 1,25(OH)₂D₃ and the increased BMD in the hip was weak, with a low r² value, and the clinical significance might be questioned.

In this pHPT cohort of patients, we found that a large portion (61%) of the patients had low oral calcium intake. Furthermore, around 10% of the patients had decreased renal function, and 3% had vitamin D levels below the normal range. Altogether, 18% of the patients (Fig. 1a) had a serum 25(OH)D₃ level below 37.5 nmol/L, which has been shown to influence both the PTH concentration and bone density and could be considered to indicate vitamin D

deficiency [36]. Vitamin D is closely related to bone remodeling, bone mass, and pHPT, and our group has previously found that 25(OH)D₃ is independently associated with fracture risk in patients with pHPT [37]. Therefore we think that patients with pHPT may benefit from postoperative calcium and vitamin D supplements. This idea is further supported by the difficulty of clearly predicting the recovery of bone density for the individual patient. A prospective randomized study is needed to determine whether patients would benefit from postoperative calcium and vitamin D supplements.

Conclusions

We found that in patients with pHPT cortical bone is more adversely affected than cancellus bone. Furthermore, postmenopausal women are more affected than premenopausal women. About 40% to 50% of pHPT patients have improved bone density after surgery, with the greatest increase being found in trabecular bone. It was not possible to determine any strong preoperative predictor of increased bone density after pHPT surgery. However, because many pHPT patients have low oral calcium intake and vitamin D deficiency, it would be of interest to evaluate, in a prospective randomized trial, the role of postoperative calcium and vitamin D supplementation.

Résumé. L'hyperparathyroïdie primitive (pHPT) est associée à une augmentation du risque de fracture et une diminution de la masse osseuse. La récupération d'une masse osseuse après chirurgie est variable. Trouver un moyen pour détecter l'augmentation de la masse osseuse après parathyroïdectomie serait donc désirable. En préopératoire et à un an après chirurgie, le contenu osseux minéral (BMC) du radius distal et la densité osseuse minérale (BMD) du rachis lombaire et de la hanche, ainsi que d'autres variables biochimiques ont été mesurées chez 126 patients pHPT, 95 femmes et 31 hommes, d'âge moyen (± ET) de 63 ± 15 ans. Les taux moyens ± ET du calcium sérique ont été de 2.78 ± 0.16 mmol/L. Soixante pourcent des patients avaient une prise orale de calcium et 18% avaient une déficience en vitamine 25(OH)D₃. En préopératoire, les femmes postménopausées avaient un score Z de BMD plus bas au niveau de la hanche ($p < 0.001$) et au niveau du rachis lombaire ($p < 0.05$), comparé à celui des femmes préménopausées. Un an après chirurgie, la densité osseuse a augmenté chez environ 50% des patients. En analyse logist multiple, il y avait une association faible entre la modification de BMD au niveau de la hanche et, respectivement, le niveau sérique de 1.25(OH)₂D₃ ($p < 0.05$) et la fonction rénale ($p < 0.05$). En conclusion environ 50% des patients augmentent leur masse osseuse après la chirurgie pour pHPT. L'augmentation de la densité osseuse est difficile à prévoir pour le patient individuel. Puisque beaucoup de patients pHPT ont une prise orale basse en calcium et une déficience en vitamine D, ce serait intéressant d'évaluer le rôle d'une supplémentation postopératoire en calcium-vitamine D.

Resumen. El hiperparatiroidismo primario (pHPT) se acompaña de un mayor riesgo de fracturas y de una disminución de la masa ósea. La recuperación de la misma tras cirugía, difiere de unos a otros casos por lo que parece importante el poder predecir de forma exacta el incremento de la masa ósea tras paratiroidectomía. En 126 pacientes con pHPT se determinaron junto con otras variables bioquímicas, tanto antes de la intervención como 1 año después de la misma el contenido mineral óseo (BMC) en la porción distal del radio y la densidad mineral ósea (BMD) en la columna lumbar y en la cadera. La muestra estudiada comprendía 95 mujeres y 31 hombres, cuya edad media y desviación estándar (SD) fue de 63 ± 15 años. La media ± SD del calcio sérico fue de 2.78 ± 0.16 mmol/L. En el 70% de los pacientes se constató un ingreso oral reducido de calcio y el 18% de los casos presentaban un déficit de la vitamina 1.25 (OH)₂ D₃. En el preoperatorio las mujeres postmenopausadas presentaban bajos niveles de BMD en cadera ($p < 0.001$) y en la columna lumbar ($p < 0.05$) frente a las mujeres premenopausadas. Al año de la intervención la densidad ósea

había aumentado en un 50% de los pacientes. En un análisis de regresión logística múltiple se observó cierta tendencia entre las modificaciones del BMD de la cadera, los niveles séricos de la 1.25 (OH)₂D₃ ($p < 0.05$) y la función renal ($p < 0.05$). Tras paratiroidectomía en, aproximadamente el 50% de pacientes con hiperparatiroidismo primario, se produce un incremento de la masa ósea. Este aumento es difícil de predecir para cada paciente, ya que en muchos enfermos con pHPT la ingesta oral de calcio es escasa y presentan déficits de vit. D. Sería interesante evaluar el papel de la administración de calcio y vitamina D en el postoperatorio.

References

- Albright F, Reifenstein EC, The Parathyroid Glands and Metabolic Bone Disease, Baltimore, Williams & Wilkins, 1948;
- Mishra SK, Agarwal G, Kar DK, et al. Unique clinical characteristics of primary hyperparathyroidism in India. *Br. J. Surg.* 2001;88:708-714
- Christiansen P, Steiniche T, Brixen K, et al. Primary hyperparathyroidism: biochemical markers and bone mineral density at multiple skeletal sites in Danish patients. *Bone* 1997;21:93-99
- Bergenfelz A, Lindergård B, Ahrén B. Biochemical variables associated with bone density in patients with primary hyperparathyroidism. *Eur. J. Surg.* 1992;158:473
- Adami S, Braga V, Squaranti R, et al. Bone measurements in asymptomatic primary hyperparathyroidism. *Bone* 1998;22:565-570
- Silverberg SJ, Gartenberg F, Jacobs TP, et al. Increased bone mineral density after parathyroidectomy in primary hyperparathyroidism. *J. Clin. Endocrinol. Metab.* 1995;80:729-734
- Silverberg SJ, Locker FG, Bilezikian JB. Vertebral osteopenia: a new indication for surgery in primary hyperparathyroidism. *J. Clin. Endocrinol. Metab.* 1996;81:4007-4012
- Guo CY, Thomas WEG, Al Dehaimi WA, et al. Longitudinal changes in bone mineral density and bone turn-over in postmenopausal women with primary hyperparathyroidism. *J. Clin. Endocrinol. Metab.* 1996; 81:3487-3491
- Abdelhadi M, Nordenström J. Bone mineral recovery after parathyroidectomy in patients with primary hyperparathyroidism. *J. Clin. Endocrinol. Metab.* 1998;83:3845-3850
- Christiansen P, Stencheik T, Brixen K, et al. Primary hyperparathyroidism: whole body mineral density in surgically treated Danish patients: a three-year follow-up study. *Bone* 1999;25:597-602
- Thorsen K, Kristofferson AO, Lorentzon RP. Changes in bone mass and serum markers of bone metabolism after parathyroidectomy. *Surgery* 1997;112:882-887
- Silverberg SJ, Shane E, De La Cruz L, et al. Skeletal disease in primary hyperparathyroidism. *J. Bone Miner. Res.* 1989;4:283-291
- Kenny AM, MacGillivray DC, Pilbeam CC, et al. Fracture incidence in postmenopausal women with primary hyperparathyroidism. *Surgery* 1995;118:109-114
- Melton LJ, Atkinson EJ, O'Fallon M, et al. Risk of age-related fractures in patients with primary hyperparathyroidism. *Arch. Intern. Med.* 1992;152:2269-2273
- Vestergaard P, Mollerup CL, Frokjaer VG, et al. Cohort study of risk of fracture before and after surgery for primary hyperparathyroidism. *B.M.J.* 2000;321:598
- Khosla S, Melton LJ, Wermers RA, et al. Primary hyperparathyroidism and the risk of fracture: a population-based study. *J. Bone Miner. Res.* 1999;14:1700
- Larsson K, Ljunghall S, Krusemo UB, et al. The risk of hip fractures in patients with primary hyperparathyroidism: a population-based cohort study with a follow up of 19 years. *J. Intern. Med.* 1993;234:585-593
- Parisien M, Silverberg SJ, Shane E, et al. The histomorphometry of bone in primary hyperparathyroidism: preservation of cancellous bone structure. *J. Clin. Endocrinol. Metab.* 1990;70:930-938
- Richardson ML, Pozzi Mucelli RS, Kanter AS, et al. Bone mineral changes in primary hyperparathyroidism. *Skeletal Radiol.* 1986;15:85-95
- Whishart J, Horowitz M, Need A, et al. Relationship between forearm and vertebral mineral density in postmenopausal women with primary hyperparathyroidism. *Arch. Intern. Med.* 1990;150:1329-1331
- Silverberg SJ, Shane E, Jacobs TP, et al. A 10 year prospective study of primary hyperparathyroidism with or without parathyroid surgery. *N.*

- Engl. J. Med. 1999;341:1249–125522. Elvius M, Lagrelius A, Nygren A, et al. Seventeen year follow-up study of bone mass in patients with mild asymptomatic hyperparathyroidism some of whom were operated on. *Eur. J. Surg.* 1995;161:863–869
22. Elvius, M, Lagrelius, A, Nygiew, A et al. (1995) Seventeen year follow-up study of bone mass in patients with mild asymptomatic hyperparathyroidism some of whom were operated on. *Eur. J. Surg.* 161: 863–869
23. Mole PA, Walkinshaw MH, Gunn A, et al. Bone mineral content in patients with primary hyperparathyroidism: a comparison of conservative management with surgical treatment. *Br. J. Surg.* 1992;79:263–265
24. Martin P, Bergmann P, Gillet C, et al. Long-term irreversibility of bone loss after surgery for primary hyperparathyroidism. *Arch. Intern. Med.* 1990;150:1495–1497
25. Christiansen P, Steiniche T, Brockstedt H, et al. Primary hyperparathyroidism: changes in trabecular bone remodeling following surgical treatment: evaluated by histomorphometric methods. *Bone* 1990;11: 75–79
26. Pfeilschifter J, Siegrist E, Wüster C, et al. Serum levels of intact parathyroid hormone and alkaline phosphatase correlate with cortical and trabecular bone loss in primary hyperparathyroidism. *Acta Endocrinol. (Copenh).* 1992;127:319–323
27. Gorton M, Marin J, Stewart A, et al. Changes in bone mass and metabolism after surgery for primary hyperparathyroidism. *Clin. Endocrinol. (Oxf).* 1995;42:493–500
28. Nakaoka D, Sugimoto T, Kobayashi T, et al. Prediction of bone mass changes after parathyroidectomy in patients with primary hyperparathyroidism. *J. Clin. Endocrinol. Metab.* 2000;85:1901–1907
29. Bergenzel A, Lindergård B, Ahrén B. Prediction of changes in bone density after operation for primary hyperparathyroidism. *Ann. Chir. Gynaecol.* 1993;82:245–249
30. Krutzén E, Bäck SE, Nilsson-Ehle I, et al. Plasma clearance of a new contrast agent, iohexol: a method for the assessment of glomerular filtration rate. *J. Lab. Clin. Med.* 1984;104:955
31. Lindergård B. Bone mineral content measured with photon absorptiometry - a methodological study carried out on normal individuals. *Scand. J. Urol. Nephrol. Suppl.* 1981;59:1
32. Becker W. Svenskar äter nyttigare: allt fler väljer gröt. *Var Foda* 1992; 24:24–27
33. Becker W, Pearson M, Riksmaten 1997-1998. Befolkningens kostvanor och näringsintag. Metod-och resultatanalys, Uppsala, Livsmedelsverket, 2002;
34. Nijweide PJ, Burger EH, Feyen JH. Cells of bone: proliferation, differentiation, and hormonal regulation. *Physiol. Rev.* 1986;66:855–886
35. Raisz LG, Kream BE. Regulation of bone formation. *N. Engl. J. Med.* 1983;309:29–35
36. Thomas MK, Lloyd-Jones DM, Thadhani RI, et al. Hypovitaminosis D in medical inpatients. *N. Engl. J. Med.* 1998;338:777–783
37. Nordenström E, Westerdahl J, Lidergård B, et al. Multifactorial risk profile for bone fractures in primary hyperparathyroidism. *World J. Surg.* 2002;26:1463–1467