Indian J Surg (July–August 2014) 76(4):308–315
DOI 10.1007/s12262-013-0898-0

REVIEW ARTICLE

Surgical Treatment of Primary Hyperparathyroidism: Description of Techniques and Advances in the Field

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Received: 15 August 2011 / Accepted: 11 March 2013 / Published online: 21 April 2013

Abstract Primary hyperparathyroidism is a disease commonly seen in patients above 60 years of age. It is the most common cause of asymptomatic or symptomatic hypercalcemia, usually found incidentally on routine check-ups. Surgical treatment is the only definitive treatment of choice in the symptomatic patient; however, it can also be employed in asymptomatic patients. First described in 1925, bilateral neck exploration is the gold standard of treatment for primary hyperparathyroidism. The recent interest in minimally invasive surgeries has led to better and improved techniques of neck exploration with improved cosmetic results and lesser chances of transient or permanent hypoparathyroidism due to inadvertent removal of normally functioning parathyroid tissue. These include unilateral neck explorations, minimally invasive parathyroidectomies and minimally invasive radio-guided parathyroidectomy. The intact parathyroid hormone assays have greatly added to the detection of normal and abnormal functioning glands, hence better surgical outcomes.

Keywords Parathyroidectomy · Neck dissection · Minimally invasive surgical procedure · Hyperparathyroidism · Parathyroid hormone

Abbreviations

iPTH	Intact parathyroid hormone
MIRP	Minimally invasive radio-guided parathyroidectomy
PTH	Parathyroid hormone
MEN	Multiple endocrine neoplasia
CT	Computed tomography
MRI	Magnetic resonance imaging
U/S	Ultrasonography
IRMA	Immunoradiometric assay
IOPTH	Intraoperative parathyroid hormone assay
ICMA	Immunochemiluminometric assay
BMD	Bone mineral density

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Introduction

Primary hyperparathyroidism occurs in 0.2–0.5 % of the population and affects 1/500 women and 1/2,000 men annually with 100,000 new cases in the USA per year [1–4]. It is a disease of unknown aetiology and occurs mostly in the sixth decade of life, with an F/M ratio of 2: 1. It is sporadic in 90 % of the cases (usually single adenoma) and familial in 10 % of cases usually as a part of MEN I or IIa (usually diffuse hyperplasia of all four glands) [5]. It is the most common cause of hypercalcaemia in non-hospitalised patients [6]. Early detection and surgery remains the gold standard of treatment of primary hyperparathyroidism for all symptomatic and for most cases of asymptomatic primary hyperparathyroidism [1, 7, 8]. Historically, the first successful parathyroidectomy was performed in Vienna in 1925 by Mandel, and since then, bilateral neck exploration has been the gold standard [4, 8]. With this approach, the cure rates in experienced hands exceed 95 % with a complication rate of <1–2 % [1, 4].

History of Parathyroidectomy

The first parathyroidectomy was performed by Felix Mandel in 1925, and in the early history of parathyroid surgery, bilateral neck exploration was the preferred approach with success rates of up to 95 % in the hands of an experienced surgeon [9, 10]. During the 1960s, the diagnosis of primary hyperparathyroidism became easier with the development of the radioimmunoassay for parathyroid hormone (PTH), and the late 1970s saw the introduction of ultrasound and the technetium–thalium scintigraphy scan for preoperative localisation of parathyroid glands. Nevertheless, bilateral neck exploration remained the only surgical procedure until 1980 when Wang and Tibblin, taking advantage of the advances in the preoperative localisation methods, advocated unilateral neck explorations. This was supported further in the 1990s with the usage of the sestamibi scan, ultrasound and intra-operative PTH immunoassays, which minimised complications and reduced operating time [3, 8, 11–13.]. The first clinical application of the rapid intra-operative intact parathyroid hormone (iPTH) assay was described in 1988 [14]. The rationale of minimally invasive parathyroidectomy is based on the fact that 85–90 % of the time it is caused by a single adenoma and that, with a combination of imaging tests and blood tests, it can be as effective as bilateral neck exploration [13].

In 1991, the usefulness of non-invasive radiologic localisation tests was evaluated by the National Institute of Health (NIH) panel [4], and it was determined that there was no indication for these localisation techniques in the preoperative evaluation of the patients with primary hyperparathyroidism [4]. Nevertheless, these techniques are still applied despite the known limited sensitivity and specificity (Table 1).

Unilateral Neck Exploration

The increasing interest towards a less invasive surgical approach for treatment of the primary hyperparathyroidism is based on the advantages offered by this technique, which include the ability to use local or general anaesthesia and reduced risk for recurrent or persistent hyperparathyroidism [8]. Lower incidence and severity of symptomatic and biochemical hypocalcaemia, shorter operative time and finally the same results as bilateral exploration with better cosmetic result have also been reported [3, 8, 11, 13]. An additional advantage of this approach is the favourable operative field in cases of re-operation for recurrent disease [11]. Of course, there are potential problems, including incorrect localisation, considering that the sestamibi scan has a sensitivity of 71 % in some studies. Moreover, it is not reliable in multi-glandular disease, which constitutes 5–15 % of the causes of hyperparathyroidism subjecting this approach to a failure risk [8].

Therefore, improvements in imaging modalities in order to increase the sensitivity in localisation of the adenoma as well as usage of the rapid intra-operative intact parathyroid hormone (iPTH) assays in order to confirm the success of the operation while the patient is on the table are the cornerstones for the success of this technique [8, 11]. However, the iPTH assay has an almost 50 % false positive result in patients with double adenomas, misleading the surgeons to stop the operation when they should have continued. iPTH also has 13 % false negative results, leading the surgeons to undertake unnecessary and often dangerously extended resections when there is no hyperfunctioning gland left. The conclusion is that, currently, we are unable to ensure that all the unexplored glands are normal but we have to respect the benefits of minimal invasive surgery while not relying entirely on the assays. The suggestion is to proceed where preoperative tests indicate solitary lesions with minimally invasive surgery knowing there is a small risk of persistent or recurrent primary hyperparathyroidism [16].

Table 1 Methods of preoperative localisation of parathyroid tumours [15]

Thallium/technetiun	Tc-99m (sodium pertechnate) thyroid
	Tl-201 (thallous chloride) both
	Subtract Tc from Tl
Sestamibi	Protein with Tc-99m which localises parathyroids
	Sensitive for single adenomas (90 %) but less for hyperplasia
	Sensitivity increases with SPEC (single photon-emission CT)
Selective venous sampling PTH	Most reliable (SVC, innominate, internal jugular, small v)
U/S/CT/MRI	See text

Technique

The patient is placed in a supine position with the head extended and arms by his/her side. Local or general anaesthesia is used. A 2-cm transverse incision is placed two fingerbreadths above the sternal notch in a skin crease over the expected position of the adenoma, and the sternocleidomastoid muscle is retracted laterally. The strap muscles are dissected and separated, and the thyroid lobe is gently retracted superiorly and towards the midline. The enlarged parathyroid is dissected and mobilised with or without identification of the recurrent laryngeal nerve. The vascular pedicle is ligated and the adenoma removed. The wound is closed in two layers with absorbable sutures [11].

Minimally Invasive Parathyroidectomy

The term was first used by Utelsman to describe a technique that uses preoperative localisation tests on which a unilateral approach is based. This is usually done under a cervical block. The success of the operation is confirmed with the use of the intra-operative iPTH determination [17]. Cure rates up to 99 % have been reported with this technique [18].

Minimally Invasive Radio-Guided Parathyroidectomy

This technique was developed by Norman and Chheda in 1997 and uses a hand held gamma camera in order to take advantage of the increased sensitivity of dual-phase Technitium-99m sestamibi during the operation. Technetium (^{99m}Tc) sestamibi is a pharmaceutical agent used in nuclear medicine imaging and is a complex of the radioisotope technetium-99m with the ligand methoxyisobutylisonitrile (MIBI). A scan using MIBI is commonly known as a "MIBI scan." This helps to locate and remove the hyper functioning gland. In this way, patients with a positive preoperative sestamibi test can be operated without the need of general endotracheal anaesthesia while retaining all the benefits of a minimally invasive radio-guided parathyroidectomy (MIRP) [6, 17]. Frozen section can be avoided altogether in this operation, which is helped by the gamma probe providing immediate feedback [19]. The risk of complications is minimal with this technique [20]. Lower hospital costs have been reported with this technique in comparison with non radio-guided parathyroidectomy. This has been attributed to shorter operative time, length of hospital stay and anaesthesia duration [21, 22]. However, being an emerging technique, it requires experience to analyse the information received through the gamma probe.

Technique

The technique involves a normal sestamibi scan (MIBI scan), which, when positive and showing a single focus of pathology in the neck, is considered an indication for a MIRP. The patient is then re-injected with (18–20 mCi) MIBI 30–60 min before the operation [11]. Then, under local or general anaesthesia, through a 2.5–4-cm transverse incision two fingerbreadths above the sternal notch, the targeted gland is located, dissected and removed. The ex vivo activity is measured (away from the patient) and compared with the neck activity after the excision. If the ex vivo activity is >20 % of the background count and it steps up during the neck scan, the operation in terminated. A 100 % cure rate is reported with this technique. There has been discussion whether this technique should be combined with intra-operative iPTH determination because in case of multi-glandular disease or a second adenoma both methods have low sensitivity and failures are expected [17].

Endoscopic Parathyroidectomy

Endoscopic approaches for most general surgical procedures are on the rise. This approach has also been employed in parathyroid surgery. Despite the need of general anaesthesia and a longer operating time, it offers the best cosmetic result as well as a safe approach to deep and ectopic locations including the mediastinum. Moreover, the magnification offers a better view of the anatomy (including the recurrent laryngeal nerve) and minimises the risk of injury [11].

Technique

The patient is placed in the supine position with the neck in neutral position. Under general anaesthesia and endotracheal intubation, a 5-mm incision is made in the midline just above the sternal notch. Then, carbon monoxide is insufflated to 10 mm Hg, while the 5-mm 0° endoscope is used to dissect bluntly the avascular subplatysmal plane towards the side of the localised adenoma. Then, a 30° endoscope is used, and two to three ports are placed in the lateral neck under direct vision. The dissection proceeds usually lateral to the strap muscles and medial to the carotid until the gland is encountered and the recurrent laryngeal nerve is identified through its entire course in the neck. The gland is then dissected free, and the vascular pedicle is ligated with a mini endoloop and removed in a bag via the 5-mm port. The wound is closed with steri-strips [11].

Intraoperative Intact Parathyroid Hormone Determination

This is not a surgical approach per se, but it is an essential component in all minimally invasive parathyroidectomies. The first clinical application of the rapid intra-operative iPTH assay (IOPTH) was described by Nussbaum et al. in 1988, and it was a two-side immunoradiometric assay (IRMA) using radio-labelled anti-PTH antibody and gamma counter [14]. However, the drawbacks of this technique, including short half-life of the radioisotopes and use of radiation, provided an impetus for the development of the two-side immunochemiluminometric assay (ICMA), which is based on the short half-life of the iPTH (3–5 min) and the tendency of the normal parathyroid glands to be suppressed in cases of hyperparathyroidism [14]. The method uses two polyclonal antibodies labelled with a non-radioactive agent (acridinium ester) directed against the intact iPTH peptide. The incubation time is as short as 7 min. Chemicals trigger these esters to emit light, which is measured in a luminometer, which is non-radioactive and safe to be kept near the operating room [14]. The assay cart is portable and can easily been carried to the operating theatre. The preferable side for blood sampling is a peripheral vein (antecubital), and the time required from the collection of blood to the result is about 12 min. Blood samples are collected at baseline after dissection of the adenoma but before excision and then at 5, 10 and 30 min after excision [11]. If there is more than 50 % reduction from the peak baseline value 10 min after excision, the operation is considered successful [11]. This is known as the Nichols criteria.

A suggested technique for improved results of the intra-operative parathyroid hormone measurement is that where blood samples are drawn as usual from a peripheral vein, first preoperatively and then after the induction of the anaesthesia and as soon as the parathyroids are visualised (baseline) in order to avoid the confusion caused by the anaesthesia (increase in the parathyroid hormone levels and decrease of ionised calcium) [8, 23]. The incision is over the point indicated by the sestamibi scan or other preoperative imaging techniques. If these are negative, then a random side is chosen and bilateral neck exploration is done if needed [13]. The dissection and handling of the glands must be precise without excessive manipulation and the vascular pedicle must be the last to be clamped [8].

There are commercially available rapid-incubation kits for quick results. After excision of the abnormal parathyroid gland, samples are obtained at 5, 10 and 15 min, and decline in the PTH levels is observed. If the levels are not <50 % of the peak pre-excision value at 10 min, it is an indication for further exploration, but there is a 13 % false negative rate in solitary adenomas. If the levels of the PTH decline more than 60 % in 15 min after gland excision, the cure rate is almost 100 % [24]. Biopsy of the gland can be undertaken or spared depending on surgeon preference [13].

While the ICMA has become widely accepted and used in parathyroid surgery, the abandonment of the technique and its replacement by the next day parathyroid hormone measurement in order to avoid the false negative cases has been suggested. These false negative results lead to extended and often complicated unnecessary operations in these patients. This paper recommends the use of next day iPTH assay instead as it provides 99.2 % accuracy [13].

Ethanol Ablation

In patients who cannot be considered for surgery, a substitute method is percutaneous ethanol ablation of the parathyroid gland. Patients with pre-existing morbid conditions precluding surgery can undergo this operation [25]. In practice, the tumour is localised by ultrasound and injected with ethanol. Post-operative parathyroid hormone values are observed for cure. Recurrence of hypercalcemia is likely, hence a follow-up of serum calcium is required, and repeat treatments may be necessary. It is used uncommonly; however, surgeons and radiologists may perform it if there are any clinical indications [26].

Bilateral Neck Exploration

Traditionally, bilateral neck exploration was the gold standard treatment of primary hyperparathyroidism for many years. It involves endotracheal intubation, careful exploration of the central neck in order to identify all parathyroid glands and then, based on the expertise and judgement of the surgeon, removal of the grossly enlarged gland [17].

Technique

Exposure and incision is similar to a standard thyroidectomy. The next step is to divide the middle thyroid veins and mobilise the thyroid lobes forward and medially. The inferior thyroid artery and the recurrent laryngeal nerve are then identified and retracted with vascular slings. Then, with or without incision of the fascia binding the thyroid posteromedially to the trachea, the superior parathyroid gland is exposed. About 90–95 % of the upper parathyroids are closely related to the inferior thyroid artery (within 2 cm radius of the vessel), while 80 % of the inferior parathyroids are within the 2-cm radius of the lower pole of the thyroid. Next comes the inspection of thyrothymic ligament (inferior thyroid veins) for ectopic glands (20 %). If none are found, they are searched for in the tracheoesophageal groove and behind the oesophagus. In addition, they can be within the thyroid gland in 2 % of the cases and within the carotid sheath (open up to the bifurcation near the angle of the jaw). The last manoeuvre is transcervical thymectomy. If, despite this approach, finding of the missing gland is unsuccessful, a more invasive approach including median sternotomy is used (mediastinal thymectomy) (1–2 %) [15].

Once the adenoma is located, the next step is to ligate and divide the pedicle, clear it from the surrounding tissue and remove the gland. The frozen section is used to confirm the diagnosis, although differentiation between adenoma and hyperplasia is often difficult.

After excising the adenoma, one approach is to identify the other three glands and, based on clinical judgement to biopsy, the next enlarged gland. Another approach would be to identify the ipsilateral gland and send a frozen section. If the result shows a normal gland (Tibblin strategy), the other side is left undisturbed. This approach ignores the 1 % chance of a double adenoma. In case of multi-glandular hyperplasia, the suggested approach is a subtotal $3^{1/2}$ parathyroidectomy (remove initially two big and one half of the other two, inspect for a while and remove the less viable one half and finally mark the remaining one half with a metallic clip [15]. The conventional technique requires identification of at least four glands through a bilateral neck exploration, resection of the most enlarged with or without biopsy of the remaining glands. Despite the long operation time and post-operative hospitalisation, the cure rate of 90–98 % and the morbidity of <5 % render this technique the gold standard procedure for hyperparathyroidism [1].

Assessment of Adequacy of Surgery

The use of intra-operative iPTH assessment is used widely to judge whether the operation is successful after it has been validated by comparison to the standard 24-h immunoradiometric assay. It was found to have 95–96 % accuracy in predicting success of the operation and return to normocalcaemia [3]. The parathyroid hormone is expected to drop 64 % at 5 min, 75 % at 10 min and 83 % at 15 min after excision of all hyper functional tissue [1]. Nevertheless, a 50 % drop in 10 min is accepted as adequate for a successful operation (Nichols criteria) [3, 13, 24]. Decreases of >46 % at 10 min and > 59 % at 20 min are predictive of postoperative normocalcaemia [1]. Some centres do parathyroid hormone assays after 5, 15 and 30 min. If parathyroid hormone is normal after 5 min or if the parathyroid hormone drops to <40 % of baseline at 15 min, operation is stopped, while search for any additional glands is continued if it is still elevated after 30 min [1, 3]. Intraoperative monitoring of total calcium in order to decide whether the operation is successful has also been proposed [3]. In this study, the total calcium was measured during the admission, before the removal of the parathyroid and then every 5 min after the removal. There was a significant drop of the calcium to normal just 5 min after the adenoma removal, while the intact parathyroid hormone became normal in the same patients 15 min after removal. Nevertheless, this drop is not explained by calcium metabolism, and it can only be hypothesised that it is based on calcium turnover in the endothelial and smooth muscles of the body. It is suggested as an alternative to intact parathyroid hormone in order to simplify the method [3]. In response to this study, which was announced in the 39th World Congress of Surgery at Brussels in August 2001, Quiros et al. [27] rejected intra-operative calcium monitoring because in their study the decrease in 5 min was only 4 % and remained the same up to 10 min in 46 % of the patients making the method inappropriate as an intra-operative assay. In vivo, calcium levels are influenced by parathyroid hormone, calcitonin and vitamin D and are relatively stable. Moreover, the kidneys, bones and bowel are involved in calcium homeostasis. Finally, the calcium exists in different forms in the body (protein-bound, ionised and complexed fractions). All these make its evaluation very difficult in contrast to the intact parathyroid hormone assay [27]. It is worth mentioning that the intra-operative intact parathyroid hormone assay is not helpful in multi-gland disease in about half of the cases. It is also wise to obtain two samples before the resection of the gland (one after the induction of the anaesthesia and one before removal) to estimate 50 % of the peak value [28].

Potential Complications of Surgery

Recurrent Laryngeal Nerve Injury

Hoarseness due to recurrent laryngeal nerve injury is a dreaded complication. The risk in parathyroidectomy is much less when compared with thyroidectomy. Surgical technique and visualisation of the nerve as a routine are the important factors determining outcome. Knowledge of anatomical variations reduces the margin of error when dissecting near the recurrent laryngeal nerve. Nerve traction is the usual mode of insult, with the anterior motor branch of recurrent laryngeal nerve, which bifurcates near the ligament of Berry being particularly at risk.

Hypoparathyroidism and Hypocalcaemia

One parathyroid gland, if preserved, is sufficient to maintain normocalcaemia. Ephemeral and permanent hypocalcaemia both can occur after parathyroidectomies, and the most common underlying reason is loss of vascularity to the remaining healthy glands resulting in ischemic injury. Meticulous dissection to preserve vascular supply or auto-transplantation of remaining parathyroid tissue is the method employed to prevent post operative hypocalcaemia [26].

Bleeding and Hematoma Formation

As with any neck surgery, bleeding along the tissue planes can result in haematoma formation. Incidence of this complication post-parathyroidectomy is 1 %. Meticulous intra-operative haemostasis to prevent excessive bleeding is the key to preventing this complication [26, 29].

Recurrent or Persistent Hyperparathyroidism

Even when performed by expert endocrine surgeons, the success rate is high but not 100 % and recurrent or persistent PHP rate is as high as 3–5 % [30]. Re-operation is more difficult with less success rate and more complications than the initial exploration because of scarring in the operating field. The most common complication is transient or permanent hypoparathyroidism (18–41 %) mostly because of devascularisation or resection of all the gland tissue during surgery [24]. This usually manifests as early and severe symptomatic hypocalcaemia, which increases the need for longer hospitalisation and supplementation of oral and IV calcium as well as calcitriol. Therefore, there is a need for sensitive preoperative localisation techniques as well as intra-operative monitor of intact parathyroid hormone levels in order to minimise the invasiveness and increase the success of re-operation [24].

In 82.7 % of patients, the cause of hypercalcaemia is a solitary adenoma, and knowledge of surgical anatomy and usual and unusual locations of the parathyroids is imperative if re-operations are to be avoided. Another reason for re-operations is overlooking multiple gland disease, which is around 15–18 % either because the pathologist cannot easily differentiate between hyperplasia and adenoma or because of the false negative localisation tests in combination with a false positive IOPTH determination. Both of these have low sensitivity when it comes to multi-glandular disease. Rarely, the reason for re-operation is unusual locations of adenomas [31]. The patients needing reoperation usually are those who complain of a worse quality of life because of higher complication rates (29.4 %). It is mostly due to failure of resolution of symptoms even after re-operation. Therefore, a careful selection of the patients to be re-operated, a good preoperative work-up and referral to specialised centres can all contribute less complications and better outcomes.

Treatment of the Asymptomatic Patient

While there is a universal agreement that symptomatic patients or patients with associated conditions must be managed surgically, there is significant controversy about which “asymptomatic” patients must be operated on [2]. The NIH consensus conference of 1990 concluded that some asymptomatic hyperparathyroid patients can safely be managed with medical treatment, while those fulfilling at least one criterion should be managed surgically (Table 2). These criteria were upgraded in the National Institute of Health workshop in 2002, and the changes were Ca>1 mg/dl above normal (11.5 mg/dl) and change in bone density more than 2.5 SD below peak bone mass [2]. The Third International Workshop on Asymptomatic Primary Hyperparathyroidism recently abridged the evidence to support surgical intervention based on beneficial outcomes for patients. The key conclusions highlight the fact that evidence on cardiovascular and neuropsychiatric benefits is inconsistent while there is solid evidence on improvement of bone mineral density (BMD). [Table 3] [26, 32]

Nevertheless, we have to consider that 20 % of the asymptomatic diagnosed patients will develop end organ involvement within 5 years from diagnosis and surgery in those patients who fail to meet the criteria for operation greatly improves their quality of life [33]. Some authors suggest widening of the criteria for surgery in these patients [2]. Moreover, larger population-based studies from Europe have shown evidence of increased morbidity (hypertension, bone fractures, and cardiovascular diseases) and mortality among these untreated patients even with mild primary hyperparathyroidism [34].

The primary operation for primary hyperparathyroidism has a morbidity of 1 %. Re-operation is usually needed because of persistence (3.7–5 %) and rarely because of a recurrence (0.4–1.3 %). This rate varies between 3.8 and 15.4 % (in the USA, 9.3–14.4 % vs Europe 5 %) [31]. This changes with re-operations, which have higher complication rates (29.4 %) (recurrent nerve palsy up to 10 %, permanent hypocalcaemia up to 35 %) and a lower success rate (80–98 %) [31].

Management of the Older Patient

Elderly patients usually present with mild hypercalcaemia and no symptoms with a slow progression of disease. In these patients, there is no adverse effect on survival and the disease can safely be controlled medically. Nevertheless, patients fulfilling one or more criterion of the National Institute of Health criteria should be considered for surgery

Table 2 National Institute of Health (NIH) criteria for parathyroidectomy [2]

Marked elevated serum Ca (1–1.6 mg/dl>N ie>12 mg/dl)>2.9 mmol/l
History of an episode of life threatening hypercalcaemia
Creatinine clearance reduced by 30 % with age match normal subjects
Marked elevated 24-h urine Ca (>400 mg/day)
Age<50
Osteitis fibrosa cystica
Reduced bone mass as determined by direct measurement (BM>2SD below controls matched for age, gender , ethnicity, etc.
Neuromuscular symptoms: proximal weakness, atrophy, hyper-reflexia, and gait disturbance

Table 3 Evidence to support surgical intervention in asymptomatic patients

Cardiovascular disease	Data too limited to provide a complete picture
Neuropsychiatric disease	Patients have complaints, but the available data remain inconsistent on precise nature and reversibility
Bone and mineral density	Surgery leads to long-term gains in spine, hip and radius bone mineral density. Patients with bone density *T* score −2.5 or less at the lumbar spine, hip, or distal one third of the radius should have surgery. Those who do not undergo surgery should undergo regular monitoring of serum calcium and 3-site BMD
Nephrolithiasis	In the absence of kidney stones, data do not support the use of marked hypercalciuria (>10 mmol/day or 400 mg/day) as an indication for surgery

because of a high probability of developing complications. With the advances in preoperative localisation techniques, methods of anaesthesia and the use of intra-operative monitoring of parathyroid hormone levels, the operation is successful with low morbidity and mortality. There are studies supporting that post-operatively bone density increases, and there is a reduction in the risk of fractures as well as the long term mortality risk. Therefore, even in these patients that can be managed medically, unless there other medical problems to preclude surgery, many authors recommend surgical management [35]. The general principles of preoperative localisation and surgical techniques can also been applied to the elder population, and the same indications are followed. Nevertheless, patients with coexisting medical problems even with clear indications for parathyroidectomy who are not candidates for surgery can be managed with medical treatment such as biphosphonates (improve trabecular bone density and stabilise calcium). However, creatinine clearance must always be evaluated before treatment to avoid overdose and toxicity. Risedronate is preferable to alendronate as the latter has a higher risk of causing oesophagitis [35].

Conclusion

Rapid advances in technology and improvement of non-invasive imaging tests for preoperative localisation of abnormal parathyroid glands, as well as the use of rapid parathyroid hormone assays, have established a trend towards less invasive surgical procedures like unilateral neck exploration and minimally invasive parathyroidectomies. These approaches have been advocated because of the shorter operative and recovery time, the avoidance of general anaesthesia and the excellent cosmetic result. It can also potentially be performed as an outpatient procedure, with a decreased risk of permanent hypoparathyroidism as the other glands are not handled during surgery. Finally, the reported cure rate is comparable with that of bilateral neck exploration. However, the success of these approaches is entirely dependent upon accurate preoperative localisation as failure of these tests lead to failure of the operation.

Conflict of Interest The authors report no conflict of interest.

Funding No funding was required for this manuscript.

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