RADIOGRAPHIC APPROACH TO ENDOCRINAL DISORDERS IN HEAD AND NECK REGION: A REVIEW

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ABSTRACT

The endocrinal system comprises of hormone secreting glands and tissues. This endocrine system is responsible for intercellular communication which maintains the homeostasis. The imbalance results in various disorders which if remained unidentified may be fatal. The purpose of this article is to review the various radiograph aspect of the endocrinal gland i.e. thyroid, parathyroid and adenohypophysis. This review article has been prepared doing a literature review from Word Wide Web and combined Medline.

Key words: *Endocrinal disorders, Radiographic approach, Endocrine glands, Thyroid gland, Parathyroid gland, Adenohypophysis.*

INTRODUCTION

The term 'endocrine' was coined by Starling.[1] The word endocrine has evolved from the following two Greek words '*ἔνδο- endo'*- 'inside, within', and 'κρίνειν *krinein'* –'to separate, distinguish'.[2] Endocrine Glands are ductless glands that secrete hormones within specific organs and release them directly into the intercellular fluid or into the blood.[4] The main endocrinal glands are: the adenohypophysis, neurohypophysis, thyroid, parathyroid, adrenal (cortex and medulla), pancreas and gonads. Hormones act as "messengers", poured into the bloodstream and carried to the target organs, which interpret these messages and act upon them.

The endocrine systems channelize the hormonal feedback mechanism. Increased hormonal activity ceases its production.[3] Endocrinal disorders occur either because of hyperactivity (increased secretion of the hormones) or hypo activity (decreased secretion of the hormones) of the gland.[4]

Endocrinal disorders have great effects on bone and teeth physiology. The function of bone not only includes support, protection and an environment for hemopoiesis but also serves as a major reserve of calcium for the body. Skeletal structure acts as the store house of >99% of total body calcium. The bone is constantly remodelling due to the effect of systemic diseases on the bone. Approximately, 5% to 10% of the total body mass is replaced each year. 20% of its mass of trabecular bone is replaced per year compared with 5% of cortical bone. The effects of endocrinal disorders involving bone is brought about by the changes in the number of the activity of osteoblasts, osteoclasts and osteocytes.[5] Systemic diseases produce various radio graphical manifestations in skull, teeth and jaws. Thus, various skull and jaw radiographs are stepping stones for the diagnosis of endocrinal disorders. This article covers radiographic features in endocrinal disorders caused by thyroid gland, parathyroid gland and adenohypophysis.

Thyroid Gland

Body is dependent on the largest endocrinal gland for its various regulatory activities.[6] The significance of the thyroid gland is to take iodine and convert it into thyroid hormones – primarily, thyroxin (T_4) and triiodothreonine (T_3).[6] It produces three hormones when stimulated by TSH, i.e. T_3, T_4 and calcitonin.[7]

Thyroxin (T_4) *and* ***Triiodoyhreonine (T_3)*** increases basal metabolic rate and regulates metabolism. **Calcitonin** released as a response to the increased blood calcium levels, resulting in decreased blood calcium and phosphate levels to normal. The targets are bone cells (inhibits osteoclast activity) and kidney tubules (causes secretion of calcium into urine).[7]

Thyroid is a butterfly shaped gland, situated between the Adam's apple and clavicle. Non-pathological thyroid gland is non-palpable, soft and flat.[6]

The negative feedback loop: as more thyroid hormones are produced, blood levels of T_3 and T_4 rise, this increased level indicates hypothalamus, indication pituitary to cease the production of TRH – shutting down the cycle.[6]

On the basis of availability of thyroxin in the body two major disorders prevail i.e. hypothyroidism and hyperthyroidism.

Hyperthyroidism is a syndrome that due to excess production of thyroxin in the thyroid gland and its circulation in the bloodstream. This condition occurs most commonly with diffuse toxic goitre

(Grave's disease) and less frequently with toxic nodular goitre or toxic adenoma, a benign tumour of thyroid gland.

Oral manifestations include: burning mouth syndrome, enlargement of extra glandular thyroid tissue (mainly in the lateral posterior tongue), development of connective tissue diseases, and alveolar atrophy in advanced cases as a consequence of osteoporosis. Periodontitis and dental caries appear more rapidly.[1]

Various appreciable radiographic features include: OPG reveal early dental eruptions (in children); with premature loss of teeth, adults may show a generalized decrease in bone density and loss of some areas of edentulous alveolar bone (maxillary and mandibular osteoporosis), increased susceptibility to caries, periodontal diseases (because these patients crave for sugar containing edibles, to meet their physical requirements).[1,5,9]

Hypothyroidism usually results from insufficient secretion of thyroxin by the thyroid glands despite the presence of TSH, due to reduced rate of oxidative energy-releasing reactions. Cretinism is a condition of hypothyroidism in children.[3]

Oral manifestations include: shortened base of the skull leading to retraction of the bridge of the nose with flaring. The face looks wider as longitudinal growth fails. Accumulation of glucose aminoglycans causes enlargement of tongue with continuous protrusion leading to malocclusion, delayed eruption, retained deciduous teeth but no impairment of tooth formation.[1]

The radiographic features of cretinism can be observed in bones and teeth. Appreciable bony radiographic features are: fontanel's remain open for an abnormal length of time, delayed closing of epiphysis and skull sutures with the production of numerous worming bones (accessory bones in the sutures), marked disproportion between the head and body (wide head), relatively small maxilla and mandible. Appreciable radiographic features of teeth are: delayed eruption of permanent teeth, short roots, thinning of lamina dura, maxilla and mandible are relatively small.[1, 5, 9, 10]

Myxoedema is a condition of hypothyroidism in adults. Oral manifestations include: serrated tongue, macroglossia (difficulty in speaking and swallowing), thick lips, dysgeusia and mouth breathing.[9,11] Appreciable radiographic features of myxoedema can be observed in bones and teeth. These are periodontal disease, delayed permanent teeth eruption, enamel hypoplasia in both dentitions, loss of teeth, loss of lamina dura, micrognathia, separation of teeth as a result of enlargement of tongue, external root resorption, open bite due to lack of condylar and mandibular growth, generalized osteoporosis leading to decreased height of the alveolar bone.[1,5,9]

Parathyroid Gland: Parathyroid glands consist of four, small, light coloured masses on the surface of the thyroid gland.[3,7] It regulates the amount of calcium and phosphorus in the blood. Produces Parathyroid hormone (PTH). PTH releases bone calcium into the extracellular fluid which causes the blood phosphate (HPO_4^{2-}) level to decrease and the ionic blood calcium (Ca^{++}) level to increase.

Parathyroid Hormone, also called parathormone, release is stimulated by a decrease in blood calcium levels. PTH targets bone cells (activates osteoclasts) and kidney cells (causes kidney tubules to resorb more calcium). The antagonistic action of calcitonin and parathormone maintains the homeostasis of blood calcium.[4, 6, 7, 11]
Five functions of Parathormone are: (1) maintain blood calcium level by increased absorption of calcium from gastrointestinal tract; (2) tap the stored bone calcium (3)increases renal calcium resorption, reducing its excretion (4) reduction of renal phosphate resorption; (5) increase the production of 1,25-dihydroxycholecalciferolby the kidney.[3]

Decreased secretion of parathormone is called hypoparathyroidism, due to insufficient parathormone production followed by reduced blood calcium level by decreasing the resorption bone calcium.[4]It is a rare condition.

In psuedohypoparathyroidism there is a defect in the response of the tissue target cells to normal levels of PTH.

Both hypoparathyroidism and pseudohypoparathyroidism produce hypocalcemia. Dental abnormalities such as enamel hypoplasia in horizontal lines, poorly calcified dentin, widened pulp chambers, soft tissue (dental pulp) calcifications, shortened roots, hypodontia, weak teeth, malocclusions, loss of bone density and mandibular tori as PTH affects the rate of eruption, formation of the matrix and calcification. A delay or cessation of dental growth and development, chronic candidacies of the oral mucosa, paresthesia of the tongue or lips and alteration of the facial muscles can occur.[4,5,9,11]

Patients with pseudohypoparathyroidism often have early closure of certain bony epiphyses and thus manifest short stature or extremities disproportions.[5]

The striking radiographic feature is calcification of the basal ganglia (calcification within the substance of the brain in the region of the basal ganglia). On skull radiographs this calcification appears flocculent and paired within the cerebral hemispheres on the posteroanterior (PA) view. Radiographic examination of the jaws may reveal dental enamel hypoplasia (may show transverse ridges across the crown), external root resorption, delayed eruption or remain unerupted, root

dilacerations, abnormal calcifications, short and blunt roots with open apical foramens but with the canal converging towards the apex and enlarged pulp chambers (with or without pulp stones).[5,10,12]

Hyper secretion of PTH is called **hyperparathyroidism**, which results in hypercalcemia.[8]It was described by von Recklinghausen in 1891 and so called as von Recklinghausen disease of bone. It is an endocrine abnormality in which excess of circulating PTH increases bone remodelling in preference of osteoclastic resorption, which mobilizes calcium from the skeleton.[1,5] When PTH is produced in excess, calcium is resorbed from the kidney, bones, and stomach back into the blood. This leads to a condition, described by Jacksn and Frame in 1972 called "stones, bones, groans and moans with fatigue overtones". This terminology refers to the classical set of four symptoms associated with hyperparathyroidism: kidney stones, demineralised bones (osteoporesis), groans of pain from intestinal distress (including duodenal ulcers), and the moans of psychosis.[1,6] *Hyperparathyroidism is of three different types: primary, secondary and tertiary*.[4]

Primary hyperparathyroidism- Is due to the development of tumour in one or more parathyroid glands, resulting in overproduction of excess PTH. An abnormality named hyperparathyroidism-jaw tumour syndrome, which involves tumour of parathyroid glands, jaws, and kidneys has been shown to have genetic basis. Less frequently, individuals may have hyperplastic parathyroid glands that secrete excess PTH. The combination of hypercalcemia and an elevated serum level of PTH are diagnostic of primary hyperparathyroidism.[4, 5]

Secondary hyperparathyroidism- Is due to the physiological compensatory hypertrophy of parathyroid glands in response to hypocalcaemia. The underlying hypocalcaemia may result from an inadequate dietary intake or poor intestinal absorption of vitamin D or from deficient metabolism of vitamin D in the liver or kidney. Hypocalcaemia prompts increased PTH production with liberation of calcium from bone. This condition produced clinical and radiographic effects similar to those of primary hyperparathyroidism.[1, 5, 8]

Tertiary hyperparathyroidism- Is hyperplasia of all the parathyroid glands that develop due to chronic secondary hyperparathyroidism.[8] The clinical symptoms are mainly related to hypercalcemia. Gradual loosening, drifting, and loss of teeth may occur. Only about one in five patients with hyperparathyroidism has radio graphically observable bone changes.[5]

In oral cavity, the most common clinical manifestation of HPT is brown tumours. Other manifestations include: chronic candidacies, parenthesis of the tongue and lips, and alteration in facial muscles, loss of bone density, weak teeth (hypodontia), malocclusions (because of drifting of teeth), soft (dental pulp) tissue calcifications. Dental abnormalities include: developmental defects, such as, enamel hypoplasia in horizontal lines, poorly calcified dentin, shortened roots, alteration in dental eruption (delay in cessation of dental development), widened pulp chambers and mandibular tori. Giant cell tumours and pseudo cysts of the jaws are the other possible lesions found. Mandible involvement is common, especially in the area of premolars and molars, and it is rare in maxilla.[1, 9]

Rubber jaw is a striking feature in which it is possible to mold the shape of the jaw with the fingers, but the teeth resumed their original positions when the pressure was relaxed. Because of an extraordinary softness of the snout, maxilla and mandible in this condition, it has been termed "rubber jaw". When pressure is applied to the skull, a crackling sensation is experienced. The cupids can be moved to and fro with ease.[10]

Brown tumours present itself as friable red-brown mass, its name is due to colour that it takes from the haemorrhagic infiltrates and haemosiderin deposits that are often found inside. Brown tumour presents as osteolytic lesion that develops due to changes in bone metabolism caused by high serum concentration of PTH. It is mainly due to secondary HPT in patients with renal insufficiency, but it has also been described as a rare manifestation of calcium malabsorption and some forms of osteomalacia.[9] These peripheral or central tumours of bone are radiolucent, which were either single cavities or multiple honeycombed ones.[5,10] Orthopantomo graphs, lateral oblique and postero-anterior views of the body of the mandible shows brown tumours of the jaws. Radio graphically, lesions are either peripheral or central, monotonic or polystotic, uni or multilocular without marginal scalloping and may produce cortical expansion. Radio graphically, they appear rounded with smooth or irregular borders and with sclerotic reactive bone margins. May appear in any bone but are frequently found in the facial bones and jaws, particularly in the long standing cases of the disease. These lesions may be multiple within a single bone. If solitary, the tumour may resemble a central giant cell granuloma (histologically) or an aneurismal bone cyst.[1,5,8,12]

An epulis is a tumour of the gum. It is sometimes the first intimation that there is more serious underlying abnormality. It is not usual for an epulis to produce any bone change, but in this disorder a saucer-shaped area of alveolar absorption at the crest in the vicinity of the tumour can be appreciated. It thus, brings about the bone resorption by pressure and not actual involvement of the bone by tumour cells.[10]

Radiographic features of skull. In Submentovertex, posterior-anterior skull and true lateral skull view, skull appears osteoporetic and this change may occur before jaw changes. Deossification appears granular caused by loss of diploic and thinning of cortical plates and is prominent in the outer third of the skull termed as pepper-pot skull (the entire calvarium has a granular appearance), which may be interrupted by one or more cystic areas representing brown tumours.[1,8,12]

Radiographic features of the jaw. In intraoral periapical radiographs, orthopantomograms, maxillary and mandibular true occlusal radiographs-generalized demineralization characterized by lack of sharpness of trabecular pattern with a more granular appearance sometimes may not have a mottled or moth eaten appearance (due to variation in density in trabecular pattern) of numerous, small, randomly oriented trabeculae, erosion of the bone from the supraperiosteal surfaces of the mandibular angle. Thinning of cortical boundaries often occur in jaws in cortical boundaries such as inferior border, mandibular canal, mental foramen and the cortical outlines of the maxillary sinuses (walls of antrum and nasal cavities). The density of the jaws is decreased, resulting in a radiolucent appearance that contrasts with the density of the teeth, thus, teeth stand out in contrast to the radiolucent jaw. Intraoral periapical radiographs and paranasal sinus view shows thinning of cortical outlines of maxillary sinus and nasal cavities. Depending on the duration and severity of the disease, the intraoral periapical radiographs show loss of lamina dura which may occur around one tooth or all the remaining teeth (due to increased uptake of calcium from bone as a result of reduction in vitamin D production), which appear as the first sign of deossification in the jaws. The loss may be either complete or partial around a particular tooth. Two relative changes are observed: thickening of PDL space and tapered appearance of roots because the lamina dura provides a definitive edge effect accentuating the density of the root (loss of image contrast) and is rounded at apex. Metastatic calcifications may occur in salivary glands.[1,5,8,12]

Radiographic features of the Teeth and Associated Structures. Although PTH mobilizes minerals from the skeleton, mature teeth are immune to this systemic demineralising process. In developing or erupting tooth: intraoral periapical radiographs reveal loss of crypt wall, pointed or tapered roots especially at apical third and large pulp chambers are seen. In erupted teeth, the pulp chambers appear large in young people but in adults they are narrower, with appreciable pulpal calcifications.[1, 5, 8, 12] Long term injuries commonly produce a significant expansion of cortical bone, alterations in trabecular bone, root resorption and displacement of roots can appear.[9]

Pituitary Gland (Anterior): Pituitary Gland, also known ashypophysis is the Master Gland because it is the main place for everything that happens within the endocrine system.[4] It is divided into two sections: the anterior lobe (anterior pituitary, adenohypophysis) and posterior lobe (posterior pituitary, neurohypophysis).[4] The control of release of hormones from the hypophysis is via a negative feedback from the target gland.[3]

Adenohypophysis secrete six different hormones: human growth hormone (HGH), thyroid stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), prolactin (PRL), follicle stimulating hormone (FSH), luteinizing hormone (LH).

Human growth hormone (HGH) controls growth of the body and targets the bone, muscle and adipose tissue.[7]

Thyroid stimulating hormone (TSH) controls the secretion of hormones by the thyroid gland and targets thyroid gland.

Adrenocorticotropic hormone (ADH) controls the secretion of hormones by the adrenal cortex and targets the outer portion of the adrenal gland (cortex).

Prolactin (PRL) stimulates the production of milk by the mammary glands and targets the mammary glands.

Follicle stimulating hormone (FSH), a gonadotropin which stimulates the maturation of primary sex organs (ovary and testis) and targets the primary sex organs.

Luteinizing hormone (LH) targets primary sex organs and causes ovulation in females and secretion of testosterone inmales.[7]

The hyperactivity of adenohypophysis, called hyperpituitarism, results in the following disorders: Gigantism, Acromegaly, Acromegalic Gigantism, Cushing's Disease.[4]

Gigantism is the pituitary disorder characterized by excess growth of the body, due to hyper secretion of GH in childhood or pre-adult life before the fusion of epiphysis of bone with the shaft.[4]

Radiographic features of the skull include: true lateral skull, lateral cephalogram, paranasal view, postero-anterior skull view characteristically reveal enlarged supra orbital ridges and the underlying frontal sinuses and increased pneumatisation of temporal bone.[5, 8, 12]

Radiographic features of the jaws include: jaw radiographs such as lateral oblique ramus, posterior body mandible, orthopantomograms reveal increase in the length of the dental arches, resulting in spacing of the teeth, maxillary widening, jaw malocclusion and overbite, protruding and prominent mandible due to mandibular and condylar overgrowth and increase in the thickness and height of alveolar processes.[1,5,8,12]

Radiographic changes associated with the teeth: intraoral periapical radiographs reveal macrodontia because the teeth size is proportional to the size of jaws and the body, roots may be larger than normal.[1, 5, 8, 12]

Acromegaly, also called adult hyperpituitarism, is a disorder characterized by progressive cosmetic disfigurement and systemic organ manifestation with the enlargement, thickening and broadening of bones, particularly in the extremities of the body.[4,5,12] It is due to hyper secretion of GH in adults after the fusion of epiphysis with shaft of the bone.[4] It is a slow process because many types of tissues have lost the capacity for growth.[5] An excess of growth hormone can stimulate the mandible and phalanges of the hand. Oral manifestations include: jaw malocclusion and overbite, enlarged lips, tongue with teeth indentations on the lateral border, and, soft palate hyperplasia causes sleep apnoea and airway obstruction.[1, 4, 5]

Radiographic features of skull include: skull radiographs such as true lateral skull, lateral cephalogram, paranasal view, postero-anterior skull view characteristically reveal enlargement (ballooning) of the sellaturcica (if an enlarged pituitary adenoma is present), prominent supra-orbital ridges, paranasal sinuses (especially the frontal sinus) and increased pneumatisation of temporal bone; because of the disproportionate growth of the facial bones and paranasal sinuses, diffuse thickening of the outer table of the skull (thickening of skull vault leading to enlargement and deformity), thickened malar bones and zygomatic arches with enlarged maxilla.[1, 5, 8, 10, 12]

Radiographic features of the jaw include: jaw radiographs like lateral oblique ramus, posterior body mandible, orthopantomograms reveal enlargement of the mandible (greatest change in the facial bones, leading to chin protrusion, responsible for typical facial appearance), excess condylar growth and height of ascending ramus resulting in class III skeletal relationship, increased angle between the ramus and body of the mandible with loss of antegonial notch, this in combination with uniform macroglossia and maxillary widening, may result in anterior flaring of the teeth and development of an apertognathia (anterior open bite). The sign of incisor flaring is helpful point of differentiation between acromegalianprognathism and inherited prognathism. The thickness and height of alveolar processes may also increase.[5, 8, 10, 12]

Radiographic changes associated with the teeth: intraoral periapical radiographs reveal that crowns of the teeth are of normal size, but the roots of the posterior teeth often enlarge as a result of hypercementosis (it may be present to compensate for the functional and structural demands of the body), supraeruption of the posterior teeth (to compensate for the mandibular overgrowth).[5, 8, 12]

Hypo activity of the adenohypyphysis, called hypopituitarism, results in the following disorders: Dwarfism, Acromicria, Simmond's disease and Progeria.[4]

Dwarfism (pituitary dwarfs) is pituitary disorder in children characterized by stunted growth or short stature of the affected person, caused by reduction in the GH secretion in infancy or early childhood. Oral manifestations include: failure of the development of the jaws (small maxilla and mandible) i.e. the face appears small, agenesis of the upper central incisor and solitary maxillary central incisor, amelogenesis imperfecta.[5, 4, 12]

Radiographic features include: lateral cephalogram, true lateral skull and postero-anterior view show small dimensions of skull and facial bones. Orthopantomograms, intraoral periapical radiographs reveal delayed exfoliation of deciduous teeth for 1-3 years and delayed eruption of permanent teeth for 3-10 years, because of delayed development of the roots of permanent teeth. Third molar buds may be completely absent, even in the fourth decade of life. Small jaws (dental arches) and retarded mandibular and maxillary growth result in overcrowding, malocclusion (due to less space for the accommodation of all teeth). The anatomical crowns are normal in size but clinical crowns are smaller because of incomplete eruption of teeth. This happens because the roots of the teeth are shorter and apices are wide open with the pulp canal diverging towards the apex leading to incomplete eruption. Over calcification of the substance of the teeth (in evident in radiographs), retrusion of chin and supported structures are retarded in growth .[1,5, 8, 10, 12]

Simmond's Disease, also called pituitary cachexia, occurs after pituitary, and is a rare pituitary disease. It occurs mostly in pan hypothyroidism (hypo secretion of all the adenohypiphyseal hormones due to atrophy or degeneration of adenohypophysis). No specific dental changes have been observed in this condition, except for greater tendency towards marked alveolar resorption and loss of teeth.[1, 4, 10, 12]

Progeria, categorized as endocrinal disorder by ICD-9 (international classification of diseases-9th revision) 259.8, characterized by premature senility in an individual of infantile proportions. The condition commences between 3months and 3 years. Clinical features include: normal at birth but by the age 1or 2 years severe growth retardation, dwarf individual with normal skeletal maturation, short stature and lower weight for height, balding, loss of eyebrows and eye lashes, skin is lax and wrinkled (widespread loss of cutaneous fat), alopecia, prominent scalp veins, prominent eyes, a beaked nose, and a "plucked bird" appearance, thin and high

pitched voice, pyriform thorax. Oral manifestations include: delayed dentition, micrognathia, thin lips. Fairbank has reported a case with "four sets of teeth".[10, 13]

Radiographic features include: osteoporosis of long bones, craniofacial disproportion, short dystrophic clavicles. The increased size of the skull is due to over development of frontal and parietal bones, with small mandible and retracted chin. The above features resemble that of a wizened old person who has a stature of a small child. Ossification may be delayed and deficient, arteriosclerosis. Also, the structure of bone is unaltered except in those areas where teeth have failed to develop when there is deficiency of trabeculae. There is wide variation in number of teeth. Overcrowding can be observed in cases of complete dentition.[10, 13]

CONCLUSION

The exploration to the black and white endocrinal world led me to know the hormonal world better. The study of the plethora of endocrinal hormones increased my horizon to the grey world of radiology. The study will help in prompt recognition of various endocrinal dysfunctions, especially in head and neck region. The knowledge will be able to prevent complications during dental treatment and will provide a safe setting for clinical and therapeutic interventions in these patients in the dental office.

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