ORAL MANIFESTATIONS OF MALNUT-RITION I. THE EFFECT OF VITAMINS

Pages with reference to book, From 44 To 48

Mohammad Iqbal Khadim (Dentistry Dept., Khyber Medical College, Peshawar.)

The tissues of the mouth often show earlier signs of nutritional disturbances than does the skin, other body tissues because stratified squamous epithelial lining of the oral cavity (with the exception of that covering the gums and palatal tissues) is not keratinized and changes in the sub-cpithelial tissues and resultant inflammatory reactions become more prominent. Oral tissues are more frequently subjected to physical, chemical, and thermal traumas by eating, talking and by the presence of irritating fillings and appliances. Healing of repeatedly traumatized tissue is limited in various nutritional deficiencies and 3) the mouth is constantly bathed with a fluid containing a variety of potentially pathogenic as well as non-pathogenic micro-organisms in abundance tissues of the mouth whose resistance has been lowered by malnutrition will more easily become infected (Zegarelli et al., 1969).

The term malnutrition means the lack, imbalance or excess of one or more of several nutrients that are required by the body. The development of oral disease is related to the type of nutritional disturbances, the severity of malnutrition and the age and general health of the individual. Poor oral hygiene and chronic inflmmation will tend to exaggerate the clinical appearance of the oral reaction to a nutritional disturbances are generalized stomatitis, glossitis, gigivitis, cheilitis, etosions and ulcerations, and mucosal thing and atrophy of specialised structures.

A good understanding and a careful search for the oral manifestations of the deficiency or excess of various dietary constituents is an important pre-requisite for arriving at appropriate diagnosis of various types of nutritional disorders. The present article briefly summarises the latest literature on the oral manifestations of deficiency and excess of vitamins.

Vitamins are organic substances that are soluble in either fat or water and are required in small amounts for health and adequate nutrition of the body. Of the vitamins, vitamin C and vitamins of the B complex group are of importance to the health of the oral tissue. Vitamin D is essential for normal bone development and metabolism (Shklar and McCarthy, 1976).

Dentistry Dept., Khyber Medical College, Peshawar.

A. Deficiency (Hypovitaminosis)

Vitamin deficiency tends to occur as a mixed clinical entity like the nutritional deficiency which is rarely of a single nutrient. The problem tends to be a deficiency of many nutrients either absent in the diet or unavailable because of some gastrointestinal disorder preventing normal absorp tion and utilization by the body.

THIAMINE (Vit. B_1)-The Oral manifestations of vitamin B_1 deficiency include hyperesthesia of the oral mucosa (Nizel, 1972), atypical neuralgias (Mann et al., 1941), burning sensation in the tongue, denition, jaws and face, and hypersensitive dentine (Shklar and McCarthy, 1976). Vitamin B_1 deficiency in infants begins with a red appearance to papillae located over the enterior third and tip of the tongue followed by a diffuse glossitis. Pinpoint vesicles resembling herpes occurring on the palate, buccal mucosa undersurface of the tongue have been reported by Weisberger (1941). Trigeminal neuralgia and delayed wound (extraction) healing have also been described (Zegarelli et al., 1969).

RIBOFLAVIN (Vit. B_2):-Two major manifestations of riboflavin deficiency are angular cheilosis and glossitis which are more clearly defined than those of Thiamine deficiency. The glossitis is characterized by a distinct purple discoloration and atrophy of the superficial papillae of the tongue contributing to a shiny, smooth appearance. The discoloration is associated with vascular engorgement (Zegarelli et al., 1969).

Experiments carried out on both pregnant and non-pregnant women showed that in riboflavin deficiency the lips become red and cracked. There may be painful glossitis accompanied by engorgement of the fungiform papillae which give the tongue a pebbly texture and very often a magenta colour. Later there is atrophy of the papillae which leaves the tongue glazed, shiny and fissured. With cheilosis a red painful area begins at the angles of the lips and in severe cases it leads to the formation of painful fissures (Serbell and Butler, 1939; Sydenstricker, 1941; Jones et al., 1944; Braun et al., 1945).

In an African camp of 1,746 men, Jones et al (1944) reported the occurrence of cheilosis and painful glossities (though not of the magenta type) which improved with supplements of riboflavin. In young adult males, there is resorption of the interdental alveolar crests and loosening of the incisors (Ross, 1944). Decrease in the size of specific organs, malformation of the jaws and retardation of growth of the condyle have also been reported (Levy, 1949). In rats, if mothers are fed on a riboflavin deficient diet, many of their progeny are affected with con- genital malformations, including defective development of the mandible and cleft palate (Warkany and Schraffenberger, 1944; Bauer, 1949).

Nicotinic Acid:In nicotinic acid or niacin deficiency the tongue becomes markedly painful, beefy red, and swollen with hypertrophy of the Papillae (Kaufman, 1943). As the condition progresses the papillae (fungiform and filiform) atrophy, and there is despuamation of the superficial epithelial layers, leaving a smooth glistening, red dorsal surface (Kruse, 1942). There is painful stomatitis, a widespread patchy inflammation of oral mucosa, with associated burning and soreness (Johnson, 1955). Necrotizing inflammation, begins at the interdental papillae and progresses rapidly until the gingiva are ulcerated (Spies et al., 1939; Dreizen, 1971).

PYRIDOXINE (Vit. B_6):The effects of Pyridoxine deficiency in man have not been determined completely. Oral lesions have been produced experimentally after the administration of a Pyridoxine antagonist (Desoxypridoxine) coupled with a pyridoxine deficient diet. These lesions have responded favourably to Pyridoxine therapy.

Mice fed on Pyridoxine deficient diet show progressive atrophy of the interdental papillae with a superficial necrosis and an inflammatory reaction of the underlying connective tissues which increases in severity as the deficiency continues. These changes are accompanied by regressive changes in the alveolar bone. In the condylar process, growth of cartilage and formation of bone are inhibited (Levy, 1950).

Pantothenic Acid.-Though the changes produced in man by a deficiency of pantothenic acid are not well defined, the healing which follows the administration of pantothenic acid suggests that a deficiency may lead to a specialized form of glossitis and cheilosis (Reither, 1957) .In dogs deficiency of Pantothenic acid leads to severe gingival inflammation with necrosis of the oral epithelium, and to osterporsis and progressive marginal atrophy of the alveolar bone which resembles the atrophic changes seen in complex periodontal disease in man (Becks et al., 1943).

Cyanocobalamin (Vit. B_{12}):-The most severe form of vitamin B12 deficiency in man is manifested as Addisonian anemia. About half of the patients with Addisonian anemia have glosso-dynia with a sore, red tongue and baldness of dorsum due to atrophic changes of the oral mucosa. The lips and oral mucosa especially of the palate have a pale yellowish appearance; occasionally a brownish pigmentation may appear in the mouth. A marked feature is the smooth tongue, termed Hunter's glossitis, which is due to atrophy of the filiform papillae. It appears red and the patient frequently complains of soreness of a burning sensation (Stones). There may be loss of the sense of taste. Glossopyrosis has been treated with some success by the oral and intramuscular injection of Vitamin B_{12}- Strean (cited by Zegarelli et al., 1969) was able to alleviate the symptoms of trigeminal neuralgia and involvement of other peripheral nerves with daily injections of vitamin B12. Slight improvement was noted after B12 therapy in patients suffering from idiopathic glossodynia (Kutscher and Lane, 1952).

Folic Acid.-The outstanding oral symptoms of folic acid deficiency in man include glossitis with burning sensation, ulcerative stomatitis and angular cheilitis. Glossitis follows a similar course to that of vitamin B_{12} deficiency. Initially the dorsum becomes reddened, swollen, and tender. Ulcers appear, either in the form of superficial erosions or as small apthae. The tongue at this stage is called as "beefy" and is most painful. Subsequently, the papillae atrophy, first the filiform and then the fungiform papillae. In early stages, the atrophic changes on the dorsal surface of the tongue tend to be patchy, often starting near the lateral borders. Numerous superficial erosions and ulcers then develop in the inflamed trophic areas. Finally the dorsum of the tongue becomes smooth and thiny. Stomatitis includes development of aphthous ulcerations on buccal, gingivae may exhibit exaggerated inflama-tory response, resulting in bright red gingivae and occasionally superimposed necrotizing gingivitis. Periodontitis is also reported to be common in folic acid deficiency (Dreizen and Levy, 1969; Rose, 1971; Dolby, 1975; Shklar and McCarthy, 1976).

Ascorbic Acid (Vit. C):- The disease resulting from deprivation of vitamin C is termed as "scurvy". Scurvy is seen most often in infants. Particularly those who are bottle-fed, since normal human milk contains sufficient quantities of vitamin C. When the deficiency occurs in artificially fed infants, it is known as infantile scurvy or Barlow's disease.

Vitamin C plays an important role in the differentiation of connective tissue cells and their capacity to form and maintain the intercellular matrix. In avitaminosis C the osteoblasts lose their function of forming bone with the result that the alveolar been undergoes resorption and becomes less dense; the periodontal membrane become weak due to defective collagen formation and there is a general loss of strength of the supporting structures of the tooth (Westin, 1925; Harman et al., 1938). Consequently, under occlusal stress, the periodontal fibers may easily rupture and the tooth becomes loose (Dalldorf and Zall, 1930). Marginal gingivoalveolar osteitis and osteomyelitis around the teeth have also been demonstrated in rats kept on a diet deficient in Vitamin C (Westin and Kalnins, 1938).

In severe vitamin C deficiency the gingivae become swollen, purplish or maroon coloured and spongy, tending to cover the teeth and bleed easily; there is also delay in wound healing (Hanke, 1935; Lanman and Ingalls, 1937; Hunt, 1941).

Vitamin A:-In infants, vitamin A deficiency may cause atrophy of the secretory ameloblasts to a nonspecialised stratified epithelium which results in poor mineralization of the dentine and enamel hypoplasia as evidenced by pits, fissures or irregularities of the enamel (Dinnerman, 1945; Sud, 1958). The normal orange pigment which is the natural product of the ameloblasts, is no longer formed, the teeth appearing white, un-glased and blunt (Irving and Richards, 1939). In young rats, whose mothers have been fed on a deficiency diet for five months preceding the birth of the off spring, there is distortion in the shape of the incisors and molars (Mellanby, 1939, 1941). In dogs there is retarded eruption and malformation of teeth (King, 1936).

The struature of the dentine is a-typical, being non-tubular and containing vascular inclusions; there are foldings and projections of dentine into the pulp (Wolbach and Howe, 1925). The mineralization of the dentine is deficient and shows many interglobular areas. This deficient mineralization still persists even when the diet is fortified with additional quantities of Vitamin D, calcium, and phosphorus. Formation of amorphous dentine in the pulp and thickening of the cementum have also been reported (Schour et al., 1941).

Avitaminosis A may play a role in the etiology of malignant and premalignant lesions of the oral cavity (Silverman et al., 1965). Since vitamin A deficiency induces metaplasia and hyperkeratosis of epithelial structures, it is suggested that vitamin A deficiency may be related to the development of leukoplakia (a premaiignant condition) and carcinoma. Good therapeutic effects of vitamin A acid have been achieved by Ryssel et al (1971) in patients with leukoplakia in the mouth and larynx.

Vitamin D:-The effects of the jaws and teeth may be pronounced, with particularly disturbing phenomena occurring in those deficiency. The deciduous teeth are not usually affected but the crowns

of permanent cental incisors and first molars and occasionally the lateral incisors and cuspids are involved. The inadequate calcification, due to vitamin D deficiency, leads to hypoplastic defects, such as the formation of pits, fiss-ures and grooves in the crowns of. These effects are frequently severe enough to cause moderate and even severe deformities or malformations of the clinical crown (Zegarelli et al., 1969). The bones of the jaw may be deformed because of the tension of the attached muscles on the markedly weakened (hypocalcified) structures. Clinically, open-bite relationship, malformations of the jaw, and malocclusion result therefrom. Changes in the dentine are also seen, consisting of deficient and improper calcification of the dentine matrix, thus leading to interglobular spaces and a broadended predentine layer (Zegarelli et al., 1969).

The dentine shows a line of disturbed mineralization in acute vitamin D deficiency. The response of growing dentine to even a slight deficiency is so sensitive that it can be used as an indicator of the adequacy of the vitamin. In mild deficiencies there is the formation of interglobular dentine (Mellanby, 1939; Mellanby, 1930). In severe chronic deficiency the dentine matrix does not mineralize so that the predentine is wider. In every severe deficiency there may be pulp inclusions and the rate of formation is retarded (Becks and Ryder, 1931). The formation of the secondary dentine is retarded and its mineralization is disturbed (Mellanby, 1930).

Vitamin K .-Vitamin K is necessary for the synthesis of prothromib, proconvertin, Stuart factor (factor X) and Christmas factor (factor IX), so that a deficiency of this vitamin leads to a disorder of coagulation with resultant hemorrhagic state (Dolby, 1975). In man, vitamin K has been used to treat hypoprothromibinemia of new born, as well as the hemorrhagic manifestations associated with such diseases as obstructive jaundice and diarrhoea (Shafer et al., 1974).

Avitaminosis K is one of the numerous causes of hemorrhage from the oral cavity and gingival bleeding is the most common oral manifestation of vitamin K deficiency (Shafer et al., 1974). Lack of this vitamin may cause excessive gingival bleeding after tooth-brushing or spontaneously. Petechiae, ecchymosis and humatoma may occur in the oral mucosa. In severe case, a slow constant, mild hemorrhage occurs from the gums.

Alpha-Tocopherol (Vit. E):- Vitamin E contains an antisterility factor. The information concerning the effect on the growing teeth of hypovitaminosis E is not sufficient. Prolonged deficiency causes loss of the normal orange brown pigmentation in the enamel of the incisors of the rat (Davies and Moore, 1941). A premature degeneration of the enamel has also been noted (Irving, 1942). The deficiency results in disarrangement of ameloblasts and the incisors(rodent) become chalk white (Nizel, 1972). Dental depigmentation depends upon the presence of highly unsaturated fatty acids in the ameloblasts in the absence of vitamin E. Administration of either protein or vitamin E restores the activity of the ameloblasts followed later by the reappearance of the incisal pigmentation, in experience albino rats fed on a vitamin E free and low protein diet (Irving, 1958). In human-beings a favourable response to Vitamin E therapy has been reported in patients having severe periodontal disease with a minimum of local irritating factors.

B. Excess (Hypervitaminosis):

The hypervitaminoses are lot catrogenic disorders caused by the administration of excessive amounts of vitamin preparation. They usually are due to an excess of fat soluble vitamin (vitamin A, D and K), since the excretion of these vitamins is slow, and large amounts, therefore, tend to accumulate in the body with continued administration of highly concentrated formulations.

Vitamin A ."-The ingestion of excessive amounts of vitamin A (7500 IU or more per day) over a period of weeks or amounts lead to various clinical manifestation. The skin may become coarse, scaly, and the lips may show fissures. There may not only be new bone formation but also calcification in tissues (Zegarelli et al., 1969).

In animals, vitamin A excess (50-100 IU) leads to vacuoles and hemorrhages in the dental pulp with deposits of calcium as well as degeneration and disorganization of the odontoblasts with amorphous mineralization of the dentine. Irving (1949) considers that primary effect is on the osteoblasts and

odontoblasts and that in hypervitaminosis, the rate of formation of alveolar bone is greatly reduced and active ameloblasts become less prominent. Osteoblasts appear to be unaffected and hence the bone becomes abnormally thin and may disappear in places. In the incisor teeth, only dentine formation is affected. This becomes decreased in appositional rate, the average predentinc width being about half the normal at the formative end of the tooth. The interfibrillar cementing substance is gradually reduced in amount and the lingual odontoblasts begin to atrophy.

Vitamin D:-Single massive doses of vitamin D have been given by numerous workers where they have found that (1) on the inner edge of the normal dentine there is a hyper-mineralized or calciotraumatic line staining with hematoxyline, (2) a mineralized hyper layer, (3) more internally a rather wide hypermineralized zone, the mineralization being accelerated (Harris and Innes, 1931; Schour and Han, 1934).

In dogs a single massive dose of vitamin D2 produces osteoperosis of the mandible and resorptive processes appear in the alveolar bone. There is pathological mineralization of the surface of the roots and wall of the pulps of deciduous teeth (Becks et al., 1946).

Overdosage of vitamin D produces hyper-mineralization of the alveolar bone cementum and there is a narrowing of the periodontal membrane (Harris and Innes, 1931) leading in dogs to ankylosis (Becks, 1942).

Vitamin K:-Although vitamin K is normally needed for the formation of prothrombin, excess vitamin K may actually induce hypoprothrom-binemia by exhausting the prothrombin processes. A bleeding tendency may therefore not only be due to lack of vitamin K, but may also be due to vitamin excess (Zegarelli et al., 1969).

Acknowledgement

The author is grateful to Dr. Abdul Qayyum, pcsir., Peshawar for useful criticism and to Mr. Yahya Jan and Mr. Mushtaq Ahmed for secretarial assistance.

References

1. Bauer, W.H. (1949) A preliminary report on the effect of maternal riboflavin deficiency of rats upon bones of their off spring with special reference to cleft palate. J. Dent. Res., 28:658.
2. Becks, H. (1942) Dangerous effects of overdosage on dental and parodental structures. J. Amer. Dent. Ass., 29:1947.
3. Becks, H., Collens, D.A. and Axerlrod, H.E. (1946) Effects of single massive dose of vitamin D2 (D-Stress therapy) on oral and other tissues of young dogs. Amer. J. Ortho-dont. ,32:452.
4. Becks, H. and Ryder, W.B. (1931) Experimental rickets and calcification of dentin. Arch. Path., 12:358.
5. Becks, H., Wainwright, W.W. and Morgan, A.F. (1953) Comparative study of oral changes in dogs due to deficiencies of pantothenic acid, nicotinic acid and unknowns of vitamin B Complex. Amer. J. Orthodont., 29:183.
6. Braun, K., Bromberg, Y.M. and Brezeniski, A. (1945) Riboflavin deficiency in pregnancy. J. Obstet. Gynaec. Brit. Emp., 52:43.
7. Dalldorf, B. and Zall, C. (1930) Tooth growth in experimental scurvy. J. Exp. Med., 52:57.
8. Davies, A.W. and Moor, T. (1941) Interaction of vitamin A and E. Nature, 147:794.
9. Dinnerman, M. (1951) Vitamin A deficiency in unerupted teeth of infants. Oral Surg., 4:1024.
10. Dolby, A.E. Oral mucosa in health and disease. Oxford, Blackwell Scientific Publications, 1975.
11. Dreizen, S. (1971) Oral indications of the deficiency states. Postgrad. Med., 49:97.
12. Dreizen, S. and Levy, B.M. (1969) Histopathology of experimentally induced nutritional deficiency

cheilosis in the marmoset (callithrix jacchus). Arch. Oral Biol., 14:577.
13. Hanke, H. (1935) Experimentelle Untersuchungen uber Beeinflussung der knochenregenration durch vitamin C. Dtch. Z. Chir., 245:530.
14. Harman, M.T., Kramer, M.M. and Kirgis, H.D. (1938) Lack of vitamin C in diet and its effects on jaw bones of guineapigs. J. Nutr., 15:277.
15. Harris, L.J. and Innes, J.R.M. (1931) Mode of action of vitamin D influence of calcium phosphate intake. Biochem. J., 25:367.
16. Hunt, A,H. (1941) Role of vitamin C in wound healing. Br. J. Surg., 28:436.
17. Irving, J.T. (1942) Enamel organ of rat's incisor tooth in vitamin E deficiency. Nature, 150:122.
18. Irving, J.T. (1949) The effect of avitaminosis and hyper-vitaminosis A upon the teeth and incisal alveolar bone of rats. J. Physiol., 108:92.
19. Irving, J.T. (1958) Curative action of alpha tocopherol and of protein upon the incisor teeth of vitamin E-depleted rats. J. Dent. Res., 37:732.
20. Irving, J.T. and Richards, M.B. (1939) Influence of age upon requirements of vitamin A. Nature, 144:908.
21. Johnson, W.B. (1955) Oral symptoms and treatment of a nicotinic acid deficiency. Oral Surg., 8:1257.
22. Jones, H.E., Armstrong, T.G., Green, H.F. and Chadwick, V. (1944) Stomatitis due to riboflavin deficiency. Lancet, 1:720.
23. Kaufman, W. Common form of niacin amide deficiency disease: Aniacinamidosis. Haven Yale University Press, 1943.
24. King, J.D. (1936) Dietary deficiency, nerve lesions and the dental tissues. J. Physiol., 88:62.
25. Kruse, H.D. (1942) Lingual manifestations of aniacinosis especial consideration of detection of early changes by biomicro-scopy. Milbank Mem. Fd. Quart-Bull., 20:290.
26. Kutscher, A.H. and Lane, S.L. (1952) Vitamin B12 in the treatment of idiopathic glossodynia. New York Dent. J., 18:316.
27. Lanman, T.H. and Ingalls, T.H. (1937) Vitamin C deficiency and wound healing; an experimental and clinical study. Ann. Surg., 105:616.
28. Levy, B.M. (1949) Effect of riboflavin deficiency on the growth of mandibular condyle of mice. Oral Surg., 2:89.
29. Levy, B.M. (1950) The effect of pyridoxine deficiency on the jaws of mice; Periodontal structures; mandibular condyle. J. Dent. Res., 29:349.
30. Mann, A.W., Spies, T.D. and Springer, M. (1941) The oral manifestations of B complex deficiencies. J. Dent. Res., 20:269.
31. Mellanby, M. (1929) Diet and teeth. An experimental study. Part I, Spec. Rep. Ser. med. Res. Coun. Lon. No. 140.
32. Mellanby, H. (1939) Preliminary note on defective tooth structure in young albino rats as result of vitamin A deficiency in maternal diet. Br. Dent. J., 67:187.
33. Mellanby, M. (1930) Diet and teeth. An experimental study. ibid., Part II, No. 153.
34. Mellanby, H. (1941) Effect of maternal dietary deficiency of vitamin A on dental tissues in rats. J. Dent. Res., 20:489.
35. Nizel, A.E. Nutrition in preventive dentistry: Science and practice. Philadelphia, Saunders, 1972.
36. Reither, W. (1957) Pantothenic acid medication in inflammation of the oral mucosa beneath removable dentures. Dent. Zahnartztl. Zschr., 12:1100.
37. Rodahl, K. (1949) Hypervitaminosis A and scurvy. Nature. 164:531.
38. Rose, J.A. (1971) Folic acid deficiency as a cause of angular cheilosis. Lancet, 2:453.
39. Ross, J.A. (1944) Some observations on dental change in possible riboflavin deficiency. Br. J. Radiol., 17:247.
40. Ryssel, H.J., Brunner, K.W. and Bollage, W. (1971) Die peroraie Anwendung von Vitamin A saure

bei Leukoplakia Hyperkeratosen und plattenepithekarzinon: Ergebnisse und vertraglickeit. Schweiz. Med. Wschr., 101:1027.
41. Schour, I. and Han, A.W. (1934) The action of vitamin D and of the parathyroid hormone on calcium metabolism as interpreted by study in the effect of single doses on the calcification of dentine. Arch. Path., 17:22.
42. Schour, I., Hoffman, M.M. and Smith, M.C. (1941) Changes in incisor teeth of albino rat with vitamin A deficiency and the effects of replacement therapy. Am J. Path., 17:529.
43. Serbell, W.H. and Butler, R.E. (1939) Riboflavin deficiency in man (ariboflavinosis). Pub. Hlth. Rep. Wash., 54:2121.
44. Shafer, W.G., Hine, M.K. and Levy, B.M. A text book of oral pathology, 3rd. ed. Philadelphia, Saunders, 1974.
45. Shklar, G. and McCarthy, P.L. The oral manifestations of systemic diseases. Boston, Butterworths, 1976.
46. Silverman, S.Jr., Eisenberg, E. and Renstrup, G. (1965) A study of the effects of high doses of vitamin A on oral leukoplakia (Hyperkeratosis) including toxicity, liver function and skeletal metabolism. J. Oral Ther., 2:9.
47. Spies, T.D., Dean, W.B. and Asche, W.F. (1939) Recent advances in treatment of pellagra and associated deficiencies. Ann. Int. Med., 12:1830.
48. Stones, H.H. Oral and dental diseases. 5th ed. Edinburgh, Livingstone, 1966.
49. Sud, V. (1958) Advanced suppurative periodontitis associated with avitaminosis. A.J. Dent. Childh., 25:45.
50. Sydenstricker, V.P. (1941) Clinical manifestations of ariboflavinosis. Am. J. Pub. Health Rep., 31:344.
51. Vilter, R.W., Mueller, J.F., Glazar, H.S., Jarrold, T., Abraham, J., Thompson, C. and Hawkins, V.R. (1953) The effect of vitamin B6 deficiency induced by desoxypyri-doxine in human beings. J. Lab. Clin. Med., 42:335.
52. Warkany, J. and Schraffenberger, E. (1944) Congenital malformations induced in rats by maternal nutritional deficiency. VI. Preventive factor. J. Nutr., 27:477.
53. Weinmann, J.P. and Schour, I. (1945) Experimental studies in calcification. I. The effect of rachitogenic diet on the dental tissues of the white rat. Am. J. Path., 21:821.
54. Weisberger, D. (1941) Lesions of the oral mucosa treated with special vitamins. Am. J. Orthodont., 27:125.
55. Westin, G. (1925) Scorbutic changes in teeth and jaws in man. Dent. Cosmos., 67:868.
56. Westin, G. and Kalnins, V. (1938) Experimental studies of Pathogenesis of marginal osteitis. Norske. Tandloeg-foren. Tid., 48:274.
57. Wolbach, S.B. and Howe, P.R. (1925) Tissue changes following deprivation of fat soluble A vitamin. J. Exp. Med., 42:753.
58. Zegarelli, E.V., Kutscher, A.H. and Hyman, G.A. Diagnosis of diseases of the mouth and jaws. London, Kimpton, 1969.