



A review

Trace elements: The unique chemical substances with fascinating biological influences on morphology and disease status of orodental tissues

Dr. Rina Girish Mehta, Rami Kamlesh B.

96/1194 Uday Apartment , Behind BSNL office Nr. Shashtrinagar, Naranpura Ahmedabad-380063 Gujarat, India

24514 W Luther Ave Round Lake ,IL 60073

Co-Author : Dr. Enosh Steward

Submitted: 01-06-2021

Revised: 16-06-2021

Accepted: 18-06-2021

ABSTRACT:

Trace elements with its unique chemical properties, adequate amounts of availability in the environment and its easily accessible forms are essential for better survival of life. Nutritional value of trace elements can be analysed by various approaches. Significant role of these elements in humans is an immense field of study for structural and functional changes by its normal, deficient or excess amount exposure at particular stage of cell. Traces like Fluoride(FI) zinc(Zn), Iron(Fe) copper(Cu) etc. are important for oral tissues health and severe changes in them can lead to discoloration, cracks, mottling of enamel, dental caries, fluorosis, glossitis, lichen planus and squamous cell carcinoma.

Any fluctuation in trace elements will reflect first on the oral hard and soft tissue which would show either presence of a normal morphology, deformity to abnormal as a disease status can be recited by the appraisal of the trace element value.

Key words: trace elements, fluorosis, squamous cell carcinoma

I. INTRODUCTION:

Cells of every living organism need nutrition for their activity like¹ development, growth, functions and survival. Amongst 100 known elements, as macro, micro, trace, hormones and vitamins, 28 are essential for metabolism² to maintain healthy status and survival of every structure. In humans, oxygen, carbon, hydrogen, nitrogen (>96% Of total body wt), calcium, phosphates, magnesium etc.³, a basic constituents in tissues, bone, teeth and muscles⁴ and are the major elements while potassium, sodium(nerve impulse) etc. for osmotic ion exchange,^{2,5} are semi major elements. Vitamins and hormones are necessary for development, growth, maturation and

functional activities of cells. Trace elements, (only 0.02% total body wt) fluoride(F-) zinc(Zn), Iron(Fe) copper(Cu), selenium(Se), chromium(Cr), cobalt(Co), Iodine(I), Manganese(Mn), Molybdenum(Mo) and Strontium(Sr)etc. from dietary source,⁶ coordinate with other elements for cellular activities i.e. physiological and metabolic activity,⁷ regeneration, repair and immunization.^{7,8} Some of them like lead(Pb), nickel(Ni), Aluminium(Al), Boron(B) are known for toxic effects on the tissues.

Equanimity of trace elements does not show any major effects during short period of its deficiency or excess. Truancy or surpluses of elements at any stage of cell biology and along with duration of time during existence show an abnormal state of a particular tissue. Oral hard and soft tissues are a mirror of humans' biological systems . Any imbalance reflects in structures and functions.

This review includes brief about effects of trace available or uptake by oral tissues and its' effects influenced by Food, habits, age, gender, geographic area and an environmental exposure.^{3,8}

II. DISCUSSION:

Nutrients of six major classes, i.e. fats, carbohydrates, proteins, minerals, vitamins and water are essentially required. Subdivisions of it as macronutrients (fats, carbohydrates and proteins) are for vital energy and as micronutrients (minerals, vitamins, trace elements, and amino-acids) are for enzymatic functions in cellular activities and as an essential trace elements, { Fluoride(F) Zinc(Zn), Iron(Fe) Copper (Cu), Selenium(Se), Strontium(Sr), Chromium(Cr), Cobalt(Co), Iodine(I), Manganese (Mn), and Molybdenum(Mo)},⁹ as a dietary supplements, are



valuable for maintenance of healthy status of an individuals.

Trace elements occurs naturally in physiological amount in normal diet and are of constant concentrations in the tissues.¹⁰ Trace elements can be ingested by food, water, soil, air¹¹ consumption and by dermal absorption,¹² which are then excreted through sweat, urine, bile, faeces and breath to control of the quantity which is stored in inactive forms to prevent its adverse reactions. Daily requirement of it is of milligrams or micrograms. With normal level, elements stabilize the cell structure and tissue functions whereas deficit or excess can cause structural abnormality and /or disease status.¹³ Elemental homeostasis is important for physiological processes, metabolism¹⁴ and to justify structural deformity, hazardous value of elements, development of pathologic status and disease condition in an individuals.⁸

Amongst 19 essential elements,¹⁵ Ca, Cr, Co, Cu, Fe, Zn, I, Se, Sr, K, Mg, Mn, Mo. etc.^{8, 12} are present in hard and soft tissues of the oral cavity. Trace amount varies from outer to inner surfaces of teeth, (enamel, dentin, pulp) and in periodontal tissue, with age and gender, primary and permanent (greater) dentition and even in carious and non carious teeth (higher) that can change physical and chemical properties with time duration.^{11,12,16} Saliva (Na, Mg, K and Zn)¹⁴ and dental plaque (Zn, F) are the reservoir of trace can influence the enamel composition.¹⁵ Toxic trace elements increase in coronal dentin with age, a useful marker in forensic age and gender investigations.¹¹ Trace release from Diet,^{8,12} Industrial exposure, biomaterials like Silver amalgam,¹⁷ Glass inomer,^{18,19} dental prosthesis¹⁵ like Casting alloy, Ortho appliances, Dental implants and Bleaching alter the teeth colour³ and physical properties^{20, 28} It also supports for radicular pulp survival and continuous root formation with revascularization, regeneration and repair of traumatic premature tooth dentin and dental pulp by angiogenesis, or creates pathologic conditions (Malignancies and Tumour) by necrosis.²¹

Trace amount is analysed by various methods i.e. X-ray micro fluorescence analysis by M.J Anjos, window technique for solubility test by M. Koray, Instrumental neutron activation analysis (INAA) By M. Saiki, Inductively coupled plasma-mass spectrometry (ICP-MS) by M.A. Amar and so on.

**Trace elements in Oral Hard and soft tissue:
Normal state:**

Enamel and Dentin:

Trace amount presence in enamel is influenced by developmental and environmental exposure, whereas in dentin it is dependent on age, sex and pathology due to its protected position. Cl, Mn, Fe, Cu and Zn are higher in outer enamel surface and permanent teeth than that of enamel-dentin border, in dentin²² and primary dentition¹³ Along with presence of Fluorine (F), Iodine (I), Strontium (Sr), and Molybdenum (Mo) in dental hard tissue, incorporation of Ca is constant, with decrease and Zn increases from enamel towards Dentino-enamel (DE) junction to pulp, in the crystals of hydroxyapatite of enamel during the formation^{3,19} and of dentin^{7,3,16,23} Co is higher in dentin of women whereas Pb in males²⁴ Pb and Sr concentrations in surface enamel are age dependent and Mg is lost with age.¹⁴

Pulp:

Traces are present in pulpal vasculature through nearer dentin. Na, Cl, and Mg (above 1000 ppm), potassium (K), sulphur (S), zinc (Zn) are in highest amount,¹⁷ while silicone (Si) and F (in a range of 100-1000 ppm), iron (Fe), aluminium (Al), lead (Pb), boron (B), and barium (Ba) (b/w 10-100 ppm), copper (Cu), molybdenum (Mo), cadmium (Cd), iodine (I), titanium (Ti), chromium (Cr) and Mg (1-10 ppm) and nickel (Ni), lithium (Li), silver (Ag), selenium (Se), cobalt (Co) are found in the range of 0.1-0.9 ppm in teeth.^{13,23}

Cementum :

Higher amount of fluoride is present in tooth's cementum.²⁴ Mg is increased from Periphery to deeper layer of cementum and half to that of dentin.²⁴ Zn is found more in concentric rings.

Alveolar Bone:

Na, F and Mg along with Ca, PO₄³⁻ and carbonate are present in normal bone.^{4,25} Magnesium (Mg), Calcium (Ca), Iron (Fe) and Rubidium (Rb) are functional traces for alveolar bone remodelling.^{4,5,14}

Periodontium:

F, Iodine, Zn, Fe (Iron), Cu, Co, Cr, Mn, Mo, Se are essential trace for normal periodontal health and its functions.^{5,14,26}

Effects of Traces:

Traces may enhance enamel hardness, colour change (gray to black spots)³, cracks, crystal size,¹⁵ caries resistance²⁷ by dental biomaterials (Zn, F) and prosthesis (Cr, Co, Ni, Fe, Ti and Mo)¹⁵ and appliances (Co, Cr),¹⁷ remineralization (Zn, Sr),^{3,9,24} wound healing by collagen synthesis



(Zn) and maintains architecture and resilience of C.T. (collagen by Si)³ also prevent root resorption and maintain periodontal health (Zn, Iron, Fluoride).⁴ Deficiency or excess of traces in teeth is related to secondary or recurrent caries, discoloration (Pb), sensitivity (Ni),^{15,28} mottling of enamel (excess fluoride) pulp pathology, re-infection with jaw bone involvement leads to disease³ (inflammation, cyst, Tumor, Necrosis) and carcinogenesis⁹ (Cr, Co, Ni etc.)

Common Disease status of oral tissues:

Glossitis occurs due to iron deficiency. Zinc deficiency causes loss of taste, poor wound healing and deformed bones. Fluoride deficiency causes caries whereas fluorosis as mottling with pitting of teeth are caused by its excess and it becomes severe with skeletal involvement. Carcinogenesis occurs due to Cr, Co, Ni, silver amalgam.

Dental caries:

Deciduous teeth are prone to caries due to inability of fluoride crossing through placental barrier.²⁹ Trace exerts cariogenic (Se, Pb, Mg) or cariostatic (F, St, Mo) effects on teeth.³⁰ Low level of fluoride in water leads to caries whereas excess leads to mottled enamel and caries with prolonged exposure of that excess^{3,9} also have impact on remineralization and demineralization. Ti, Sr and zinc with F reduce the solubility of enamel (in brown spots) and cementum,³¹ enhance remineralization³ with caries arresting effect. Carious enamel has Cl, Mn, Sr and Zn (more near untreated caries) are higher and Na, K in dentin with Mg is lower in carious dentin compared with that of sound enamel.^{12,17,32} Toxic elements like Pb, Mg, Cd are higher in adult teeth pulps¹² and caries by allowing infiltration of other toxic traces like Hg along with Pb.³³

Periodontitis:

Zinc is reduced and Na, Mn, Fe and Cu increase in saliva with periodontitis.³⁴ Fe deficiency Anaemia patients have deeper periodontal pocket with bleeding on probing. Zn deficiency is related with poor periodontal health with test disorder.^{3,24,26} Se is an antioxidant for collagen synthesis and protective for wound healing, prevent disease progression.²⁶

Oral Lichen Planus(LP) and lichenoid reaction(LR) :

Oral lichen planus (allergy)³⁵ and lichenoid reactions (hypersensitivity) are related to Cr, Co, Ni, and silver amalgam alloy^{7,9} with risk of malignant transformation.⁹

Oral condition, lesion, Malignancies:

Cu, Zn, Se, Iron are biomarkers^{3,9} for malignant potential of lesions like leukoplakia,²⁴ premalignant condition like Oral Submucous Fibrosis (OSMF) and malignant lesion like Squamous Cell Carcinoma (SCC).³⁶ Cu is higher and Zn is lower in amount in serum of Leukoplakia, OSMF and SCC patients.^{7,9} Se deficiency increases with cancer,³⁷ serum copper increases with disease progression,^{7,9} whereas iron decreases in OSMF^{7,37} and SCC, guide for diagnosis and disease progression analysis.^{36,38} Zn is anticarcinogenic by interfering mucosal absorption of Cu from areca nut in OSMS.^{3,9,37}

Major elements' impact on the oral tissues:

Fluoride(FI):

It is a major source in drinking water with 0.5 to 0.8mg required as daily uptake. Altered tooth morphology as fluoride pits, crystal dissolution, surface defects are³⁹ caused by fluoride incorporation during secretory stage of tooth development. Porosity²⁸ around striae of Retzius and Von Ebner lines causes accentuations of lines.³⁹ Cariostatic effects on erupted teeth are dependent on pH of plaque and saliva in oral fluid,³⁹ and as fluoroapatite [(Ca₅(PO₄)₃F)] crystals^{2,18,28} formation, replacing hydroxyapatite [Ca₅(PO₄)₃(OH)] crystals and enhance remineralization,^{2,3,4,15,16,19,24,28} while crippling fluorosis^{1,12,15,28} (Ca₁₀(PO₄)₆F₂) and skeletal defects (ligament calcification lameness and stability with brittleness) with its excess suggesting amount and time duration dependency.^{9,28,40} Bone density by osteoblastic activity is stimulated by fluoride conjunction with reserved Ca⁷ amount in plaque.^{3,28} It prevents teeth to be dissolved in acidic state between meal time.²⁷ Uptake and retention of fluoride by topical application of varnishes or gel dentifrices can control active caries and diminish new caries in children.⁴¹ Fluoride toothpaste and mouth washes help to reduce localized demineralization around orthodontic appliances and inaccessible microorganisms and debris accumulation over teeth surface (pits-fissures).¹⁸ Post-radiation root caries in cancer patients causes enamel and dentin sensitivity which is reduced by fluoride use but may induce bad taste and teeth discoloration.

Zinc(Zn) :

Daily requirement is 15mg. Zinc is naturally present in plaque, saliva (antiplaque % agent)^{3,34,42} and enamel,⁴³ higher in males,^{7,35,42} dental pulp and increase near untreated carious lesions.^{17,18,44} It reduces dental calculus, plaque and



malodour through its built up effects (in saliva and plaque) by frequent oral applications,^{7,43} and fluoride induced lesions by its arrest through remineralization.^{3,7,43} Age related degenerative changes eg. increased adhesion sites and porous sieve-like areas at Sharpey's fibres level in PDL²² show increased fragility with thin and few collagen fibres,^{26,45} alveolar bone resorption^{22,26,43}, irregular contour,⁴⁵ dysplastic incisors, fractured teeth, irregular molar crown and abnormal root dentin in KO (knock out) mice, lacking **Zinc Transporter gene ZIP 13** were found in study by Idaira.⁴⁵ Zinc with folic acid and riboflavin deficiency may induce cleft lips and palate in new born.²⁹ Deficiency and low serum level of zinc are related with oral and periodontal disease, lack of oral wound healing,^{4,46} aphthous stomatitis, xerostomia, burning mouth syndrome, atrophic glossitis,³⁵ susceptibility of infection of oral mucosa due to altered keratinisation and thickening²⁶ with loss of filiform papillae, altered taste,^{6,7,9,40,46} and parakeratosis in cheek, tongue, buccal mucosa.^{7,24} It acts as a biomarker in development and progression of oral lesions like leukoplakia, OSMF, SCC with increase amount of it in blood and Low serum level in patients^{7,9,46}

Iron(Fe):

Daily requirement is 18mg. Normal serum iron level is required for the integrity of oral epithelium.⁴⁷ Level of it is high in caries and low in OSMF^{9, 48} Thin hydrous iron oxide coating through oral beverages and food, coats the teeth as an acid resistant layer to prevent caries⁴⁹ and erosion.¹⁶ Low level in serum causes atrophic glossitis,^{8,40,50} stomatitis,⁸ angular cheilitis, fungal infections,^{7,24} sore throat, salivary gland swelling,¹ epithelial atrophy due to lack of maturation and fibrosis, ulceration and vesicle formation⁴⁷ with pallor atrophic oral mucosa along with anaemia.^{4,9} Iron overload symptoms are discoloration of deciduous teeth with iron drops,⁴⁹ progressive alveolar bone loss and periodontitis with sickle cell anaemia and thalassemia.⁵¹ Reduction of micro hardness occurs by acidic drink and black external stains in teeth are with oral supplements of iron.⁴⁹ Its assessment in various stages of OSMF, predicts malignant potential, guides to stop progression by iron therapy in time by various measures.⁷ Other carcinomas are also treated by iron therapy.⁷

Copper(Cu):

Daily requirement is 2000 μg . It act as an antioxidant for an inflammatory protection for periodontal tissue.²⁶ Zn, Fe, Se and Cu have role in immune function during infection.²⁶ Copper is necessary for enzymatic activity and hormone

function, synthesis of collagen and elastin to strengthen epithelium and connective tissue.⁷ Prolonged copper deficiency shows defective oral keratinisation, Anaemia symptoms,⁴⁶ infection, caries promotion^{7,15,24} and bony trabeculae loss with thinning of cortex. Increase in serum level of copper is associated with leukoplakia, OSMS and SCC progression.^{7,24}

Selenium(Se):

Daily requirement is 70 μg . It is a protective non metallic trace micronutrient for periodontium as a dietary regulator of an inflammatory cascade.²⁶ Zn, Fe, Se and Cu have role in immune function during infection. Initial enamel decay shows its presence, suggestive of progressive dissolution.²⁴ It is a vital trace elements having anti-inflammatory, anti oxidative and supplemental element reduce oxidative stress in oral premalignant lesion and condition.⁷ It cures oral mucosities in patient after chemotherapy²⁶

Chromium(Cr):

Daily requirement is 120 μg . Deficiency of it shows OLR, suppurative periodontitis, teeth staining, gingival pigmentation, mucosal ulceration, bone necrosis and haemorrhage,¹ hypo salivation and fungal infections in diabetic patients.⁷ Progressive reduction of amount is detected from healthy to premalignant and malignant lesions, eg. leukoplakia, OSMF and squamous cell carcinoma¹³ and needs supplementation to reduce damage by oxidative stress inside body tissue.⁷

Cobalt (Co):

Daily requirement is 6 μg . Pernicious anaemia as Moeller's glossitis with burning sensation is associated with its deficiency. Dental alloy causes allergic reaction and colour change of teeth.¹⁶

Iodine(I) :

Daily requirement 150 μg iodine causes greater attrition, reduce decay and prevent premature loss of teeth⁷. Deficiency related symptoms are macroglossia, lip thickening, delay teeth eruption and diffuse brown pigmentation on gingival, buccal mucosa, tongue and palate in hyperthyroidism.

Manganese (Mn):

It increase with caries^{15,24}

Molybdenum(Mo) :

Daily requirement is 75 μg . It is a Strong cariostatic when used with fluoride. Antagonistic



effect of it is with copper as higher amount of it leads to copper deficiency.⁷

Strontium(Sr):

It increases with age^{11,14} and with fluoride. It helps in remineralisation of enamel,²⁴ dentin and bone. It increases dentin thickness, slows down the caries rate of progression. It replaces Ca ions in teeth and bone causing Rickets.^{11,33}

III. CONCLUSION:

Trace elements are necessary for normal body tissue functions. Effectual traces in oral tissues include fluoride, iron, zinc, copper, cobalt, selenium etc. during development and physiological functions may alter their structural properties from mild to disease status and also important for premalignant to malignant transformation with either of its deficit or its excess. Trace elements deserve special attention by amount and exposure analysis as it is useful for maintenance of healthy status, to study structural abnormality, disease progression and control and for forensic investigations of dental tissues.

ACKNOWLEDGEMENT:

I acknowledge my deep sense of gratitude to my guide Mr. Rami Kamlesh B. for encouraging guidance and kind supervision. His deep thoughts and knowledge have created an opportunity for me to present this review at its best. I also thankful for Dr Enosh Steward for his immensable support in this review.

Conflict of interest -NIL

REFERENCES:

- [1]. Shafer
- [2]. 7.5 Trace Elements in Biological Systems, chemistry 4/7/2020 Data from CRC Handbook of Chemistry and Physics (2004).
- [3]. Adabache-Ortiz, A., Silva-Briano, M., Campos-Esparza, M.R. and Ventura-Juárez, J. (2014) Comparison of Chemical Elements on Carious & Normal Premolar's Enamel Layers Using Energy Dispersive X Ray Spectrometer (X Ray-EDS). *Microscopy Research*, 2, 81-91.
- [4]. Shariq Najeeb et al. Review The Role of Nutrition in Periodontal Health: An Update *Nutrients* 2016, 8, 530,1-18.
- [5]. Federica Romano ICP-Mass-Spectrometry Ionic Profile of Whole Saliva in Patients with Untreated and Treated Periodontitis *Biomedicine* 2020, 8, 354 1-14
- [6]. Osamu WADA What are Trace Elements?— Their deficiency and excess states *JMAJ*, August 2004—Vol. 47, No. 8
- [7]. Preeti Tomar Bhattacharya et al. Review Article Nutritional Aspects of Essential Trace Elements in Oral Health and Disease: An Extensive Review *Hindawi Publishing Corporation Scientifica* Volume 2016, Article ID 5464373, 12 pages Aaa
- [8]. Margarita G. Skalna et al. Essential trace elements in human health: a physician's view *Tomsk : Publishing House of Tomsk State University*, 2018. – 224 p. ISBN 978-5-9462 1-683-8
- [9]. Kulkarni N et al. Trace elements in oral health and disease: An updated review. *J Dent Res Rev* 2014;1:100-4
- [10]. Andrew Taylor Detection and monitoring of disorders of essential trace elements *Ann Clin Biochem* 1996; 33: 486-510
- [11]. Ana C. Fernández- Escudero et al. Aging and trace elements in human coronal tooth dentine *Scientific Reports* | (2020) 10:9964
- [12]. Mohamed A. Amr*et al. Analysis of Trace Elements in Teeth by ICP-MS: Implications for Caries *Journal of Physical Science*, Vol. 21(2), 1–12, 2010 (12 number article)
- [13]. Prashanth L et al. A review on role of essential trace elements in health and disease. *J NTR Univ Health Sci* 2015; 4:75-85
- [14]. Bhasker et al. Trace Elements in Dentistry: A Review *IHRJ* Volume 1 Issue 10 2018 *International Healthcare Research Journal* 2018;1(10):309-314
- [15]. Ghadimi et al. Trace elements can influence the physical properties of tooth enamel *SpringerPlus* 2013, 2:499
- [16]. Qamar Influence of trace elements on dental enamel properties: A review *Journal of the Pakistan Medical Association* · January 2017 115-120)
- [17]. M.J. Anjos et al. / *Nucl. Instr. and Meth. in Phys. Res. B* 213 (2004) 569–573
- [18]. Rizwan Ullah, ORAL AND DENTAL DELIVERY OF FLUORIDE: A REVIEW *Research review Fluoride* 48(3)195-204 July-September 2015
- [19]. Arifa MK, Ephraim R, et al. Recent Advances in Dental Hard Tissue Remineralization: A Review of Literature. *Int J Clin Pediatr Dent* 2019;12(2):139–144.
- [20]. Sumit Gaur et al Trace Minerals Micronutrients and chronic periodontitis-A review *Abstract Biological trace elements Resaerch* 176,225-238(2017)



- [21]. Mohammad Ali Saghiri A new era considering inorganic trace elements and biological activity of dental biomaterials (angiogenic activity) *Acta Biomater Odontol Scand.* 2016 Dec; 2(1): 93–94
- [22]. F. O. Falla-Sotelo et al. Analysis and Discussion Of Trace Elements in Teeth Of Different Animal Species *Brazilian Journal of Physics*, vol.35no.3B,September,2005,761-2,
- [23]. Who and Frieden 1981 classification²³
- [24]. M.S.Dogan Trace Elements - Human Health and Environment Faculty of Dentistry, Harran University, Pediatric Dentistry, Şanlıurfa, Turkey <http://dx.doi.org/10.5772/intechopen.75899> 71-83
- [25]. Suchetha A. et al. Alveolar bone in health *International Journal of Periodontology and Implantology*, October-December 2017;2(4):112-116
- [26]. Adiya Apon 2021 “Apon A, Kamble P. Role of trace mineral in periodontal health: a review. *Clin Trials Degener Dis* 2019;4:30-6” Apon A, Kamble P. Role of trace mineral in periodontal health: a review. *Clin Trials Degener Dis* 2019;4:30-6
- [27]. Dr. Rekha P. Shenoy¹, Trace Elements and Oral Health. *JOURNAL OF THE INDIAN ASSOCIATION OF PUBLIC HEALTH DENTISTRY* Vol:2011 ISSUE:18 SUPPL. I 607
- [28]. Domen Kanduti FLUORIDE: A REVIEW OF USE AND EFFECTS ON HEALTH *Mater Sociomed.* 2016 Apr; 28(2): 133-137
- [29]. Ramachandra Prabhakar¹, Nutrition and Its Imbalance and Effects on Developing Oral Tissues *INTERNATIONAL JOURNAL OF PHARMACEUTICAL AND CHEMICAL SCIENCES* Vol. 2 (4) Oct-Dec 2013
- [30]. Monica M et al PREVALENCE' OF' DENTAL'CARIES' AND' ITS' RELATIONSHIP' WITH 'TRACE' ELEMENTS' PRESENT' IN' DRINKING' WATER'AMONG'12'YEAR'OLD' CHILDREN' IN' RURAL' AREAS 'OF' ANDHRA' PRADESH ,(INDIA') *JRD Journal of Research in Dentistry, Tubarão*, v.3, n.4, sep/oct.2015
- [31]. M. KORAY The Effects of Fluorides and/or Trace Elements on the Solubilities of Enamel and Cementum *J. Trace Elements Med. BioI.* Vol. 10. pp. 255-259 (1996)
- [32]. Mitiko Saiki Elemental comparison in sound and carious human teeth by instrumental neutron activation analysis *J Radioanal Nucl Chem* (2009) 282:29–32
- [33]. Lisa Lefever Laser Ablation of Modern Human Cementum The examination of trace element profiles 2010
- [34]. Federica Romano et al Icp Mass – Spectrometry Ionic Profile of Whole Salivain Patients with Untreated and Treated Periodontitis *Biomedicines* 2020,8,354 page 3-14
- [35]. Zhe-Xuan Bao Bao ZX, Yang XW, Shi J, Liu LX. Serum zinc levels in 368 patients with oral mucosal diseases: A preliminary study. *Med Oral Patol Oral Cir Bucal.* 2016 May 1;21 (3):e335-40
- [36]. Sunali S Khanna Research Circulating Immune Complexes and trace elements (Copper, Iron and Selenium) as markers in oral precancer and cancer : a randomised, controlled clinical trial *Head & Face Medicine* 2006, 2:33
- [37]. Rathod S, Rathi P, Harkare V. Trace elements as a diagnostic biomarker for premalignant lesions and malignant conditions. *SRM J Res Dent Sci [serial online]* 2019 [cited 2020 May 3];10:40-6
- [38]. Kumar H, Kumar P, Jain S, Suryawanshi H. Analysis of serum copper and iron levels in oral submucous fibrosis patients: A case–control study. *Indian J Dent Sci [serial online]* 2016 [cited 2020 Apr 21];8:145-9
- [39]. Ole FEJERSKOV ET AL. Dental tissue effect of fluoride *ADV DENT RES* JUNE 1994, 8: 15
- [40]. Tarun Kumar Dutta, Mukta V *Medicine Update* 2012 □ Vol. 353-357
- [41]. Jeremy A. Horst, et al. Fluorides and Other Preventive Strategies for Tooth Decay *Dent Clin North Am.* 2018 April ; 62(2): 207–234.
- [42]. Milaim Sejdini The Role and Impact of Salivary Zn Levels on Dental Caries *Hindawi International Journal of Dentistry* Volume 2018, Article ID 8137915, 6 pages
- [43]. Richard J.M. Lynch Zinc in the mouth, its interactions with dental enamel and possible effects on caries; a review of the literature *International Dental Journal* 2011; 61 (Suppl. 3): 46–54
- [44]. Mitiko Saiki Elemental comparison in sound and carious human teeth by instrumental neutron activation analysis *J Radioanal Nucl Chem* (2009) 282:29–32
- [45]. Yayoi Idaira Role of Zinc Transporter ZIP13 in Degenerative Changes in Periodontal Ligament and Alveolar Bone *Journal of Hard Tissue Biology* 25[1] (2016) 49- 56



- [46]. Falah S. Al-Fartusie Essential Trace Elements and Their Vital Roles in Human Body. Indian Journal of Advances in Chemical Science 5(3) (2017) 127-136
- [47]. Hegde Karthik, Role of Hemoglobin and Serum Iron in Oral Submucous Fibrosis: A Clinical Study The Scientific World Journal Volume 2012, Article ID 254013, 5 pages
- [48]. R. Venkateswara Rao et al Estimation of Trace Elements in Various Parts of Human Teeth using External Beam PIXE International Journal of Physics and Applications Volume 2, Number 1 (2010), pp. 123—134
- [49]. Imaneh Asgari et al Soltani, S., Sadeghi, S. M effects of iron products on Decay, tooth microhardness and dental discoloration: A systemic Review Arch Pharma Prac2020;11(1):60-82
- [50]. Mukta V, Puducherry , Trace elements Medicine Update 2012 □ Vol. 22 353
- [51]. Susilena Arouche Costa Et al Iron overload and periodontal status in patients with sickle cell anaemia : A case series Journal of Clinical Periodontology /volume 47, issue 6 /p.668-675,
- [52]. Phillip Wong et al Bone Disease in Thalassemia : A molecular and Clinic Overview Endocrine Reviews, Volume 37, Issue \$! August 2016 , Pages 320-346