Vanishing Mandible in a 7-year Old Child: Response to Radiation Therapy

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Massive osteolysis in a 7-year old child is a rare condition. The etiology of massive osteolysis is unknown and it results in the progressive destruction of bony structures. There is no standard therapy available in the literature. Conservative treatment is often used for its management. Radiotherapy is considered as an accepted form of treatment with greater chance of success when it is used in the early course of disease. There are few case reports in the literature in which radiotherapy has been used for the treatment. This article highlights the literature update on various treatment modalities and a case managed by radiation therapy.

Key Words: Vanishing bone disease, Gorham's disease, mandible, radiation therapy.

INTRODUCTION

Vanishing bone disease is an extremely rare idiopathic disease. It is characterized by spontaneous and progressive destruction of skeletal bones. The rapid resorption of bone is caused by uncontrolled, destructive proliferation of vascular or lymphatic capillaries within bone and the surrounding soft tissue.[1,2] The rapid proliferation often spread to contiguous bones with progressive resorption of whole or a part of the bone.[1-3] The lesion is usually nonexpansile, monocentric and rarely polyostotic.[2] It is usually nonfamilial and occurs sporadically in children and young adults.[2] The aetiology of this disease is unknown, however an initial trauma or modifications of local conditions like variation of pH, inflammations etc. are suspected. Histologically, bone is replaced by numerous thin-walled capillary-sized vessels and at a later stage, by fibrous connective tissue.[4] Regeneration of bone following arrest of osteolysis usually does not occur and spontaneous fractures are common.[5]

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Vanishing bone disease was first described in 1838[6] and again in 1872 by Jackson[7], who reported a case of a ''boneless arm''. This condition can affect any bone develop by intramembranous ossification.[8-11] Most commonly involve bones are the skull, shoulder and pelvic girdle.[8-11] Romer[12] in 1924 reported the first case involving the jaws in a 31-year old woman. Frederiksen *et al* [13] observed that the mandible is involved most frequently, followed by the maxilla with varying degrees of involvement of contiguous structures including the hard palate, sphenoid bone and zygomatic bone. However, most of the reported cases in the literature are monocentric and involve solely the mandible.[14] Initial presentation of vanishing bone disease with maxillofacial involvement can be evident as mobile but vital teeth with accompanying gingival hemorrhage. Hypoplasia, pain, malocclusion and resorption of the affected alveolar and adjacent bone can occur.[15-22] Involvement of the temporomandibular joint by vanishing bone disease can also mistaken as temporomandibular joint dysfunction.[23] Mandibular involvement can leads to pathological fracture.[23] Jaw bone involvement can also affect mastication, swallowing, speech, breathing and cosmetic appearance.

As the disease entity is rare and its etiology remains unclear, so there is no standard treatment available in the literature. There are only few reports in the literature mentioning the vanishing disease in maxillofacial region of a child within the first decade of life.[16] This article highlights the various treatment modalities available in the literature and response to radiation therapy in a 7-year old child with vanishing bone disease of mandible.

The goal of treatment of vanishing bone disease is to arrest the progression of osteolysis. Several treatment options have been proposed with varying results. The treatment is either alone or in combination of surgery,[15,24,25] radiation,[26,27] antiosteoclastic medication (bisphosphonates)[15,28] and angiogenesis inhibitors.[29,30] As the disease is often self-limiting, conservative treatment is considered as an appropriate treatment. A summary of various treatments for the vanishing bone disease abstracted from the literature is highlighted.

Medical management

It is primarily centered on the use of bisphosphonates for their antiosteoclastic properties[31] and alpha-2b interferon which acts to prevent angiogenesis and production of IL-6.[28-30] Both treatments have variable success rate. Other medical treatment including embolization, calcitonin, calcium, estrogen, vitamin-D, vitamin-B_{12}, magnesium, fluoride, cisplatin, actinomycin D, aluminium acetate solution, ultraviolet radiation, somatotrophin, amino acids, placental extracts and transfusions of placental blood have been tried and found unsuccessful.[15,29,32-35]

Radiation Therapy

Radiotherapy is considered as an accepted form of treatment with greater chance of success when it is used in the early course of disease. Radiotherapy cause sclerosis of proliferating blood vessels, and thus prevents their re-growth and further osteolysis.[15,26,27] Definitive radiation therapy in moderate dose (40-45Gy, 2-Gy fractions) over a period of 4-weeks appears to result good clinical outcome[36,37] with few long-term complications.[26] Fontanesi [27] showed excellent results using a total dose of 15 Gy in a case that involved the upper extremity. Hanly *et al* [38] reported rapid relief of symptoms and prevention of further bone destruction during a 6-year follow-up period with a total dose of 3000 rads. Re-growth of bone after radiation therapy usually does not occur but has been reported in few patients.[39,40] The major complications of radiation therapy in children and adolescents include potential for secondary malignant transformation, growth restrictions and damage to tooth formation and eruption.[15,16,41] In patients with large symptomatic lesions with longstanding disabling functional instability, radiation along with surgical treatment are preferred.[42]

Surgical Treatment

Surgical intervention has been proposed as the method of choice by many clinicians.[15,24,25,43-45] It involves local resection of the affected bone during the active stage of disease followed by bone grafting and/or prostheses.[15,24,25,43-45] This is typically attempted in monostotic or localized disease in which the entire lesion can be removed. Bone grafting is performed after complete stabilization of the osteolytic process because resorption of bone grafts can occur when it implanted during the active phase of disease.[44,46,47] The fragmentation and dissolution of the graft from erosion of lymphangiomatous tissue results a low success rate.[26,45,48] Sympathectomy also has been suggested but found unsuccessful.[15]

Case report

A 7-year-old girl referred from Pediatric OPD to Dental OPD with provisional diagnosis of Bell's palsy. Her chief complaint was asymmetrical face. The patient was apparently alright 6-months back when her father observed gradual deviation of her chin towards the right side. There was no history of any trauma to the mandible. She had received treatment for pulmonary tuberculosis at the age of 5-year. None of the family members had similar problem. On examination, there was gross mandibulo-facial asymmetry with chin deviation towards right side. (Figure-1) There was fullness on the right side and depression on the left side of her face causing a gross facial asymmetry (Figure-1). There was mandibular deviation towards the right side on mouth opening. The morphology of the external ears was normal. On palpation, the condyle and the body of mandible on right side were not palpable. On intra-oral examination, right side mandibular permanent first molar was mesially tipped with grade-3 mobility and vital. There was no ulceration or any hemorrhagic spots over the alveolar ridge. Mandibular right primary second molar was clinically missing. The alveolar ridge was not palpable. She had unilateral open bite on right side and moderate malocclusion due to mandibular deviation. Panoramic radiograph revealed loss of the mandibular bone affecting the right condyle,

Figure-1: Extra-oral photograph of the patient showing gross mandibulo-facial asymmetry with chin deviation towards the right side, fullness of the face on right side and depression on the left side of face causing a gross facial asymmetry.

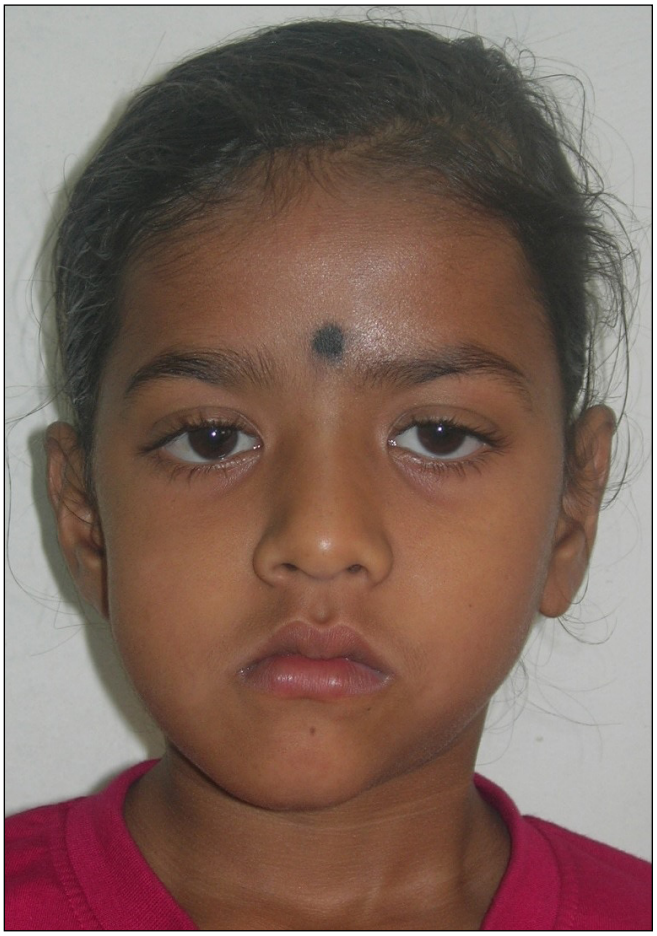
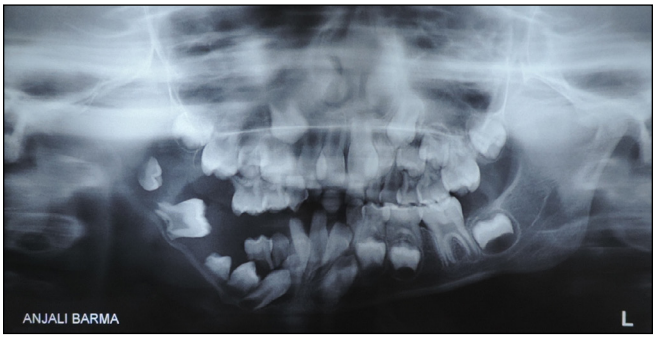


Figure-2: Panoramic radiograph showing loss of the mandibular bone affecting the right condyle, coronoid process and ramus to the body just distal to the mental foramen with thin layer of bone around the mandibular canal.



coronoid process, ramus and body of the mandible up to the mental foramen with thin layer of bone surrounding the mandibular canal. (Figure-2) Chest X-ray did not reveal any abnormality. The initial computerized tomography (CT) scan images showed complete loss of mandible from the condylar and coronoid process till the mental foramen region on right side. (Figure-3) The serum calcium level, parathyroid, calcitriol, alkaline phosphatase and Bence Jones proteins were within normal range. Thus bone resorption due to any metabolic disease was ruled out. Histopathology revealed stratified squamous epithelium over fibrocollagenous stroma. There was dense infiltration of lymphocytes, plasma cells, histiocytes and few polymorphs with numerous congested blood vessels in the stroma. Based on the clinical, radiographic and histopathological findings, provisional diagnosis of massive osteolysis of the mandible was considered. The patient was followed for another 6-months. The follow-up CT scan was recorded which showed progressive bone destruction of the mandible with discontinuation of bone surrounding the mandibular canal in the mandibular permanent first molar region. (Figure-4) Thus the provisional diagnosis of vanishing bone disease of the mandible was confirmed. The patient was again referred to the Pediatric OPD for detail systemic evaluation for any internal organ involvement. However there was no involvement of any internal organ. Then the case was discussed with the Orthopedician and Radiotherapist. The goal of the treatment was to arrest the progression of the osteolysis and reconstruction of the lost tissue. A conservative treatment was attempted as the progression of the disease had resulted in significant disfigurement and functional problems. Treatment modalities considered low-dose radiotherapy. On the basis of literature, external beam radiation was administered at 2 Gy/day for 20 fractions over a period of 4-weeks to a planned total dose of 40Gy.[26,36] The patient was followed regularly in every 3-months. The follow-up CT scan images after a period of 9-months revealed complete arrest of osteolytic process and no further bone resorption. (Figure-5)

Figure-3: CT scan images showing complete loss of mandible from the condylar and coronoid process till the mental foramen region on right side.

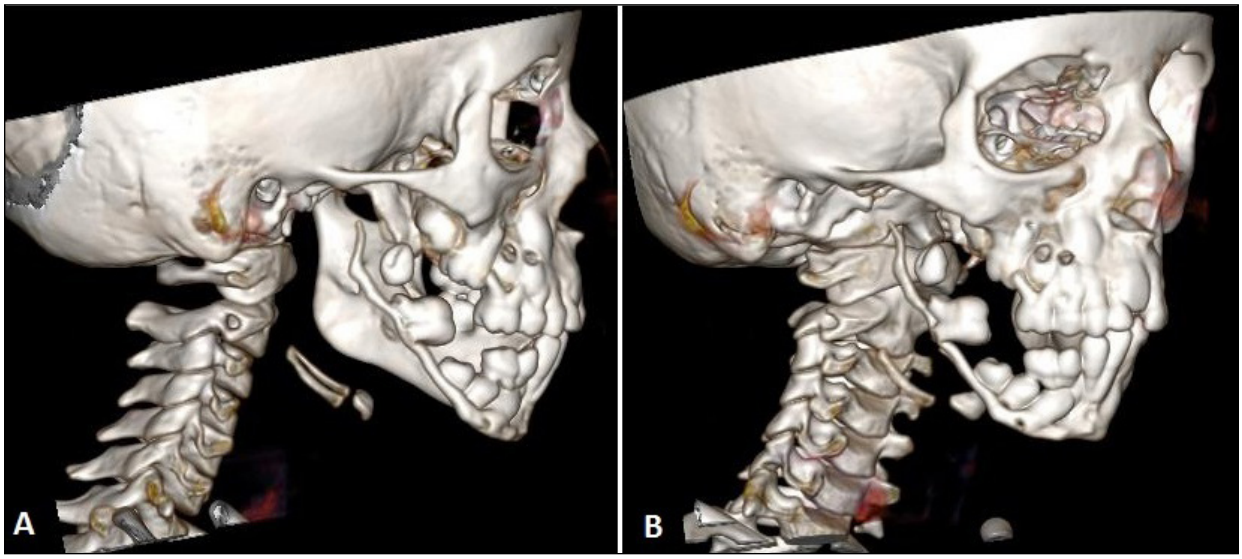


Figure-4: Follow-up CT scan images showing progressive bone destruction of the mandible and discontinuation of bone surrounding the mandibular canal.

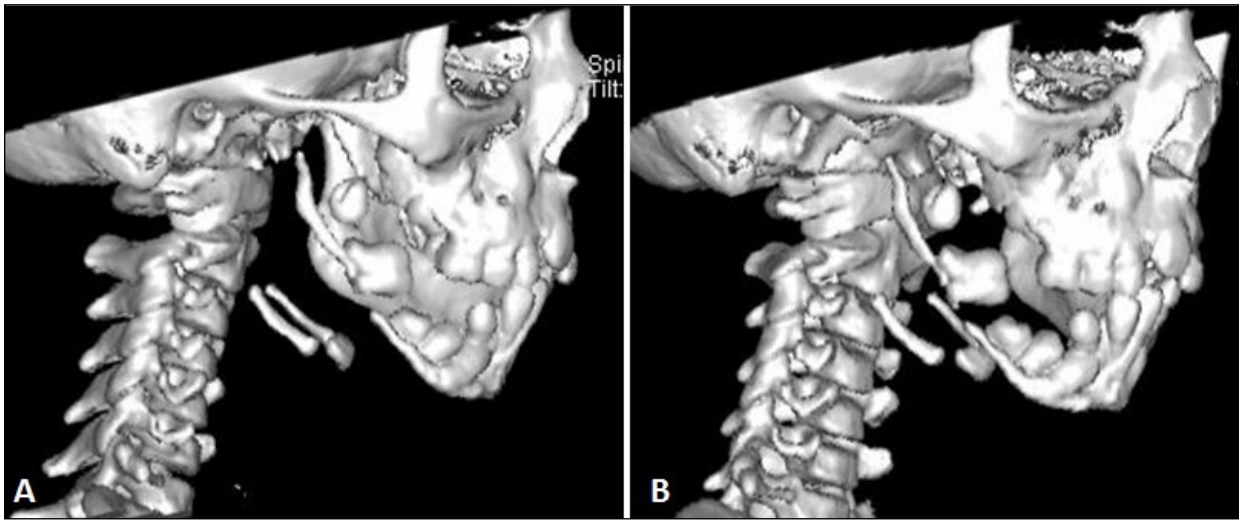
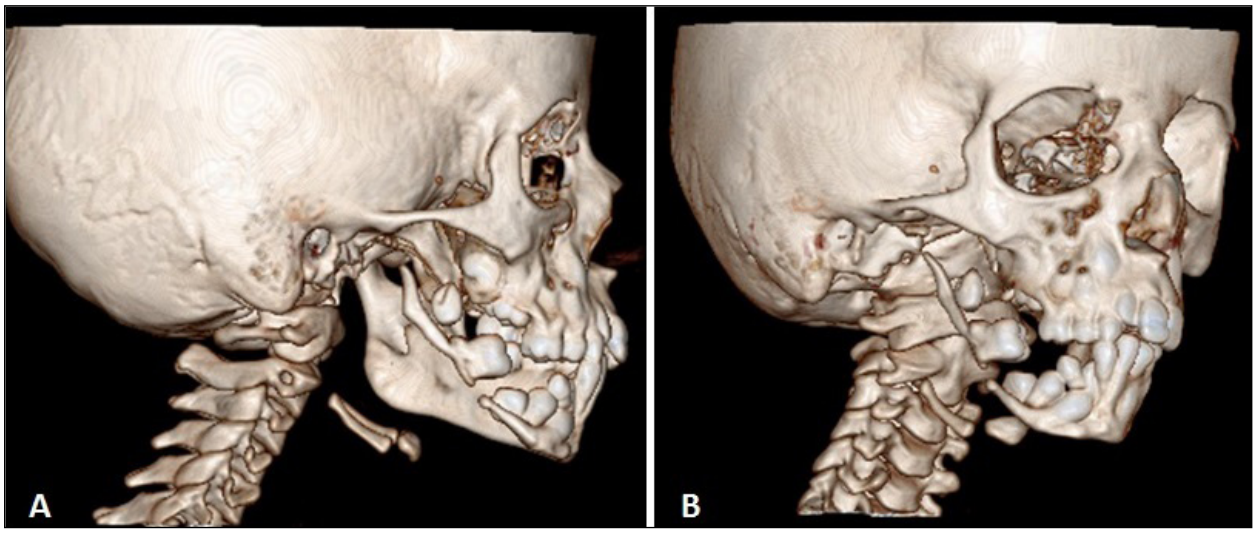


Figure-5: Nine-months post radiation therapy CT scan images showing no further of bone resorption as compared to the previous CT scan images.



DISCUSSION

Massive osteolysis is an extremely rare disease. It involves extensive locally aggressive resorption of the bone by proliferation of blood vessels and lymphatic tissue.[13] The first stage of hemangiomatosis is characterized by vascular proliferation in connective tissue and the second is the stage of fibrosis that replaces the absorbed bone.[3] The mechanism of bone resorption is unknown. However, trauma, local hypoxia, acidic environment and some hydrolytic enzymes such as acid phosphatase and leucine aminopeptidase can be considered as the cause of bone destruction.[49,50] The involvement of osteoclasts in the mechanism of bone destruction is controversial. There may be an increase in the sensitivity of osteoclast precursors to humoral factors which promotes osteoclast formation and bone resorption at the level of bone microenvironment.[43] There are many case reports in the literature and most of the lesions in the craniofacial region are monocentric involving solely the mandible.[14,51] In our patient the disease was also monocentric involving mandible only.

The disease has been classified into five categories.[2] Type I is hereditary multicentric involvement with dominant transmission. Type II is hereditary multicentric involvement with recessive transmission. Type III is nonhereditary multicentric involvement with nephropathy. Type IV is Gorham's massive osteolysis which may occur at any age and bone is replaced by hemangiomatous tissue. It is neither a hereditary condition nor associated with nephropathy. The lesion may develop in any part of the skeleton and it is benign as the osteolysis stops after a few years. Type V is autosomal recessive childhood carpotarsal osteolysis without nephropathy. Thus from this classification it is evident that our case is possibly belongs to type IV category.

The diagnosis of massive osteolysis is based on clinical features, radiographs and histopathology. The CT scan images play vital role in evaluating the involvement and extension of facial bones and the skull.[52] Scintigraphy including three-phase radionucleotide bone scan and thallium scan can be done to demonstrate slightly decrease activity in the affected portion of bone in its early phase and increased activity in the delayed stage.[53] Heffez *et al* [54] described the criteria for the diagnosis of massive osteolysis as: evidence of local progressive osseous resorption, minimal or no osteoblastic response and an absence of dystrophic calcification, non-expansile, non-ulcerative lesion, absence of visceral involvement, osteolytic radiographic pattern and negative findings for a hereditary, metabolic, neoplastic, immunologic or infectious origin. Our case also fulfilled most of the diagnostic criteria suggested by Heffez *et al* [54]

Management of massive osteolysis is difficult. The most appropriate treatment remains controversial. There are no definite guidelines available and there are few reports on the treatment of this rare condition involving the mandible. The principal treatment involves surgery and radiation therapy.[55] Surgical treatment is usually involves resection of the lesion followed by reconstruction by bone graft and/or prostheses. This is typically attempted in monostotic or localized disease in which the entire lesion can be removed. However in our case, the lesion was very large. The placement of bone graft was also difficult as the patient was only 7-years old. Thus surgery was avoided in this patient. Escande *et al* [14] found that most of the massive osteolysis patients receive surgery and a bone graft with or without radiation treatment. Only small number of patients receives bisphosphonates for the treatment.[14] The use of bisphosphonate is considered to be off-label, because there is no FDA approval for the use in the treatment of vanishing bone disease.[56,57] Abdulai also found no evidence of cessation of bone resorption following bisphosphonate treatment.[58] However, Tong *et al* [51] successfully arrested the osteolytic process with the use of zoledronic acid. Thus considering the controversy on use of bisphosphonate for the treatment of massive osteolysis, we considered the use of radiation therapy in our case. Although the use of radiation therapy for the treatment of vanishing bone disease is still controversial and not widely accepted, we used low dose of radiotherapy to arrest the course of osteolysis. The bone resorption was arrested successfully in our patient. Thus early intervention with definitive radiation therapy in low dose can result in an excellent patient outcome. The regeneration of bone following radiation therapy is unusual but some authors have reported bone regeneration in some patients.[39,40] Also in some reports, radiotherapy has lead to recalcification.[23,26] The major problem of radiation therapy is the risk of post-irradiation malignant change. However it has been reported that definitive radiation therapy in doses of 40-45 Gy in

2-Gy fractions can result good clinical outcome with few long-term complications.[26] As there are few case reports in the literature in which radiotherapy was used for the treatment of vanishing bone disease, so its potential is difficult to determine accurately.[15,27,32,36]

Reconstruction of large mandibular defect by using bone regeneration and tissue engineering technology is also possible.[59] Experimental studies have shown new bones formation by using tissue engineering technology that involves the use of stem cells from deciduous teeth, dental pulp, bone marrow and adipose tissue[60-62] and a scaffold that provide mechanical support, facilitates cell attachment and supports cellular communications.[63-65] Thus various patient specific scaffolds can also be tried in vanishing bone disease patients to reconstruct large bone defects with sufficient accuracy.

Thus from the present case and from the literature we can conclude that the low dose of radiotherapy can be considered as a definitive treatment for the management of massive osteolysis.

CONCLUSION

Massive osteolysis of the mandible in a 7-year child is a rare clinical entity. Massive osteolysis of the mandible can lead to severe disability. Often clinical diagnosis is difficult but serial radiographic evaluation plays an imperative role in the diagnosis of this condition. Although the definitive treatment of massive osteolysis has not yet been fully proven, however radiotherapy alone can be used to arrest the progression of the osteolysis.

REFERENCES

1. Aviv RI, McHugh K, Hunt J. Angiomatosis of bone and soft tissue: A spectrum of disease from diffuse lymphangiomatosis to vanishing bone disease in young patients. Clin Radiol 56: 184-90, 2001.
2. Hardegger F, Simpson LA, Segmueller G. The syndrome of idiopathic osteolysis: Classification, review, and case report. J Bone Joint Surg Br 67: 89-93, 1985.
3. Yoo SY, Hong SH, Chung HW, Choi JA, Kim CJ, Kang HS. MRI of Gorham's disease: findings in two cases. Skeletal Radiol 31: 301-6, 2002.
4. Fisher KL, Pogrel MA. Gorham's syndrome: a case report. J Oral Maxillofac Surg 48: 1222–5, 1990.
5. Tilling G, Skobowytsh B. Disappearing bone disease, Morbus Gorham: report of a case. Acta Orthop Scand 39: 398-406, 1968.
6. Jackson JBS. A boneless arm. Boston Med Surg J 18: 368–9, 1838.
7. Jackson JBS. Absorption of humerus after fracture. Boston Med Surg J 10: 245–7, 1872.
8. Gorham LW, Stout AP. Massive osteolysis (acute spontaneous absorption of bone, phantom bone, disappearing bone): its relation to hemangiomatosis. J Bone Joint Surg 37-A: 985-1004, 1955.
9. Gowin W, Rahmanzadeh R. Radiologic diagnosis of massive idiopathic osteolysis (Gorham-Stout Syndrome). Rontgenpraxis 38: 128-34, 1985.
10. Horst M, Zsernaviczky J, Delling G. A rare case of so-called idiopathic osteolysis associated with a lymphangioma of the fibula. Z Orthop 117: 88-95, 1979.
11. Florchinger A, Bottger E, Claass-Bottger F, Georgi M, Harms J. Gorham Stout syndrome of the spine: case report and review of the literature. Rofo 168: 68-76, 1998.
12. Romer O. Die pathologic der Zahne. In: von Henke F, Lubarsch O (eds). Handbuch der speziellen pathologischen anatomie und histologie. Vol 4. Berlin: Springer Verlag, 1924, pp 135–499.
13. Frederikson NL, Wesley RK, Sciubba JJ, Helfrick J. Massive osteolysis of the maxillofacial skeleton: a clinical, radiographic, histologic and ultrastructural study. Oral Surg Oral Med Oral Pathol 55: 470-80, 1983.
14. Escande C, Schouman T, Franc¸oise G, Haroche J, Ménard P, Piette JC, et al. Histological features and management of a mandibular Gorham disease: a case report and review of maxillofacial cases in the literature. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 106: e30-7, 2008.
15. Patel DV. Gorham's disease or Massive osteolysis. Clin Med Res 3: 65-74, 2005.
16. Ricalde P, Ord RA, Sun CC. Vanishing bone disease in a five year old: report of a case and review of the literature. Int J Oral Maxillofac Surg 32: 222-62, 2003.
17. Moizan H, Talbi M, Devauchelle B. Massive mandibular osteolysis: a case with non-contributive histology. J Oral Maxillofac Surg 65: 772-6, 2007.
18. Anavi Y, Sabes WR, Mintz S. Gorham's disease affecting the maxillofacial skeleton. Head Neck 11: 550-7, 1989.
19. Benhalima H, Lazrak A, Boulaich M, Mezahi M, Ourlai A, Kzadri M, et al. Massive osteolysis of the maxillo-facial bones: case report and review of the literature. Odontostomatol Trop 24: 35-40, 2001.
20. Raghuveer HP, Jayaleshmy R. Gorham's massive osteolysis of the mandible–a progressive radiographic presentation. Dentomaxillofac Radiol 38: 292-5, 2009.
21. Klein M, Metelmann, HR, Gross U. Massive osteolysis (Gorham-Stout syndrome) in the maxillofacial region: an unusual manifestation. Int J Oral Maxillofac Surg 25: 376-8, 1996.
22. Ohya T, Shibata S, Takeda Y. Massive osteolysis of the maxillofacial bones: report of two cases. Oral Surg Oral Med Oral Pathol 70: 698-703, 1990.
23. Schiel H, Prien J. Seven-year follow-up of vanishing bone disease in a 14-year-old girl. Head Neck 15: 352-6, 1993.
24. Rubel IF, Carrer A, Gilles JJ, Howard R, Cohen G. Progressive Gorham disease of the forearm. Orthopedics 31: 284, 2008.
25. Poirier H. Massive osteolysis of the humerus treated by resection and prosthetic replacement. J Bone Joint Surg 50: 158–60, 1968.
26. Dunbar SF, Rosenberg A, Mankin H, Rosenthal D, Suit HD. Gorham's massive osteolysis: the role of radiation therapy and a review of the literature. Int J Radiat Oncol Biol Phys 26: 491–7, 1993.

27. Fontanesi J. Radiation therapy in the treatment of Gorham disease. J Pediat Hematol Oncol 25: 816–7, 2003.
28. Avelar RL, Martins VB, Antunes AA, de Oliveira Neto PJ, de Souza Andrade ES. Use of zoledronic acid in the treatment of Gorham's disease. Int J Pediat Otorhinolaryngol 74: 319–22, 2010.
29. Hagberg H, Lamberg K, Astrom G. α-2b interferon and oral clodronate for Gorham's disease. Lancet 350: 1822–3, 1997.
30. Devlin RD, Bone HG, Roodman GD. Interleukin-6: a potential mediator of the massive osteolysis in patients with Gorham-Stout disease. J Clin Endocrinol Metabol 81:1893–7, 1996.
31. Hammer F, Kenn W, Wesselmann U, Hofbauer LC, Delling G, Allolio B, et al. Gorham-stout disease—stabilization during bisphosphonate treatment. J Bone Miner Res 20: 350-3, 2005.
32. Papadakis BSA, Khaldi L, Babourda EC, Papadakis S, Mitsitsikas T, Sapkas G. Vanishing bone disease: review and case reports. Orthopedics 31: 278, 2008.
33. Tsang WM, Tong AC, Chow LT, Ng IO. Massive osteolysis (Gorham disease) of the maxillofacial skeleton: report of 2 cases. J Oral Maxillofac Surg 62: 225-30, 2004.
34. Bruch-Gerharz D, Gerharz CD, Stege H, Krutmann J, Pohl M, Koester R et al. Cutaneous lymphatic malformations in disappearing bone (gorham-stout) disease: A novel clue to the pathogenesis of a rare syndrome. J Am Acad Dermatol 56: S21-5, 2007.
35. Radhakrishnan K, Rockson SG. Gorham's disease: An osseous disease of lymphangiogenesis? Ann NY Acad Sci 1131: 203-5, 2008.
36. Skidmore TB, Lee CM, Abbott TM, Wiggins RH, Anderson GE, Tward JD et al. Gorham disease of the mandible: Radiographic findings and radiotherapy response. Ear Nose Throat J 87: E4-7, 2008.
37. Gondivkar SM, Gadbail AR. Gorham-Stout syndrome: a rare clinical entity and review of literature. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 109: e41-e48, 2010.
38. Hanly JG, Walsh NM, Bresnihan B. Massive osteolysis in the hand and response to radiotherapy. J Rheumatol 12: 580-2, 1985.
39. Campbell J, Almond HG, Johnson R. Massive osteolysis of the humerous with spontaneous recovery. J Bone Joint Surg Am 57: 238-40, 1975.
40. Bek V, Halcl Z, Kolar J, Bednar B. Radiotherapy of the Gorham-Stout syndrome. Cesk Radiol 35: 291-8, 1981.
41. Prasanna R, Sankar J, Ramachandran P. Gorham's disease: Vanishing bone syndrome. Indian Pediatr 46: 255-6, 2009.
42. Kulenkampff HA, Richter GM, Hasse WE, Adler CP. Massive pelvic osteolysis in the Gorham-Stout syndrome. Int Orthop 14: 361-6, 1990.
43. Turra S, Gigante C, Scapinelli R. A 20-year follow-up study of a case of surgically treated massive osteolysis. Clin Orthop Relat Res 250: 297-302, 1990.
44. Woodward HR, Chan DP, Lee J. Massive osteolysis of the cervical spine: a case report of bone graft failure. Spine 6: 545-9, 1981.
45. Cannon SR. Massive osteolysis: a review of seven cases. J Bone Joint Surg Br 68: 24-8, 1998.
46. Sharma A, Iyer N, Mittal A, Das D, Sharma S. Vanishing mandible. J Oral Science 52: 513-6, 2010.
47. Resnick D. Osteolysis and chondrolysis. In: Resnick D, editor. Diagnosis of bone and joint disorders. 4th ed. Philadelphia: WB Saunders; 2002. p. 4920-44.
48. Mendez AA, Keret D, Robertson W, MacEwen GD. Massive osteolysis of the femur (Gorham's disease): a case report and review of the literature. J Pediat Orthop 9: 604–8, 1989.
49. Pazzaglia UE, Andrini L, Bonato M, Leutner M. Pathology of disappearing bone disease: A case report with immunohistochemical study. Int Orthop 21: 303-7, 1997.
50. Hirayama T, Sabokbar A, Itonaga I, Watt-Smith S, Athanasou NA. Cellular and humoral mechanisms of osteoclast formation and bone resorption in Gorham-Stout disease. J Pathol 195: 624-30, 2001.
51. Tong ACK, Leung TM, Cheung PT. Management of massive osteolysis of the mandible: a case report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 109: 238-41, 2009.
52. Assoun J, Richardi G, Railhac JJ, Le Guennec P, Caulier M, Dromer C, et al. CT and MRI of massive osteolysis of Gorham. J Comput Assist Tomogr 18: 981–4, 1994.
53. Speith ME, Greenspan A, Forrester DM, Ansari AN, Kimura RL, Gleason-Jordan I. Gorham's disease of the radius: radiographic, scintigraphic and MRI findings with pathologic correlation. A case report and review of literature. Skeletal Radiol 26: 659–63, 1997.
54. Heffez L, Doku HC, Carter BL, Feeney JE. Perspectives on massive osteolysis: report of a case and review of literature. Oral Surg Oral Med Oral Pathol 55: 331-43, 1983.
55. Kiran DN, Anupama A. Vanishing Bone Disease: A Review. J Oral Maxillofac Surg 69: 199-203, 2011.
56. Landesberg R, Eisig S, Fennoy I, Siris E. Alternative indications of bisphosphonate therapy. J Oral Maxillofac Surg 67(Suppl 1): 27-34, 2009.
57. Migliorati CA. Commentary: massive osteolysis or Gorham-Stout disease. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 109: 242-3, 2010.
58. Abdulai AE, Nuamah IK, Avogo D, Konadu Akua B. Vanishing Bone (Gorham's) Disease of the Mandible: A Case Report. Sch J Med Case Rep 2: 183-7, 2014.
59. Kontio R. Update on mandibular reconstruction: computer-aided design, imaging, stem cells and future applications. Curr Opin Otolaryngol Head Neck Surg 22: 307-15, 2014.
60. D'Aquino R, De Rosa A, Lanza V, Tirino V, Laino L, Graziano A, et al. Human mandible bone defect repair by the grafting of dental pulp stem/progenitor cells and collagen sponge biocomplexes. Eur Cell Mater 18: 75–83, 2009.
61. Xu H, Han D, Dong JS, Shen GX, Chai G, Yu ZY, et al. Rapid prototyped PGA/PLA scaffolds in the reconstruction of mandibular condyle bone defects. Int J Med Robot 6: 66–72, 2010.
62. Yamada Y, Ito K, Nakamura S, Ueda M, Nagasaka T. Promising cell-based therapy for bone regeneration using stem cells from deciduous teeth, dental pulp, and bone marrow. Cell Transplant 20: 1003–13, 2011.
63. Warnke PH, Springer IN, Acil Y, Julga G, Wiltfang J, Ludwig K, et al. The mechanical integrity of in vivo engineered heterotopic bone. Biomaterials 27: 1081–7, 2006.
64. Abukawa H, Zhang W, Young CS, Asrican R, Vacanti JP, Kaban LB, et al. Reconstructing mandibular defects using autologous tissue-engineered tooth and bone constructs. J Oral Maxillofac Surg 67: 335–47, 2009.
65. Grayson WL, Fro¨ hlich M, Yeager K, Bhumiratana S, Chan ME, Cnnizzaro C, et al. Engineering anatomically shaped human bone grafts. Proc Natl Acad Sci USA 107: 3299–304, 2010.