Clinical and radiological assessment of rhinomaxillary syndrome in Hansen's disease

Rachel Bertolani do Espírito Santo, Rachel Azevedo Serafim, Rafael Maffei Loureiro[1], Daniel Vaccaro Sumi[1], Ricardo Andrade Fernandes de Mello[2], Izabelle Felix Nascimento[3], Arthur Ferraz Jong Mun Lee[3], John D. Collin[4], Simon M. Collin[5], Patrícia Deps[3]

Postgraduate Programme in Infectious Diseases, Universidade Federal do Espírito Santo, Vitória, Espírito Santo, Brazil, [1]Department of Imaging, Hospital Israelita Albert Einstein, São Paulo, Brazil, [2]Department of Internal Medicine, Universidade Federal do Espírito Santo, Vitória, Espírito Santo, Brazil, [3]Department of Social Medicine, Universidade Federal do Espírito Santo, Vitória, Espírito Santo, Brazil, [4]Department of Oral and Maxillofacial Surgery, University Hospitals Bristol NHS Foundation Trust, Bristol, United Kingdom, [5]National Infection Service, Public Health England, London, United Kingdom

Abstract

Background: More than four million people today live with Hansen's disease, and 200,000 new cases are diagnosed every year. Lifetime effects of Hansen's disease manifest as changes to bones of the face, hands and feet, resulting in physical impairment, secondary complications and facial changes that can be detrimental to quality of life, particularly among the elderly.

Aims: This study aimed to perform a detailed characterization of rhinomaxillary syndrome and its clinical manifestations in older persons treated in the past for Hansen's disease.

Methods: This was a cross-sectional study to characterize rhinomaxillary syndrome among older persons (age 60+ years) resident at Pedro Fontes Hospital, Cariacica, Espírito Santo, Brazil. Computed tomography images were examined with three-dimensional reconstructions to assess alterations to maxillofacial bones according to criteria for radiological rhinomaxillary syndrome. Participants were examined to assess facial alterations according to criteria for clinical rhinomaxillary syndrome.

Results: Rhinomaxillary syndrome was investigated in 16 participants (ten females and six males), median age 70 (range 60–89) years, age at diagnosis 20 (6–43) years and time since diagnosis 46 (26–70) years. Four participants fully met radiological rhinomaxillary syndrome criteria, four partially. All participants with full radiological rhinomaxillary syndrome presented with facial changes which met criteria for clinical rhinomaxillary syndrome, including "saddle nose" (loss of nasal dorsal height and shortened length of nose, due to cartilaginous and/or bone collapse), concave middle third of the face with sunken nose, maxillary retrognathia and inverted upper lip.

Limitations: Clinical histories were incomplete for some participants because records were lost at the hospital over time.

Conclusion: Until Hansen's disease is eliminated from endemic countries, persons affected will continue to present with rhinomaxillofacial alterations caused by *Mycobacterium leprae* infection. Clinical protocols for assessment and long-term care need to include otorhinolaryngological evaluation, mainly to prevent secondary complications. When rhinomaxillofacial bone changes are suspected, this evaluation should be supported by computed tomography imaging, if available.

Key words: Facial bones, facial profile, Hansen's disease, rhinomaxillary syndrome, tomography

Plain Language Summary

Hansen's disease, also known as leprosy, is an infectious disease caused by a bacterium, *Mycobacterium leprae*. More than 200,000 new cases of Hansen's disease are diagnosed each year worldwide. If the disease is diagnosed too late, it can alter bones in the skull, leading to facial changes and disfigurement. These are associated with stigma and with other medical

How to cite this article: do Espírito Santo RB, Serafim RA, Loureiro RM, Sumi DV, de Mello RA, Nascimento IF, et al. Clinical and radiological assessment of rhinomaxillary syndrome in Hansen's disease. Indian J Dermatol Venereol Leprol 2022;88:483-93.

Corresponding author: Prof. Patrícia Deps, Departamento de Medicina Social, Centro de Ciências da Saúde, Avenida Marechal Campos, 1468. Maruípe, Vitória, Espírito Santo, Brazil. patricia.deps@ufes.br

Received: September, 2020 **Accepted:** May, 2021 **EPub Ahead of Print:** October, 2021 **Published:** June, 2022

DOI: 10.25259/IJDVL_1203_20 **PMID:** 35138068

complications. These bone alterations have been examined in skulls from archaeological sites, and the associated changes have been called "rhinomaxillary syndrome." In living persons affected by Hansen's disease, rhinomaxillary syndrome can be assessed by computed tomography imaging of maxillofacial bones, but a simpler method of looking at external changes to the face could also be useful in clinical practice, particularly in the countries where Hansen's disease is endemic. The authors used both techniques in a group of elderly people from Brazil to evaluate a set of diagnostic criteria based on changes to the face which matched the underlying bone alterations. This simpler method could be incorporated into clinical guidelines to improve the assessment and care of persons affected by Hansen's disease. When rhinomaxillofacial bone changes are suspected, clinical evaluation should be supported by computed tomography imaging where these facilities are available.

Introduction

Delayed diagnosis of Hansen's disease increases the risk of disabilities.[1-4] Hansen's disease-related changes to bones, particularly of the hands, feet and face,[5] impact on quality of life and contribute to stigmatization.[6,7] Rhinomaxillofacial changes caused by *Mycobacterium leprae* infection of the nasal passages and the palate includes collapse of the bridge of the nose, resorption of the central part of the maxilla and inflammation of the floor and walls of the nasal cavity and hard palate.[8,9] The degree of bone alteration correlates with the type of the disease at diagnosis, ranging from little or no detectable change in the tuberculoid type to severe changes at the "lepromatous" pole.[8,9]

Rhinomaxillary syndrome was defined in 1992 to identify Hansen's disease in skulls from archaeological sites based on changes to the pyriform aperture, orbital bones and alveolar process of the maxilla.[10-12] Rhinomaxillary syndrome criteria may have clinical utility in providing a standardized method for grading rhinomaxillofacial changes in persons affected by Hansen's disease.[13]

The aim of our study was to perform the first *in vivo* investigation of rhinomaxillary syndrome using computed tomography imaging with three-dimensional reconstructions, to determine whether rhinomaxillary syndrome correlated with a clinical definition based on facial profile alterations.

Methods

Participants

Older persons (age 60+ years) affected by Hansen's disease resident at the Hospital Colônia Pedro Fontes, Espírito Santo, Brazil, were invited to participate when they required medical assessment as part of routine care between September 2015 and December 2016. Demographic data and medical history were obtained by interview and from medical records. All participants received general medical, dermatological and otorhinolaryngological examinations.

Computed tomography imaging

Participants attended the Radiology and Computed Tomography Service at Hospital Universitário Cassiano Antônio Moraes, Espírito Santo, Brazil, for computed tomography scans of the head. Images were acquired in a 64-section multidetector computed tomography scanner (Aquilion, Toshiba Medical Systems Corp., Tochigi, Japan) with parameters 120 kVp, 100 mAs, 1.125 mm spiral pitch factor. Field of view was limited to the maxillofacial area. Three-dimensional reconstructions and cephalometrics were generated from volumetric data by DePuy Synthes TRUMATCH CMF Solutions (DePuy Synthes Inc., PA 19380, USA). Cephalometrics comprised maxillary height and width, nasofrontal angle, ANS angle (A=A point, N=nasion and S=Sella turcica mid-point) and maxillary volume measured at Le Fort 1 level.

Rhinomaxillary syndrome

Rhinomaxillary syndrome is defined by changes to: (I) anterior nasal spine; (II) alveolar processes of maxilla; (III) nasal surface of the palatine process of the maxilla; (IV) oral surface of the palatine process of the maxilla; (V) nasal turbinates and septum; (VI) pyriform aperture and (VII) posterior alveolar margins of the maxilla.[11] To identify rhinomaxillary syndrome from computed tomography images, we combined criteria III and IV because both sides of the hard palate can be examined in physical remains but not in computed tomography images. To criteria VI, we added resorption of the nasal bones which are part of the pyriform aperture but usually absent from paleopathological specimens. Abnormalities were graded as "severe" or "mild to moderate" [Figure 1]. Full or partial radiological rhinomaxillary syndrome was based on assessment of the number and severity of alterations. "Fully met" required severe resorption of anterior nasal spine (criterion I) and severe loss of sharpness of pyriform aperture and/or resorption of nasal bones (criterion VI) plus at least one of the other criteria rated severe and one rated mild to moderate. Partial radiological rhinomaxillary syndrome

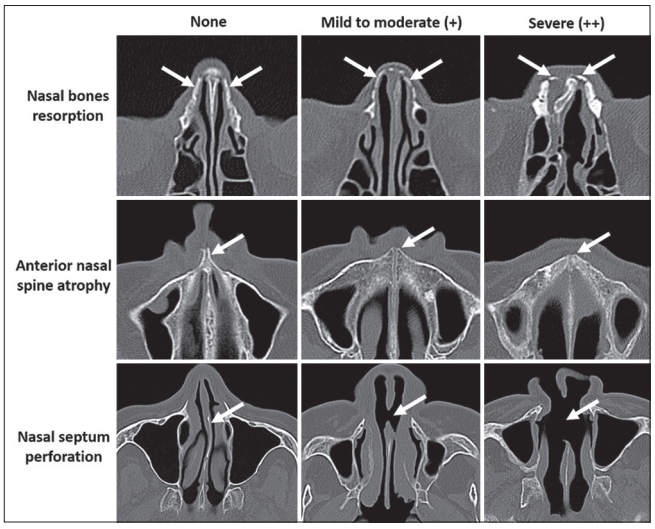

Figure 1: Grading by computed tomography imaging of maxillofacial bone alterations in rhinomaxillary syndrome

typically required two–three severe plus two–three mild-to-moderate bone alterations. Computed tomography images were examined independently and in parallel by two radiologists.

Clinical rhinomaxillary syndrome

Assessment of clinical manifestation of rhinomaxillary syndrome was based on clinical rhinomaxillary syndrome criteria comprising four facial profile alterations: (1) saddle nose, characterized by loss of nasal dorsal height and shortened length of nose, due to cartilaginous and/or bone collapse; (2) concave middle third of the face with sunken (retracted) nose, caused by erosion of the zygomatic process and enlargement and loss of the pyriform shape of the nasal aperture; (3) reduced maxillary projection (maxillary retrognathia/reduced ANS) and (4) inverted upper lip because of reduced maxillary height.[13] Alterations were scored: saddle nose (no = 0, mild = 1, moderate = 2 and severe = 3); concave middle third of face with sunken nose (no = 0, either = 1 and both = 2); maxillary retrognathia (reduced ANS) (no = 0 and yes = 1) and inverted upper lip (no = 0 and yes = 1). The sum of scores was categorized: normal = 0, mild = 1, moderate = 2–4 and substantial (clinical rhinomaxillary syndrome) = 5–7.

Ethical Approval

This study was approved by the Research Ethics Committee of the Health Sciences Center of the Federal University of Espírito Santo (no. 4.248.419, August 31, 2020). Informed consent including for use of images was obtained from all participants.

Results

Participants

Sixteen former Hansen's disease patients participated (ten females and six males) with median age 70 (range 60–89) years, age at diagnosis 20 (6–43) years and time since diagnosis 46 (26–70) years. Original Hansen's disease diagnosis by Madrid Classification was the "lepromatous" form in 13 patients, "borderline" in two and "tuberculoid" in one patient [Table 1]. Most patients had received two–three courses of dapsone monotherapy during the 1960s to 1980s; seven had received multidrug therapy (dapsone, rifampicin and clofazimine). Type 1 and 2 reactions before, during or after Hansen's disease treatment were recorded for ten patients.

Maxillofacial bone changes

All participants had alterations to the alveolar process of maxilla to varying degrees (eight severe and eight mild to moderate) [Table 2]. The second most frequent alteration was resorption

Table 1: Diagnosis, treatment history and reactions in older persons affected by Hansen's disease

ID	Age	Sex	Madrid classification at diagnosis[a]	Age at diagnosis	Delay (months)[b]	Monotherapy start year (drug)[c]	Months of monotherapy (drug)[c]	Multidrug therapy start year	Months of multidrug therapy	Hansen's disease reactions[d]			Reaction therapy[e]
										Before	During	After	
P1	87	M	L	42		1970 (D)	144 (D)	2000	12		II		P, T
P2	77	M	L	27		1977 (D)	156 (D)	None				III	P
P3	89	M	L	43		1978 (D)		None				II	P, T
P4	65	F	T	20	120							I	P
P5	62	F	L	25	2	1978 (D) 1990 (R)		None			II	II	P, T
P6	68	F	B	13		1975 (D)		None				II	T
P7	77	F	L	31	60	1975 (C) 1979 (R) 1983 (D)	300 (D)	Yes		II	II		T
P8	76	M	L	6	12	1969 (D) 1984 (C) 1984 (R)	252 (D)	Yes					
P9	79	F	L	9		1960 (D) 1984 (C) 1990 (D)		None					
P10	79	F	L	11		1959 (D) 1975 (C) 1979 (R)		Yes					
P11	60	F	L	17	3	1976 (D) 1979 (R)	180 (D) 36 (R)	Yes					
P12[f]	70	F	L	17	96							I	P
P13	70	M	L	26		1963 (D) 1984 (R) 1988 (C)	300 (D) 60 (R) 36 (C)	Yes					
P14	76	F	L	23		1968 (D) 1984 (C) 1987 (R)	60 (D) n/r (C) 24 (R)	Yes					
P15	61	F	L	15	48	1972 (D) 1975 (C) 1978 (D)	36 (D) 180 (C) 96 (D)	None			II		T
P16	66	M	B	40	36	1970 (D) 1980 (C)	120 (D)	None		II	II		P, T

[b]Madrid classification: L="lepromatous;" B= "borderline;" T= "tuberculoid". [b]Delay in diagnosis was defined as being the time (in months) from awareness of the first symptom to the start of treatment. [c] Drugs: D=dapsone; R=rifampicin; C=clofazimine. [d]Hansen's disease reactions: type I ("reversal reaction"); type II (erythema nodosum leprosum); type III (isolated neuritis). [e]Hansen's disease reaction treatments: P=prednisone; T=thalidomide. [f]This person came from Rio de Janeiro, therefore, data are incomplete

of the anterior nasal spine, observed in 12/16 participants (six severe). Resorption of nasal bones was observed in ten/16 participants (five severe), loss of sharpness of the pyriform aperture in ten/16 (five severe) and atrophy of the inferior and middle nasal turbinates in eight/16 (one severe) and seven/16 (two severe). Three participants had severe perforation of the nasal septum and eight had thinning of the hard palate with bony discontinuities [Table 2]. None had perforated palate.

Table 2: Evaluation of maxillofacial bone alterations and diagnosis of radiological rhinomaxillary syndrome in older persons affected by Hansen's disease

ID	Frontal, zygomatic, lacrimal bones	Anterior nasal spine	Alveolar process of maxilla (anterior)	Hard palate (palatine process of maxilla)	Nasal septum	Inferior nasal turbinates	Middle nasal turbinates	Pyriform aperture	Nasal bones	Alveolar process of maxilla (posterior)	Radiological rhinomaxillary syndrome[a]	Figure
		I	II	III + IV		V		VI		VII		
		2.1.1	2.1.2	2.1.3 (nasal) 2.1.4 (oral)		2.1.5		2.1.6		2.1.7		
	Osteitis	Resorption[b]	Resorption[b]	Thinning with bony discontinuities	Perforation[b]	Atrophy[b]	Atrophy[b]	Loss of sharpness[b]	Resorption[b]			
P1	Yes	++	++	Yes	++	++	++	++	++	+	Full	Figure 2
P2	No	++	+	No	++	+	+	++	+	-	Full	
P3	No	+	+	No	-	+	+	-	-	+	No	
P4	No	-	++	No	-	+	-	-	-	+	No	
P5	No	+	++	Yes	-	-	-	-	-	++	No	
P6	No	-	++	Yes	-	-	-	-	-	++	No	
P7	No	++	+	Yes	++	+	+	++	+	+	Full	Figure 3
P8	No	++	+	No	+	+	+	++	++	++	Full	Figure 4
P9	No	++	++	Yes	-	+	+	+	+	++	Partial	
P10	No	++	++	No	-	-	-	+	++	+	No	Figure 5
P11	No	+	++	Yes	-	-	-	+	++	++	Partial	
P12	No	+	+	No	-	-	-	-	-	+	No	
P13	Yes	-	+	No	-	-	++	+	-	+	Partial	
P14	No	-	++	Yes	-	-	-	-	+	++	No	
P15	No	+	+	No	-	-	-	++	++	-	Partial	
P16	No	+	+	Yes	-	+	-	+	+	++	No	

[a]Radiological rhinomaxillary syndrome adapted from criteria defined by Anderson and Manchester (see Methods). [b]–None, + mild to moderate, ++ severe

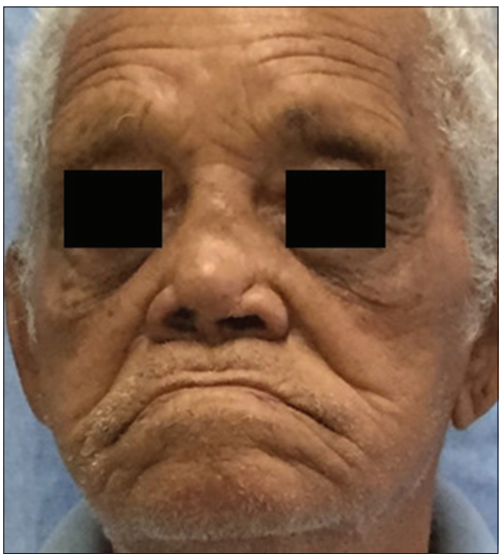

Figure 2a: Patient (P1), male, age 87, with full rhinomaxillary syndrome: frontal facial aspect showing facial profile changes comprising severe saddle nose which was sunken in concave middle third of face and maxillary retrognathia with inverted upper lip, meeting clinical rhinomaxillary syndrome criteria

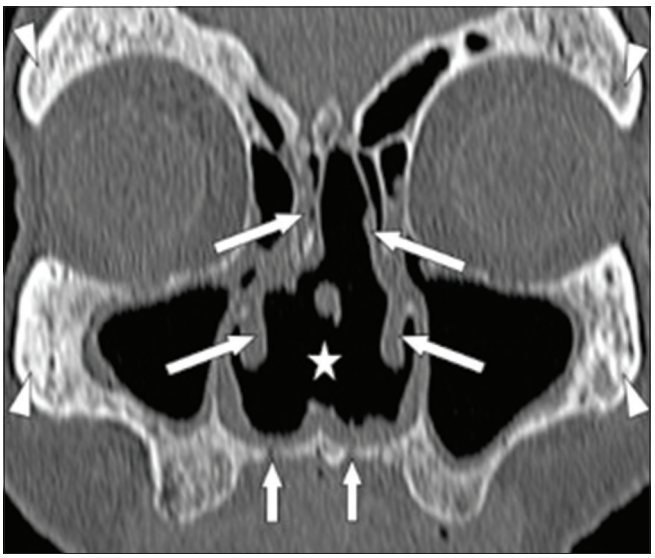

Figure 2b: Patient (P1), male, age 87, with full rhinomaxillary syndrome: coronal computed tomography image showing atrophy of the middle and inferior nasal turbinates (long arrows), a large perforation in the nasal septum (star), thinning of the hard palate with focal discontinuities (short arrows), as well as thickening and sclerosis of zygomatic and frontal bones, consistent with osteitis (arrowheads)

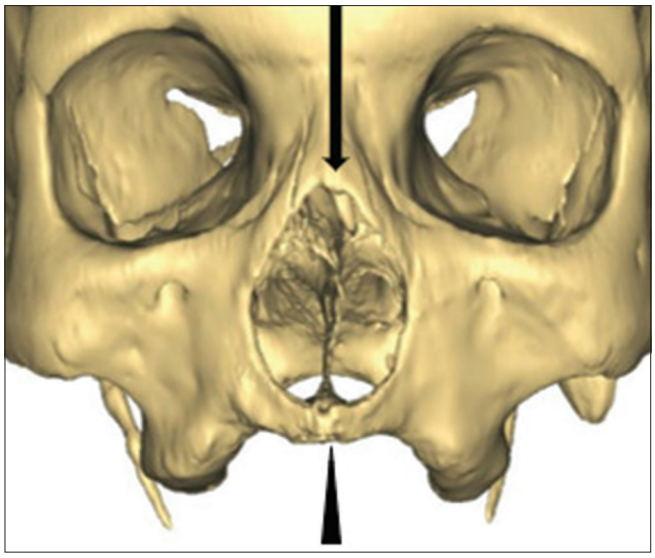

Figure 2c: Patient (P1), male, age 87, with full rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (anterior view) showing loss of sharpness of the pyriform aperture, deformity and resorption of the nasal bones (arrow) and marked, crescentic resorption of the central part of the alveolar process of the maxilla (arrowhead)

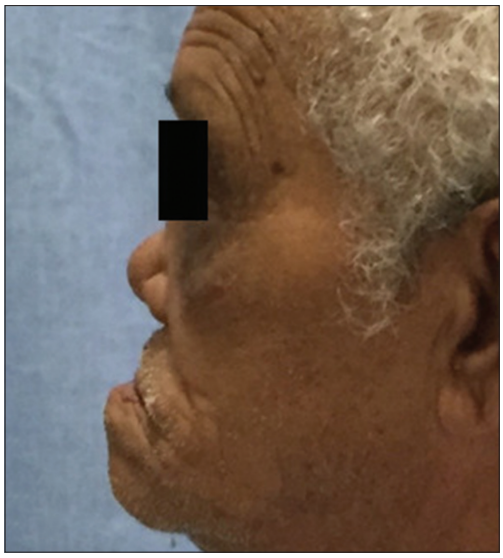

Figure 2d: Patient (P1), male, age 87, with full rhinomaxillary syndrome: lateral facial aspect showing substantial facial profile changes including severe saddle nose

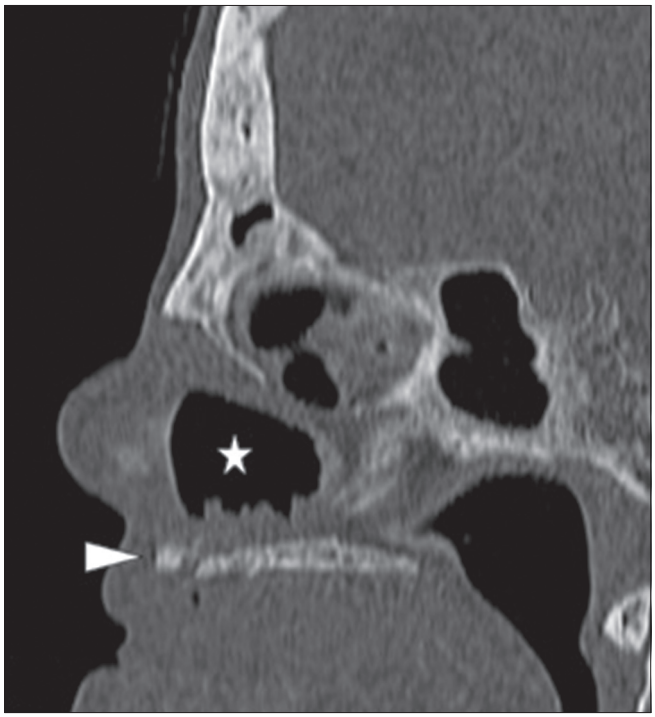

Figure 2e: Patient (P1), male, age 87, with full rhinomaxillary syndrome: sagittal computed tomography image showing marked resorption of the anterior nasal spine (arrowhead) and a large perforation in the nasal septum (star)

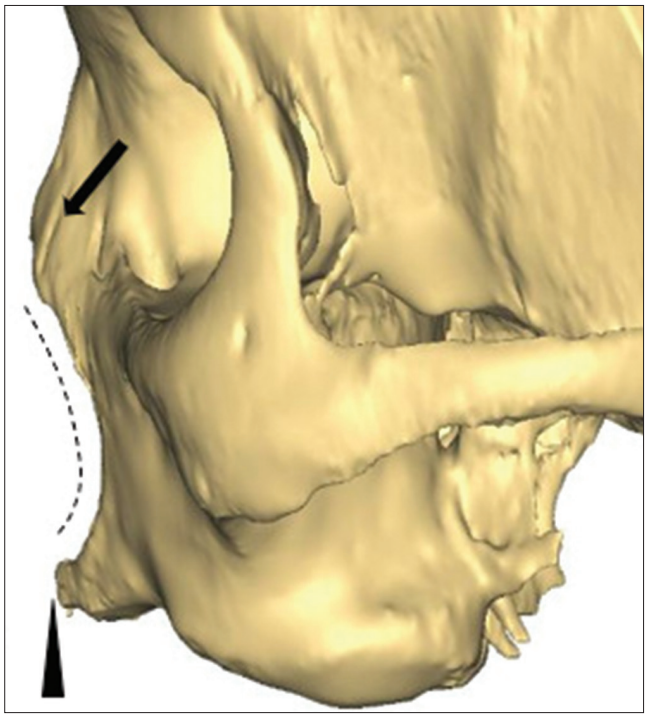

Figure 2f: Patient (P1), male, age 87, with full rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (lateral view) showing marked resorption of the anterior nasal spine (arrowhead) and nasal bones (arrow), as well loss of sharpness of the pyriform aperture (dashed line)

Clinical rhinomaxillary syndrome and radiological rhinomaxillary syndrome

Four participants (P1, P2, P7 and P8) fully met the criteria for radiological rhinomaxillary syndrome [Table 2], all of whom had facial profile changes which met criteria for clinical rhinomaxillary syndrome [Table 3]. Four participants (P9, P11, P13 and P15) had partial radiological rhinomaxillary syndrome, of whom three had moderate and one had mild facial profile changes. Three cases (P1, P7 and P8) with bone alterations meeting criteria for full radiological rhinomaxillary syndrome are illustrated in Figures 2-4, together with one case (P10) with bone alterations which did not meet radiological rhinomaxillary syndrome criteria [Figure 5]. Cephalometrics for P1, P7, P8 and P10 are reported in Table 4.

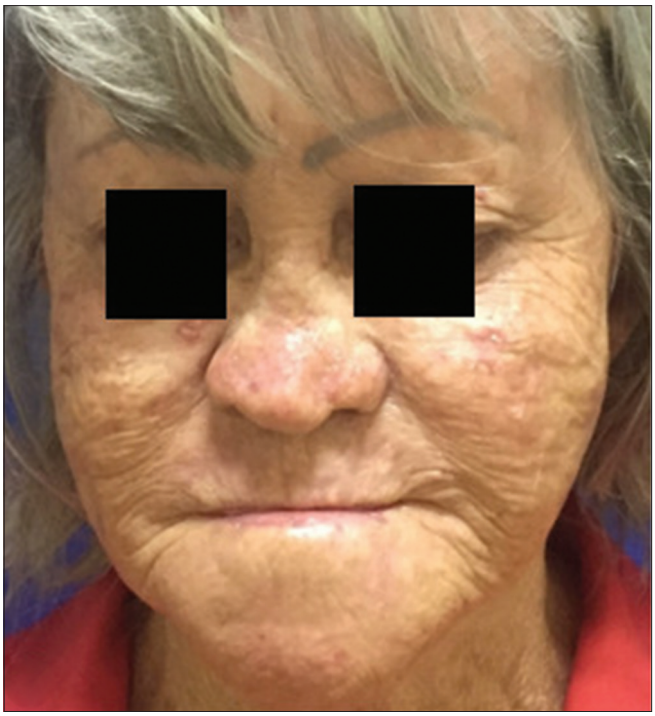

Figure 3a: Patient (P7) female, age 77, with full rhinomaxillary syndrome: frontal facial aspect showing facial profile changes including moderate saddle nose which was sunken in concave middle third of face, and maxillary retrognathia with inverted upper lip, meeting clinical rhinomaxillary syndrome criteria

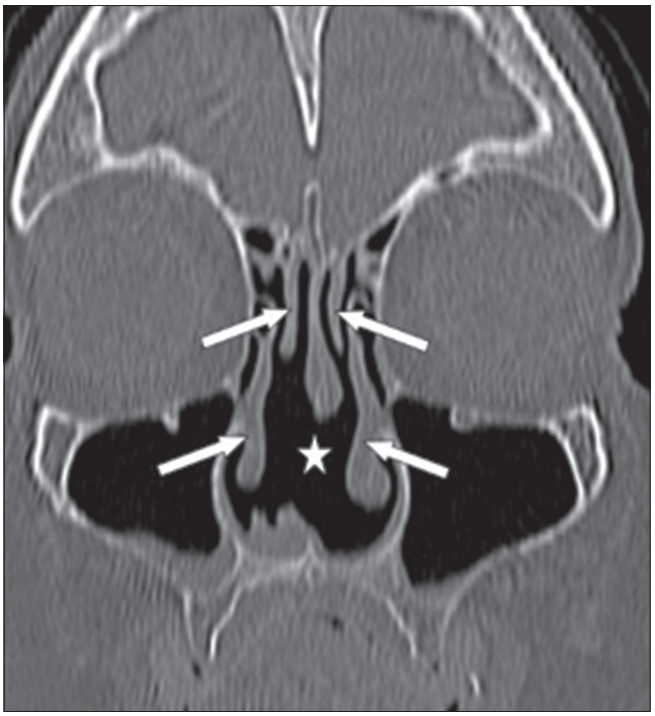

Figure 3b: Patient (P7) female, age 77, with full rhinomaxillary syndrome: coronal computed tomography image showing resorption of the middle and inferior nasal turbinates (arrows) and a large perforation in the nasal septum (star)

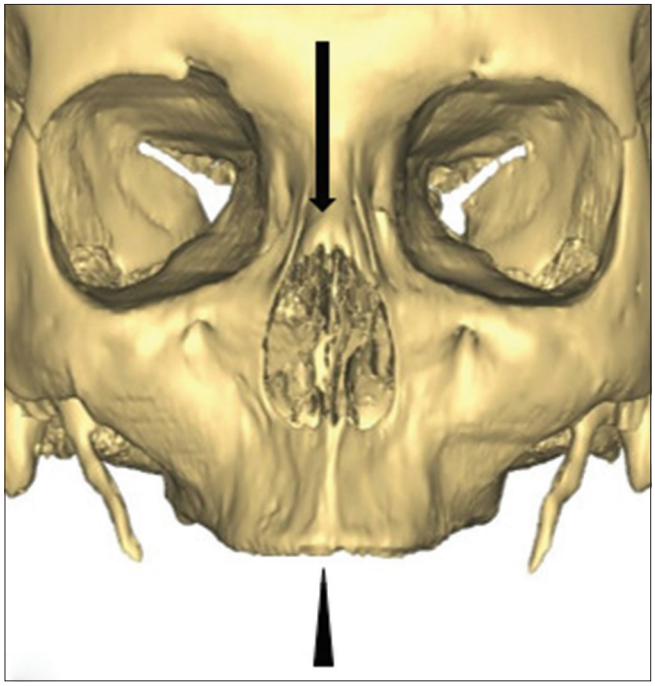

Figure 3c: Patient (P7) female, age 77, with full rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (anterior view) showing resorption of the nasal bones (arrow) and alveolar process of the maxilla (arrowhead)

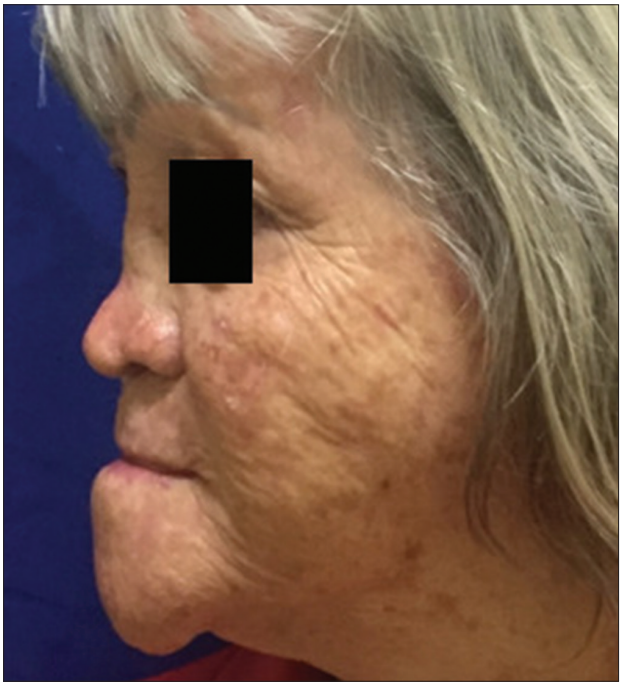

Figure 3d: Patient (P7) female, age 77, with full rhinomaxillary syndrome: lateral facial aspect showing substantial facial profile changes including a sunken and folded nose

Discussion

This group of elderly adults previously treated and cured of Hansen's disease displayed at least one maxillofacial bone alteration consistent with the pathophysiological effects of clinical *Mycobacterium leprae* infection. All participants had alterations to the alveolar process of the maxilla and most presented with resorption of the anterior nasal spine, but the number of other bones affected and the degree of alterations

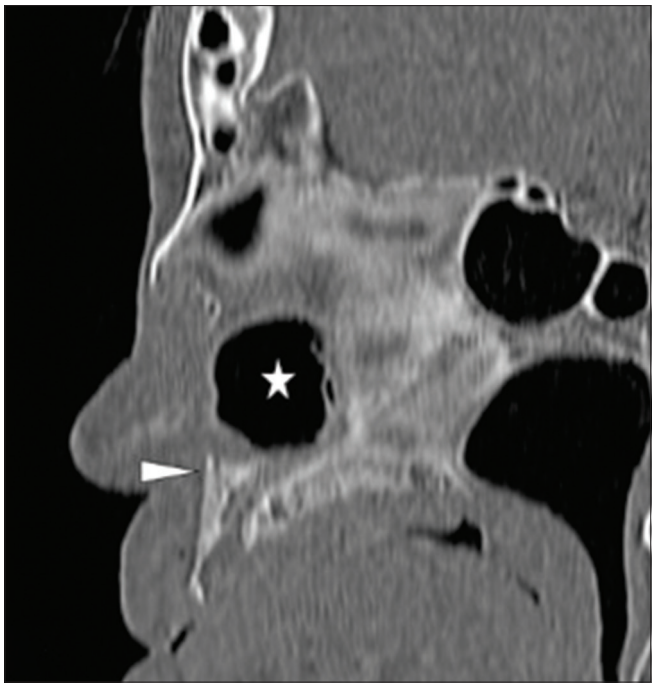

Figure 3e: Patient (P7) female, age 77, with full rhinomaxillary syndrome: sagittal computed tomography image showing marked resorption of the anterior nasal spine (arrowhead) and a large perforation in the nasal septum (star)

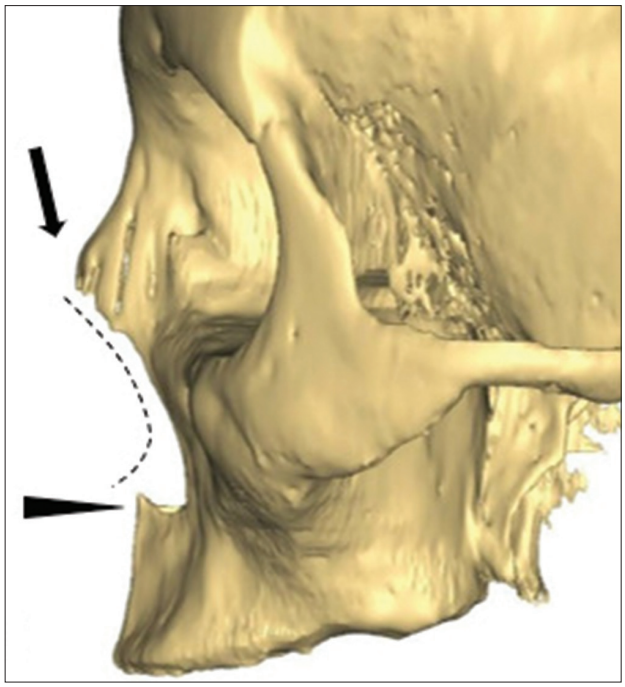

Figure 3f: Patient (P7) female, age 77, with full rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (lateral view) showing marked resorption of the anterior nasal spine (arrowhead), resorption of the nasal bones (arrow) and loss of sharpness of the pyriform aperture (dashed line)

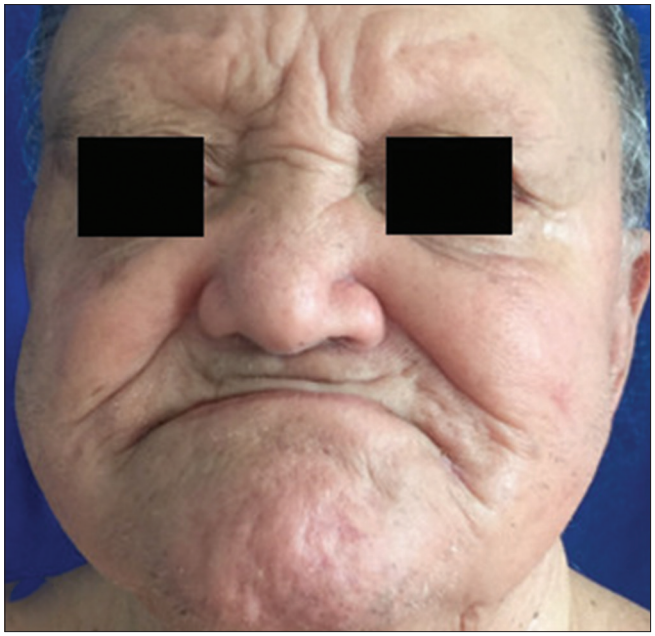

Figure 4a: Patient (P8) male, age 76, with full rhinomaxillary syndrome: frontal facial aspect showing facial profile changes including moderate saddle nose which was sunken in concave middle third of face, and maxillary retrognathia with inverted upper lip, meeting clinical rhinomaxillary syndrome criteria

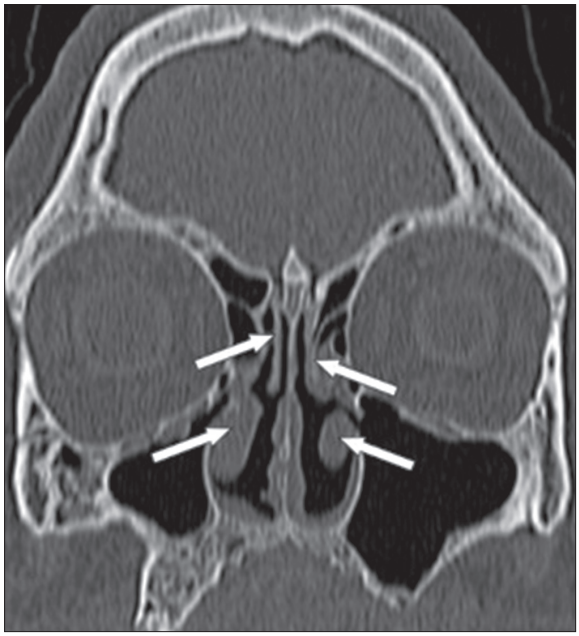

Figure 4b: Patient (P8) male, age 76, with full rhinomaxillary syndrome: coronal computed tomography image showing variable atrophy of the middle and inferior nasal turbinates (arrows)

varied widely. Maxillofacial bone alterations in four participants met the criteria for radiological rhinomaxillary syndrome fully, while four participants had partial radiological rhinomaxillary syndrome. Participants with full radiological rhinomaxillary syndrome presented with substantial facial changes including saddle nose, concave middle third of face with sunken nose, inverted upper lip and maxillary retrognathia. In all four full radiological rhinomaxillary syndrome patients, these alterations met a set of criteria defining "clinical RMS."

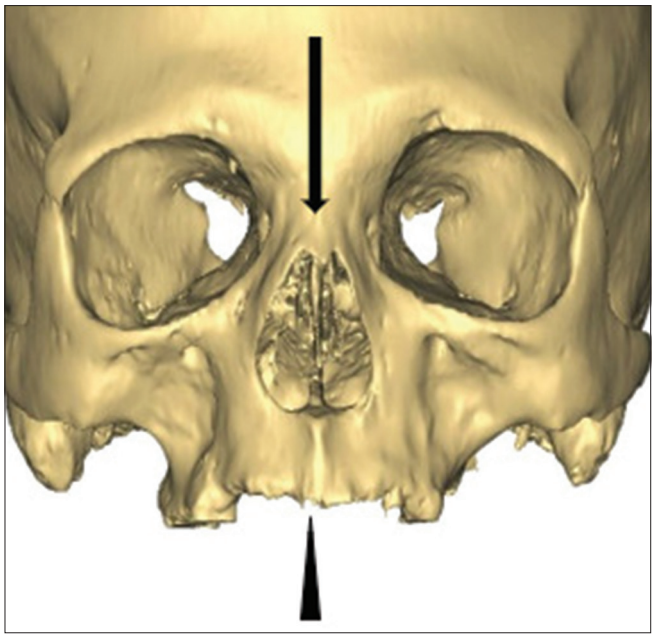

Figure 4c: Patient (P8) male, age 76, with full rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (anterior view) showing resorption of the nasal bones (arrow) and alveolar process of the maxilla (arrowhead)

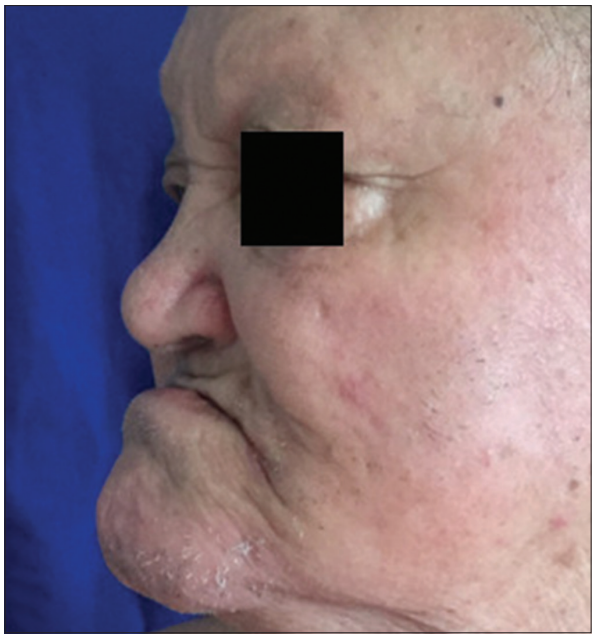

Figure 4d: Patient (P8) male, age 76, with full rhinomaxillary syndrome: lateral facial aspect showing substantial facial profile changes including a sunken and folded nose

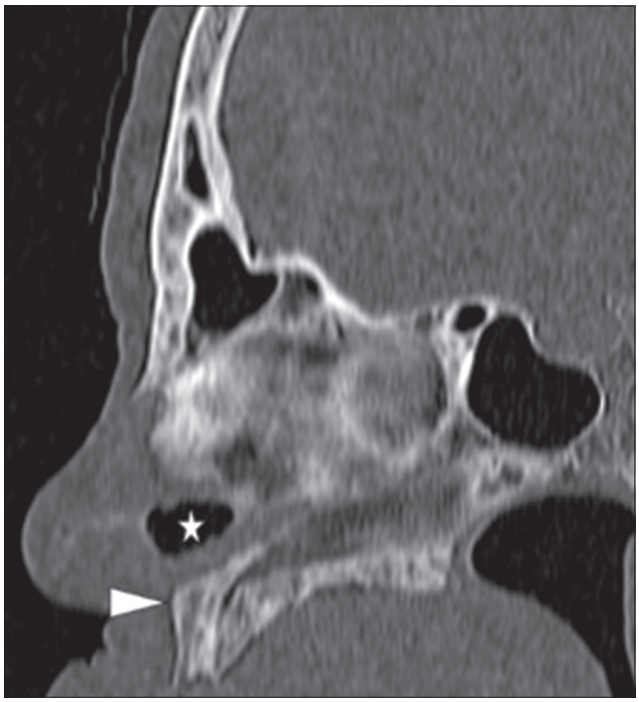

Figure 4e: Patient (P8) male, age 76, with full rhinomaxillary syndrome: sagittal computed tomography image showing marked resorption of the anterior nasal spine (arrowhead) and a perforation in the nasal septum (star)

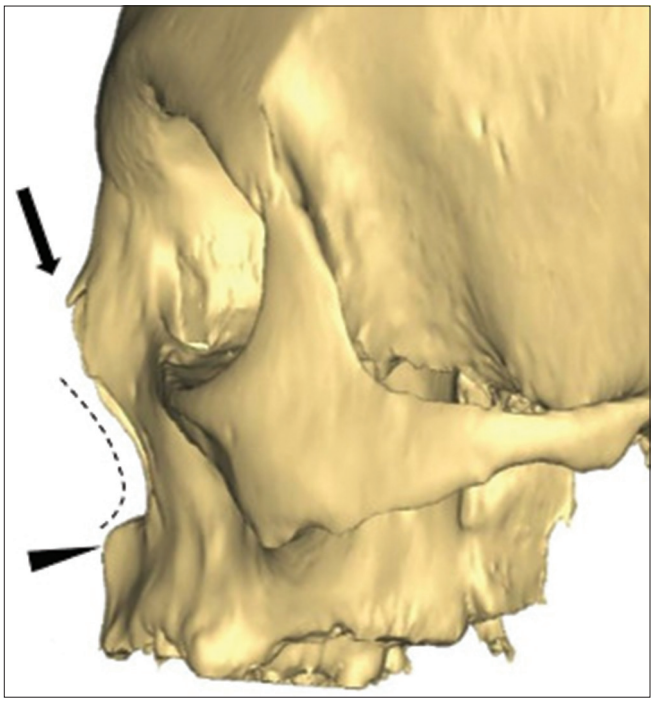

Figure 4f: Patient (P8) male, age 76, with full rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (lateral view) showing marked resorption of the anterior nasal spine (arrowhead) and nasal bones (arrow), as well loss of sharpness of the pyriform aperture (dashed line)

Maxillofacial bone changes assessed *in vivo* by computed tomography imaging have been described in only one previous study.[14] This study of ten former Hansen's disease patients residing in a National Sanatorium in Japan reported a range of alterations similar to those observed in our participants with four of ten participants having severe maxillary changes and saddle nose, and three of ten having no bone alterations.

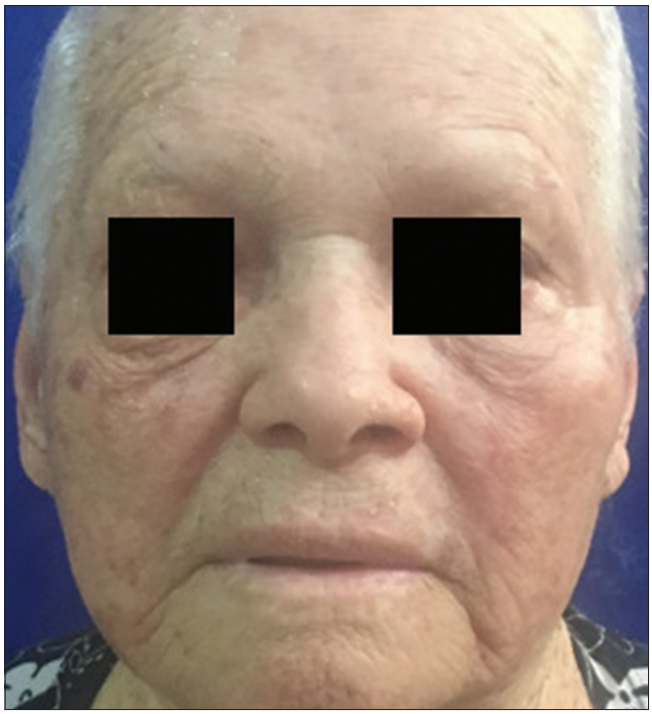

Figure 5a: Patient (P10) female, age 79, without rhinomaxillary syndrome: frontal facial aspect showing normal facial profile

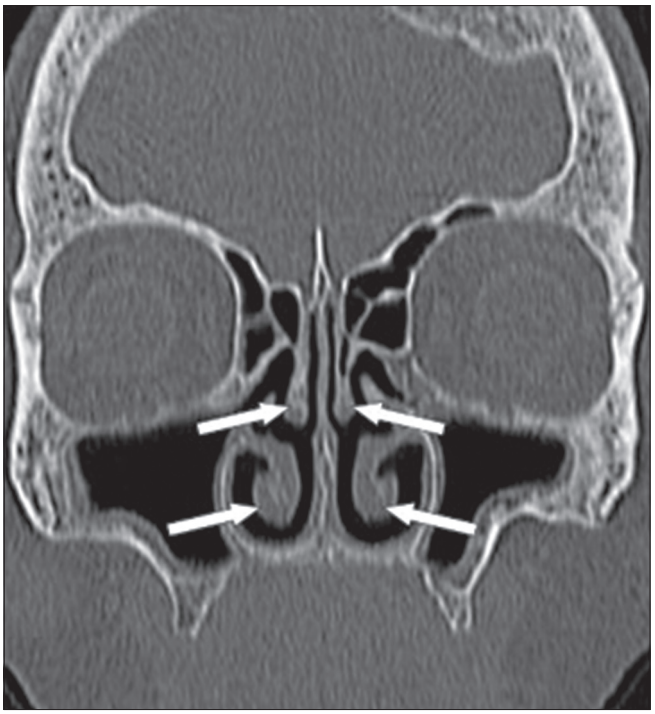

Figure 5b: Patient (P10) female, age 79, without rhinomaxillary syndrome: coronal computed tomography image showing normal middle and inferior nasal turbinates (arrows)

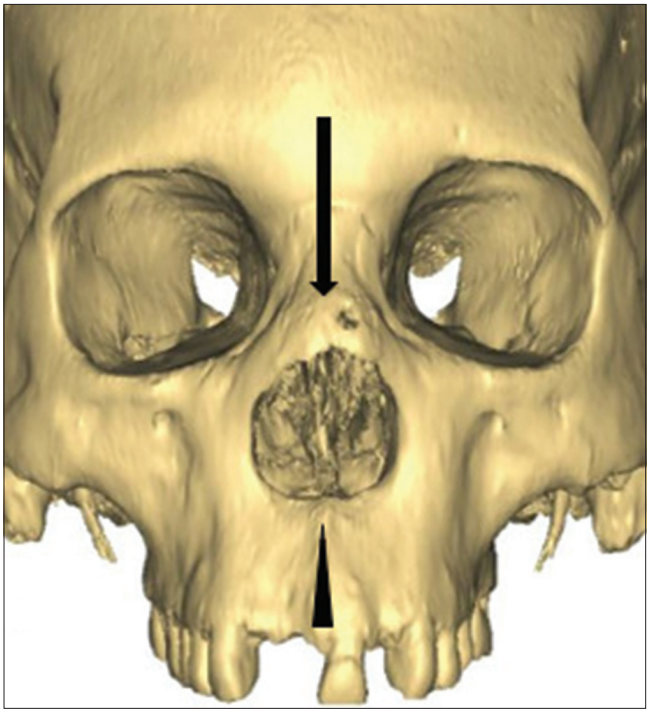

Figure 5c: Patient (P10) female, age 79, without rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (anterior view) showing resorption of the nasal bones (arrow) and the anterior region of the alveolar process of the maxilla (arrowhead)

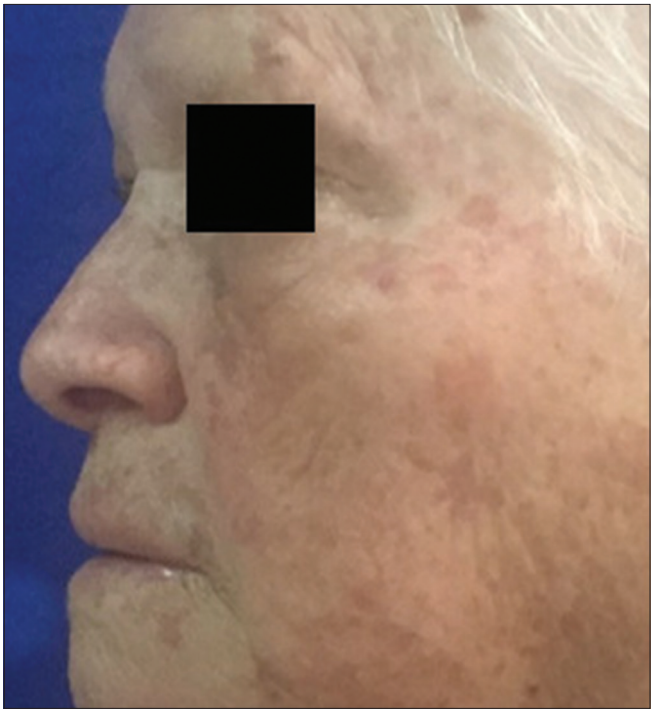

Figure 5d: Patient (P10) female, age 79, without rhinomaxillary syndrome: lateral facial aspect showing normal facial profile

Strengths and weaknesses

A limitation of our study is the lack of a control group to differentiate age-related changes to the maxilla. However, Kasai *et al*. reported that Hansen's disease-related changes occur predominantly in the median frontal part with characteristic interruption of the U-shaped process, as we

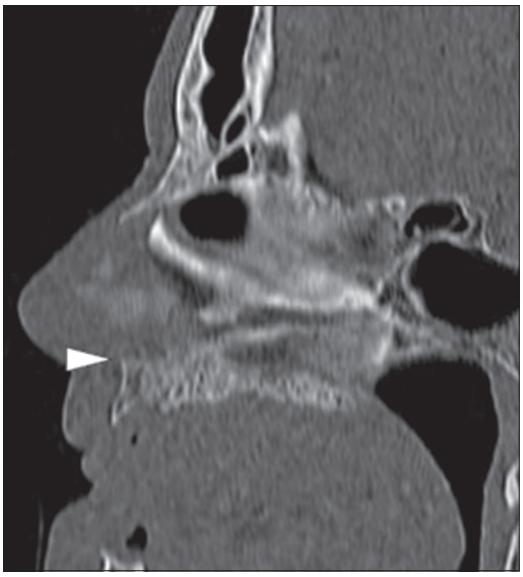

Figure 5e: Patient (P10) female, age 79, without rhinomaxillary syndrome: sagittal computed tomography image showing marked resorption of the anterior nasal spine (arrowhead) and no perforation in the nasal septum

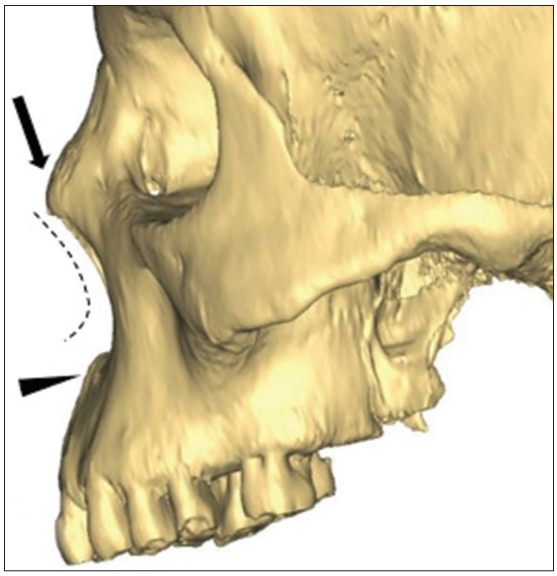

Figure 5f: Patient (P10) female, age 79, without rhinomaxillary syndrome: three-dimensional reconstruction computed tomography image (lateral view) showing marked resorption of the anterior nasal spine (arrowhead), resorption of the nasal bones (arrow) and loss of sharpness of the pyriform aperture (dashed line)

Table 3: Diagnosis of clinical rhinomaxillary syndrome in older persons affected by Hansen's disease

ID	1. Saddle nose	2. Concave middle third of the face with sunken nose	3. Maxillary retrognathia (reduced ANS)[a]	4. Inverted upper lip	Overall grading of facial changes (score)	Clinical rhinomaxillary syndrome[b]	Radiological rhinomaxillary syndrome[c]
P1	Severe	Yes	Yes	Yes	Substantial (7)	Yes	Full
P2	Severe	Yes	No	No	Substantial (5)	Yes	Full
P3	No	No	Yes	Yes	Moderate (2)	No	No
P4	No	No	Yes	No	Mild (1)	No	No
P5	Mild	No	Yes	No	Moderate (2)	No	No
P6	No	No	Yes	Yes	Moderate (2)	No	No
P7	Severe	Yes	Yes	Yes	Substantial (7)	Yes	Full
P8	Moderate	Yes	Yes	Yes	Substantial (6)	Yes	Full
P9	Mild	Yes	Yes	No	Moderate (4)	No	Partial
P10	No	No	No	No	Normal (0)	No	No
P11	Mild	No	Yes	Yes	Moderate (3)	No	Partial
P12	No	No	No	No	Normal (0)	No	No
P13	Mild	No	No	No	Mild (1)	No	Partial
P14	No	No	Yes	Yes	Moderate (2)	No	No
P15	Moderate	Yes	No	No	Moderate (4)	No	Partial
P16	No	No	No	No	Normal (0)	No	No

[a]ANS measures maxillary projection/retrusion relative to skull base, where A=A point (maximum concavity of maxilla, viewed sagittally), N = Nasion, S = Sella turcica mid-point (pituitary fossa). [b]Clinical rhinomaxillary syndrome criteria as defined by the authors (see Methods). [c]Radiological rhinomaxillary syndrome adapted from criteria defined by Anderson & Manchester (see Methods)

Table 4: Cephalometric measurements in three dimensional computed tomography images of older persons affected by Hansen's disease

ID	Age	Sex	Maxillary height (mm)	Maxillary width (mm)	Maxillary volume (cm^3)	Nasofrontal angle (°)	ANS[a] (°)	Clinical RMS[b]	Radiological RMS[c]
P1	87	M	6.5	62.6	19.3	151.8	84.0	Yes	Full
P7	77	F	19.8	53.9	9.0	150.3	82.4	Yes	Full
P8	76	M	16.4	56.8	16.4	164.8	81.2	Yes	Full
P10	79	F	24.5	61.4	29.6	152.7	85.2	No	No

[a]Maxillary projection/retrusion relative to skull base, where A = A point (maximum concavity of maxilla, viewed sagitally), N = Nasion, S = Sella turcica mid-point (pituitary fossa), [b]Clinical rhinomaxillory syndrome criteria as defined by the authors (see Methods), [c]Radiological rhinomaxillory syndrome adapted from criteria defined by Anderson & Manchester (see Methods). Figures from left to right illustrating: maxillary height (vertical) and width (horizontal); nasofrontal angle; ANS angle (reduced ANS angle = maxillary retrognathia); maxillary volume (blue) measured at le fort 1 level (horizontal through piriform aperture)

also observed in our participants, compared with the typical horizontal and vertical age-related atrophy of the maxillary alveolar processes.[14] Furthermore, reported evidence of substantial age-related maxillary bone loss is limited, although some may be secondary to poor nutrition, loss of teeth (all participants had a partially or completely edentulous maxilla) and changes in mechanical function.[15] In our cases of full and partial rhinomaxillary syndrome, maxillofacial bone changes were consistent with those considered to be pathognomonic of Hansen's disease.[8]

We had incomplete clinical histories for some participants because records were lost over time. Resorption and atrophy of nasal bones can be a consequence of trauma which may not have been recorded in medical histories. Similarly, we did not have complete records to support our assessment of differential diagnoses such as syphilis and mucocutaneous leishmaniasis,[11] and less common rhinological diseases such as granulomatosis with polyangiitis and nasal extranodal lymphoma.[16] Although two researchers assessed and graded facial changes independently, this remains a subjective process, and our clinical rhinomaxillary syndrome criteria require validation.

Conclusion

Availability of computed tomography scanning even in endemic countries means that assessment of rhinomaxillofacial bone changes, where suspected, could become a component of specialist care, primarily to prevent secondary complications. We propose that clinical protocols for Hansen's disease are extended to include otorhinolaryngological evaluation, supported by imaging where necessary. In the meantime, practical steps need to be taken at the health system level to ensure timely diagnosis and prompt treatment initiation to prevent Hansen's disease-related disability.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Henry M, GalAn N, Teasdale K, Prado R, Amar H, Rays MS, *et al*. Factors contributing to the delay in diagnosis and continued transmission of leprosy in Brazil-an explorative, quantitative, questionnaire based study. PLoS Negl Trop Dis 2016;10:e0004542.
2. Souza EA, Ferreira AF, Boigny RN, Alencar CH, Heukelbach J, Martins-Melo FR, *et al*. Leprosy and gender in Brazil: Trends in an endemic area of the Northeast region, 2001-2014. Rev Saude Publica 2018;52:20.
3. de Assis IS, Berra TZ, Alves LS, Ramos AC, Arroyo LH, Dos Santos DT, *et al*. Leprosy in urban space, areas of risk for disability and worsening of this health condition in Foz Do Iguacu, the border region between Brazil, Paraguay and Argentina. BMC Public Health 2020;20:119.
4. Deps PD, Guedes BV, Filho JB, Andreatta MK, Marcari RS, Rodrigues LC. Delay in the diagnosis of leprosy in the Metropolitan Region of Vitoria, Brazil. Lepr Rev 2006;77:41-7.
5. Rathod SP, Jagati A, Chowdhary P. Disabilities in leprosy: An open, retrospective analyses of institutional records. An Bras Dermatol 2020;95:52-6.
6. Souza CDF, Fernandes T, Matos TS, Tavares CM. Leprosy in the elderly population of an endemic state in the Brazilian Northeast (2001-2017): Epidemiological scenario. An Bras Dermatol 2020;95:91-4.
7. Mohammad W, Malhotra SK, Garg PK. Clinico-radiological correlation of bone changes in leprosy patients presenting with disabilities/deformities. Indian J Lepr 2016;88:83-95.
8. Andersen JG, Manchester K, Roberts C. Septic bone changes in leprosy: A clinical, radiological and palaeopathological review. Int J Osteoarchaeol 1994;4:21-30.
9. Brachman PS, Abrutyn E. Bacterial Infections of Humans: Epidemiology and Control. New York: Springer; 2009.
10. Møller-Christensen V. Case of leprosy from the Middle Ages of Denmark. Acta Med Scand Suppl 1952;266:101-8.
11. Andersen JG, Manchester K. The rhinomaxillary syndrome in leprosy. Int J Osteoarchaeol 1992;2:121-9.
12. Deps PD, Collin SM, Robin S, Charlier P. Leprosy in skulls from the Paris Catacombs. Ann Hum Biol 2020;47:42-7.
13. Deps P, do Espírito Santo RB, Charlier P, Collin SM. Rhinomaxillary syndrome in Hansen's disease: A clinical perspective. Int J Dermatol 2020;59:e404-6.
14. Kasai N, Kondo O, Suzuki K, Aoki Y, Ishii N, Goto M. Quantitative evaluation of maxillary bone deformation by computed tomography in patients with leprosy. PLoS Negl Trop Dis 2018;12:e0006341.
15. Boskey AL, Coleman R. Aging and bone. J Dent Res 2010;89:1333-48.
16. Laudien M. Orphan disease of the nose and paranasal sinuses. Laryngorhinootologie 2015;94 Suppl 1:S272-87.