STEREOPHOTOGRAMMETRY: A POSSIBLE EMPLOYMENT IN THE DENTAL FIELD

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ABSTRACT

The rapid palatal expansion appliance is an orthopedic device for the adjustment of the transversal hypoplasias of the upper jaw.

The aim of this work is to assess, by stereophotogrammetry, the volumetric variations relative to the palate after the active phase of rapide expansion, after constriction and six months after the removal of the appliance.

RESUME

Le disjoncteur rapide du palais est un appareil orthopédique pour la correction des ipoplasies transversales de la mâchoire supérieure.

Le but de ce travail est d'évaluer, par stéréophotogrammètrie, les variations volumétriques relatives au palais, après la phase active d'expansion rapide, après la contention et à partir de six mois du déplacement de cet appareil.

KEY WORDS

Biosterometric, Photogrammetry, Visualization.

1. INTRODUCTION

The rapid palatal expansion appliance is an orthopedic device for the adjustment of the transversal hypoplasias of the upper jaw.

Made known by the American Angell since 1860, this appliance can be used in deciduous, mixt and permanent dentition, carrying out a maxillary expansion mostly orthopedical.

As a matter of fact we try to carry out the expansion of the median suture of the palate and of the pterigo-maxillary, associated with the concomitant reaction of other craniofacial sutures.

On an orizontal plane, the expansion of the median suture takes place mainly in the front area with respect to the back one, realizing a triangular opening with a hinder top.

Also on the front plane the separation of the jaws takes place in a triangular way, that is to say with the rotational centre at the forehead-nasal suture level.

As a consequence of this opening on the front and transversal plane, the jaw undergoes a displacement downwards and forward.

It follows that, besides the expansion of the dental arch, an expansion of the front superior aereal ways is obtained for the widening of the lower part of the nose and the lower straining of the cartilage of the nasal septum.

For these reasons the employment of the palatal expantion appliance is particularly suitable for the patients who are mouth breathers.

As it has already been said it can be used in all dentitions, but it's necessary to point out that the orthopedical effect doesn't take place or can't take place if the median suture of the palate is welded, and this generally happens between 16 and 18 years of age.

The occured expansion of the suture is proved by the appearance of a diastema between the incisors, that eventually closes up spontaneously for the action of the transeptual fibres during the constriction period.

The appliance, in its classical variant, is made up by a screw defined "spidery" for being provided with four steel arms that are joined by means of soldering with stripes put on the first molars and the first premolars in a permanent set of teeth.
In a mixt or deciduous set of teeth it is possible to use the stripe system or solder the arms of the screw to a metal structure immersed in the resin.

The screw is rapidly set going with various turns a day (2-4) to minimize the orthodontical effect: each turn of the screw corresponds to an expansion of the screw itself of about 0.2 mm.

It is estimated that with the initial working, a power varying between 1.5 and 4.5 Kg that disperses rapidly can be produced.

After the active phase a period of constriction of about three months has to follow to allow the resetting of the median suture and the formation of the bone (fig.1).

Fig. 1

Rapid palatal expansion appliance

The aim of this work is to assess the volumetric variations relative to the palate after the active phase of rapid expansion and after constriction, six months after the removal of the appliance.

So it's a matter of carrying out a comparative study of the variations of the set of teeth in three different moments, employing plaster casts (or other material) taken after each phase of the treatment using a tecnique that allows the maximum limitation of the inaccuracies in the survey of the measurements.

Up to now the transversal diameter was measured by means of calipers while plaster casts were put in occlusion to estimate the expansion of both dental arches. From here aroused the search for a method of tridimensional surveying that could allow a more accurate and reliable metrical analysis.

As a matter of fact, the analytical photogrammetry, starting from two castings, allows the creation of a "model" of the object that has the characteristic of being the same as the object and from which all the measurements of the distance and of the level differences between all visible points can be carried out.

The points are obtained from the onward intersection, carried out from two points called "projection centres" of a pair of homologous radii relative to the same detail seen on two different photograms.

The production of the model and its insertion in a complete reference system, whose information are obtained through topographical operations, can be realized through two operations of relative and absolute orientation from which it is possible to calculate the tridimensional values (x, y, z) of each point of the model.

One of the first problems brought about by this kind of study is represented precisely by the possibility of making the three different takings of the casts comparable through the creation of just one reference system and through the possibility of finding a method that starting from various points taken from objects with uneven shapes and no directly recognizable element allows a highly precise evaluation and the comparison of the deformations.

It is necessary to underline anyway that the choise of photogrammetry doesn't depend exclusively on the advantages connected with the higher precision of the measurements, but also on the amount of information it provides, that enable the specialists to produce estimates which are undoubtedly more accurate (Vozikis, 1985).

2. DATA ACQUISITION

The study, then, was about six plaster casts respectively: three for the upper arch and three for the lower one, corresponing to the three different phases of the treatment. In particular they correspond to: 1) Pair C (upper arch cast n° 6 and lower arch cast n° 5) before the expansion orthopedical treatment; 2) Pair B (upper arch cast n° 4 and lower arch cast n° 3) after the three month expansion and contention; 3) Pair A (upper arch cast n° 1 and lower arch cast n° 2) after six months from the removal of the appliance.

For the stereoscopical photographs the casts have been fixed to a bar placed inside a "cage" metrically predetermined using 40 points that allowed to carry out all the orientation operations of the casts making them homogeneous between them.

The photographs have been taken with a metric camera terrestrial model WILD P31 with a focal lengh of 99.24 mm at a distance of 1.00 m from the object for the photographs 1-2 relative to the left side of the casts and for the 5-6 photographs relative to the right side, and of 1.70 m for the photographs 3-4 relative to the front view for an overall of 6 photographs (3 models) (fig.2).

3. DATA PROCESSING

Eventually a restitution of each cast was got under way separately so to get to the representation in scale 1:1 of the cast's morfology seen frontally and from both sides of a series of orizontal and vertical profiles each 2 mm (figg.3-4-5-6). The appliance used for the restitution is an analytical system of the WILD BC1 whose data have been subsequently turned in the .DXF size of AutoCad to allow further processing of tridimensional representation and modelling.

From the restitution protocols it is already possible to define within which endurance margins our analysis was carried out with respect to the prepared survey conditions.

From the table relative to the absolute orientations of the three models with respect to the points of the cage, appeared precisions in the three co-ordinates on an average of about 8 tenths of a millimetre (tab.1).

The estimated taking conditions permitted to carry out directly on the stereoscopical models controls on the tridimensional changes of the palate with respect to the three phases of the therapy, choosing some elements of the set of teeth clearly identifiable and comparable between them in the different casts (tab.2).

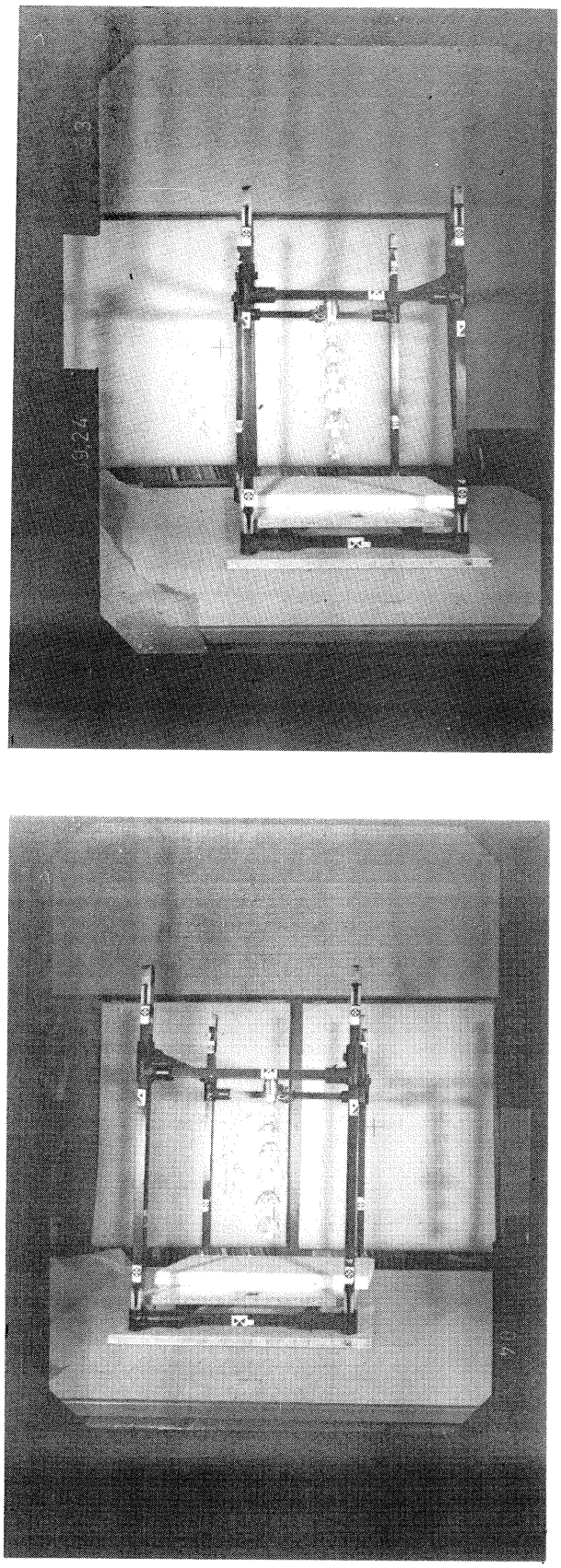


Fig. 2

Pair of the photographs of the front view

ORIENTATION DATE - RESIDUALS ON PHOTO COORDINATES

model name: den1
photo 1-2

Pt.NO	DXG(mm)	DYG(mm)	DZG(mm)
101	0.009	- 0.236	- 0.068
103	0.032	- 0.075	0.030
104	- 0.060	- 0.304	0.071
102	- 0.026	0.011	0.012
105	- 0.040	- 0.047	- 0.142
109	0.228	0.246	0.218
108	- 0.081	0.275	- 0.211
110	- 0.060	0.131	0.090

model name: den2
photo 3-4

Pt.NO	DXG(mm)	DYG(mm)	DZG(mm)
119	0.011	0.082	0.132
120	- 0.066	- 0.106	0.119
115	- 0.013	- 0.061	- 0.050
113	- 0.072	- 0.045	- 0.030
111	0.057	- 0.052	0.152
112	0.034	- 0.025	0.029
117	- 0.023	- 0.055	- 0.127
118	- 0.002	0.095	- 0.120
116	0.075	0.167	- 0.105

model name: den3
photo 5-6

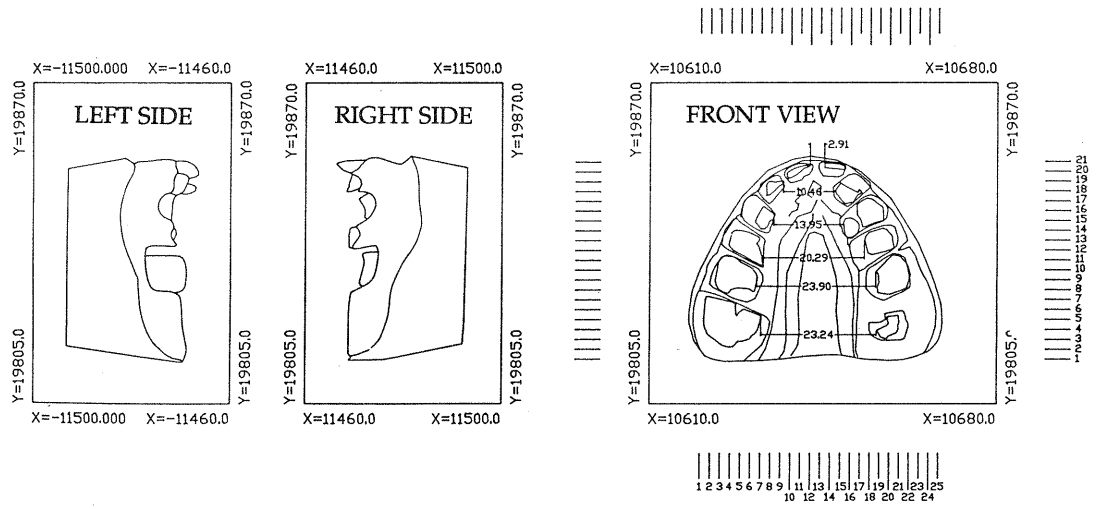
Pt.NO	DXG(mm)	DYG(mm)	DZG(mm)
138	- 0.041	- 0.046	0.103
134	0.119	0.124	- 0.107
133	0.019	- 0.076	0.096
131	- 0.031	0.086	0.017
132	- 0.024	- 0.125	0.103
139	0.001	0.016	0.050
136	- 0.063	- 0.022	- 0.169
137	0.020	0.043	- 0.093

Table 1 - Orientation data

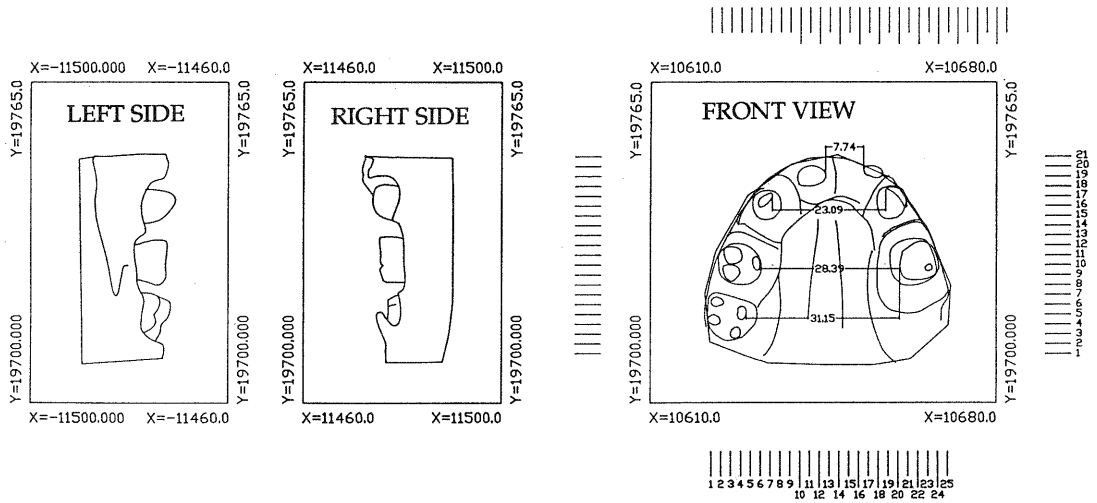
The data analysis shows a constant expansion, even after the removal of the appliance at the level of the molar while the distance between the incisors undergoes a reduction probably due to the dental displacement of the transeptual fibres .

This is an initial result that only partially uses the potential of the photogrammetric tecnique. As previously mentioned, this tecnique is able to provide an amount of data that will surely allow more thorogh analyses.

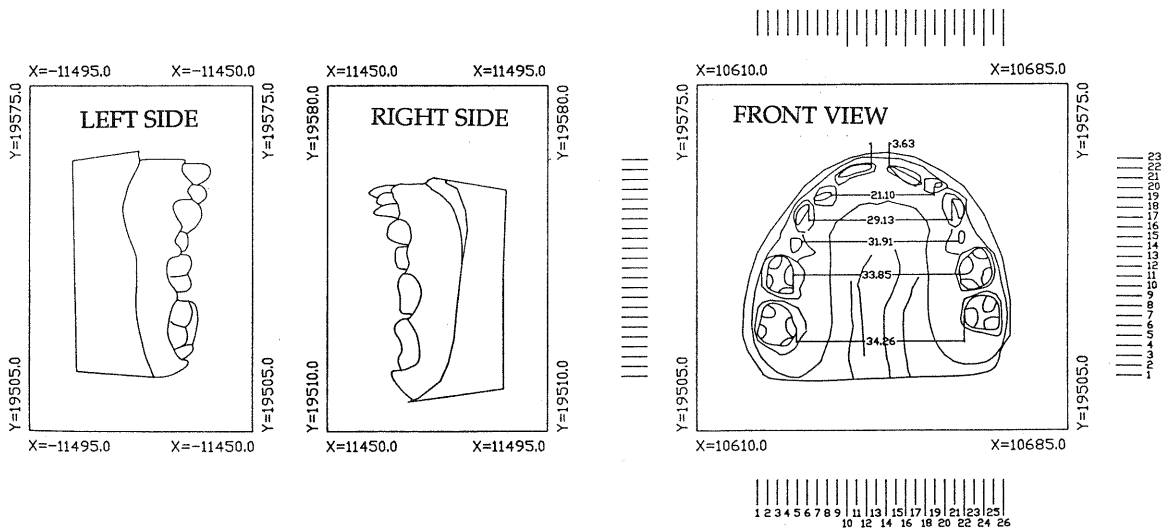
The photogrammetry applied to dentistry allows a more effective study. In fact, the metric study in this particular field could provide a biological explanation of the orthopedical phenomenon determined by the expansion appliance (Curry, 1982).



C: arch cast n. 6 before the expansion orthopedical treatment



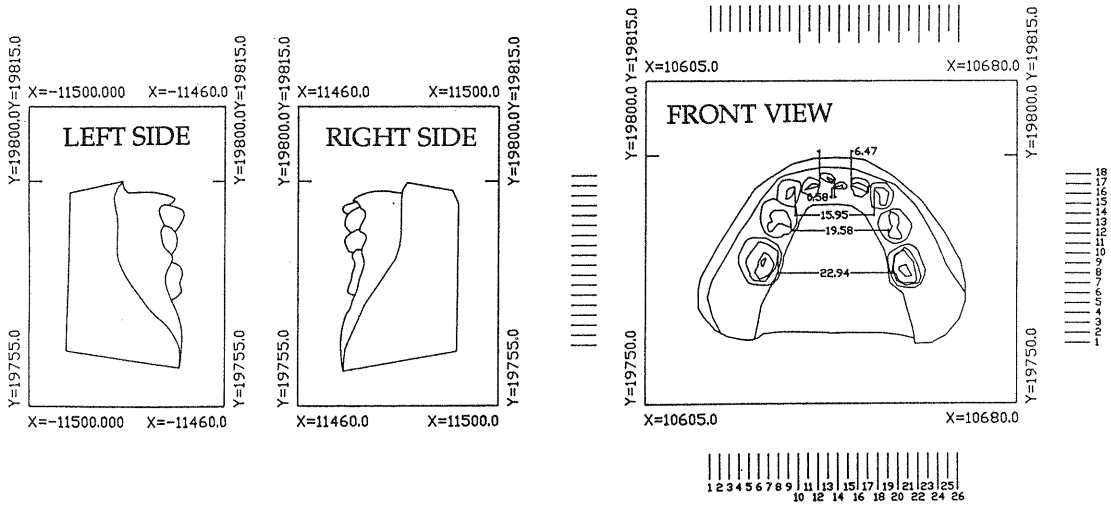
B: arch cast n. 4 after the three month expansion and contention



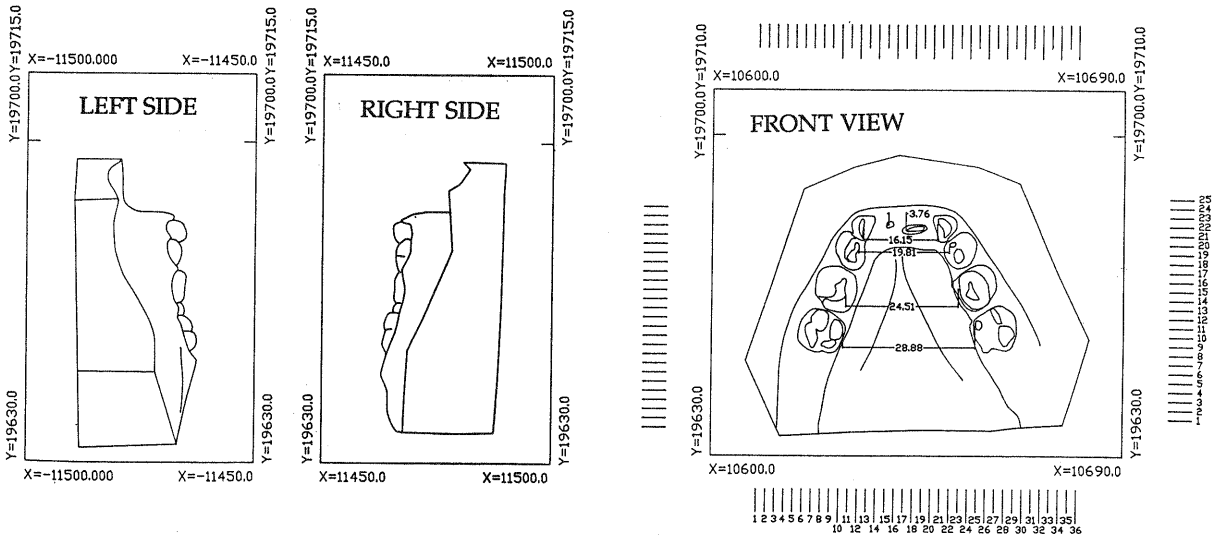
A: arch cast n. 1 after six months from the removal of the appliance

Fig. 3

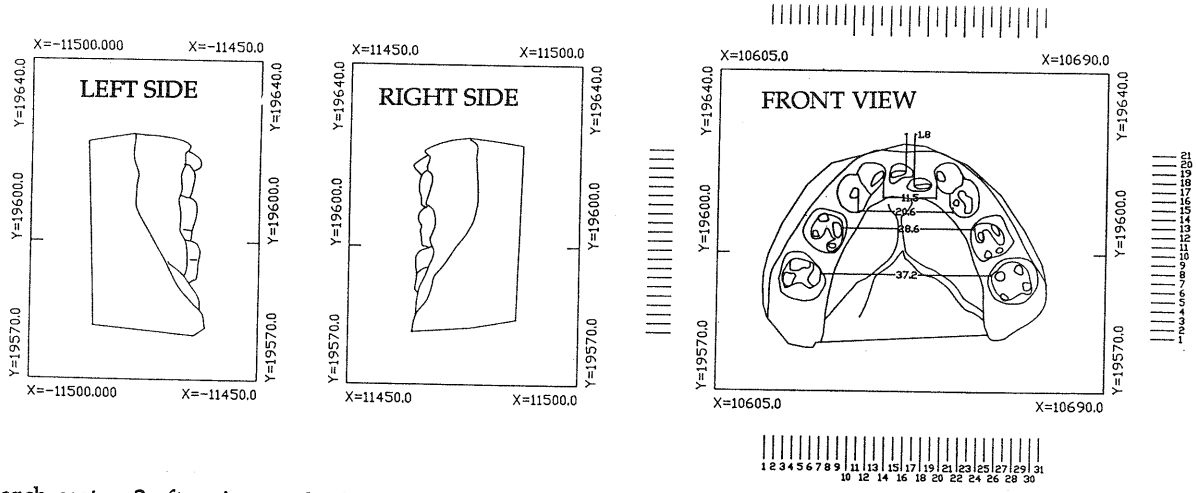
Analytical restitution of the upper casts.



C: arch cast n. 5 before the expansion orthopedical treatment



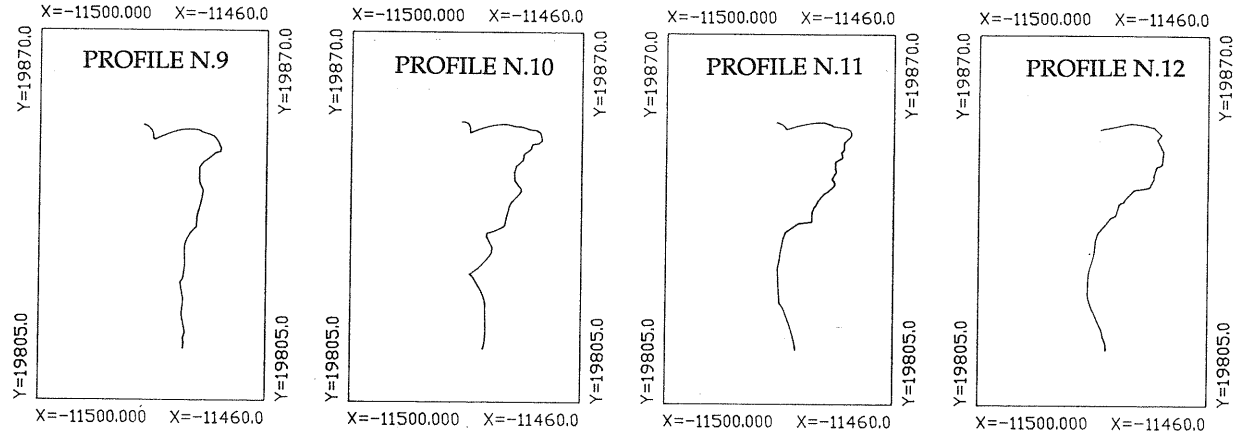
B: arch cast n. 3 after the three month expansion and contention



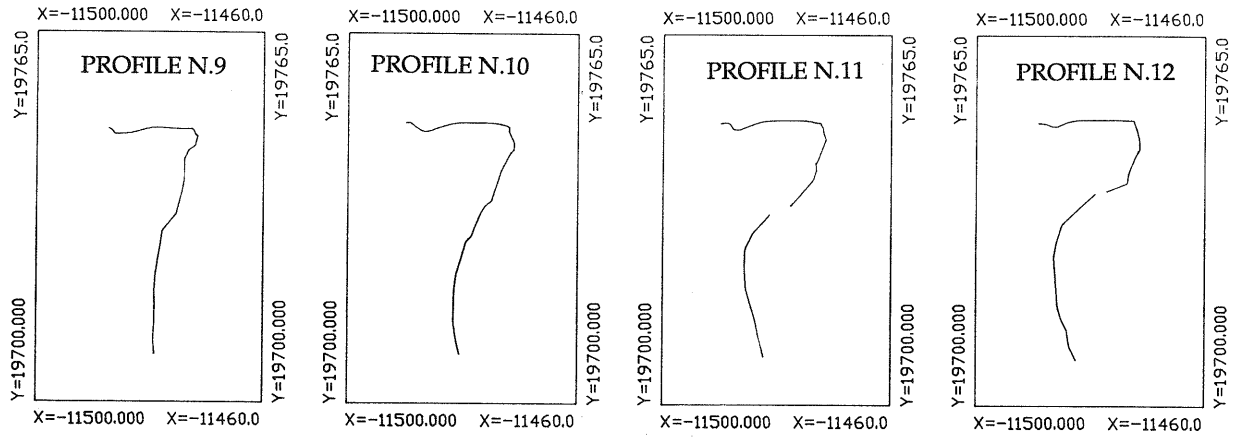
A: arch cast n. 2 after six months from the removal of the appliance

Fig. 4

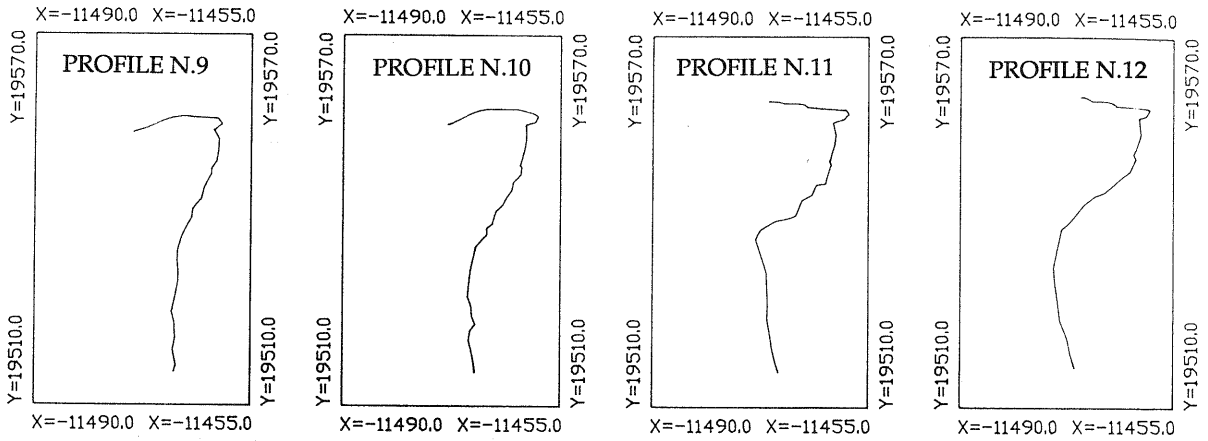
Analytical restitution of the lower casts.



C: arch cast n. 6 before the expansion orthopedical treatment



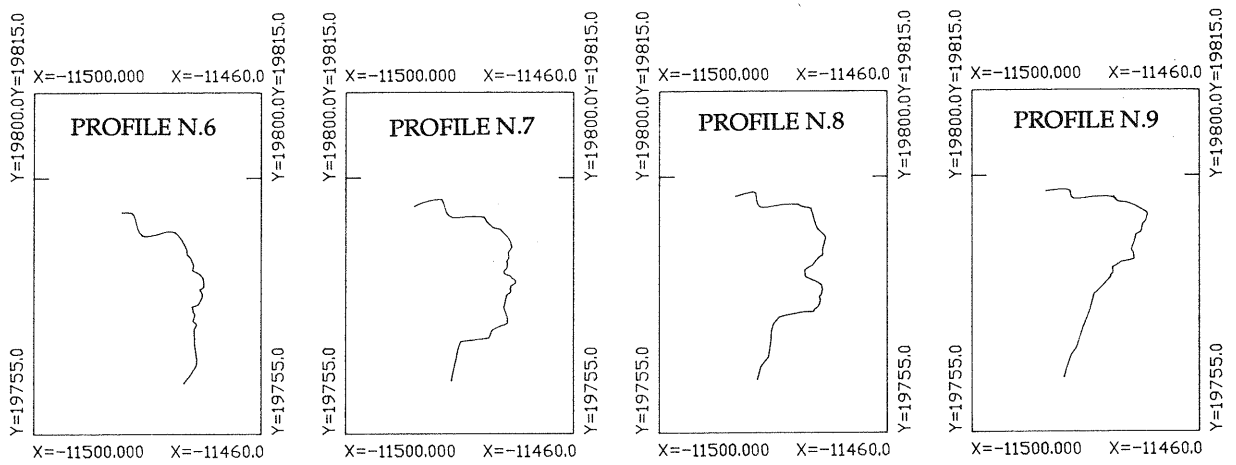
B: arch cast n. 4 after the three month expansion and contention



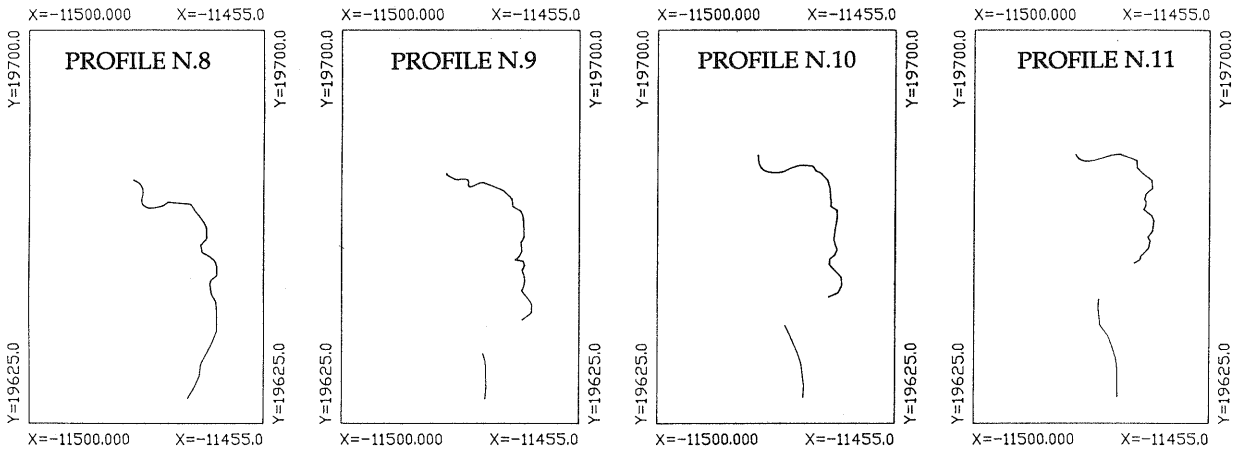
A: arch cast n. 1 after six months from the removal of the appliance

Fig. 5

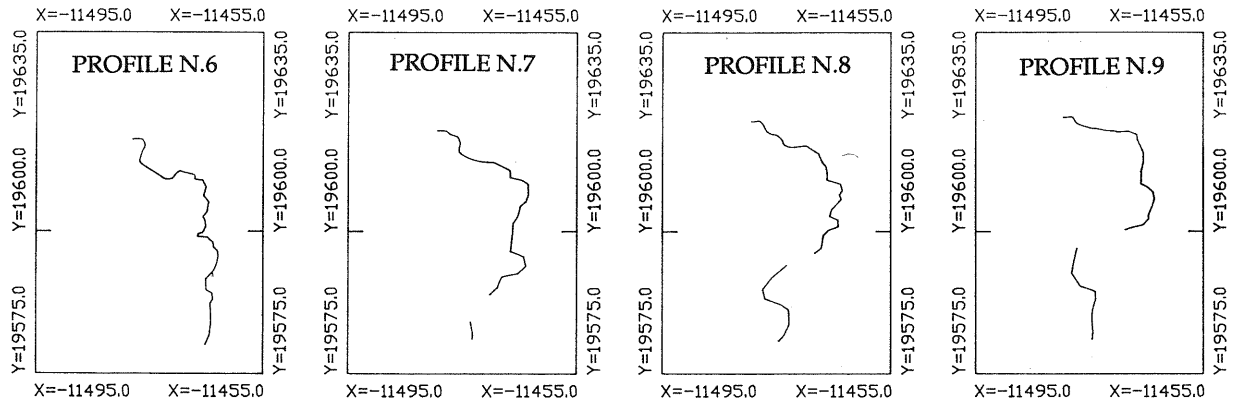
Details of the some vertical profiles of the upper casts.



C: arch cast n. 5 before the expansion orthopedical treatment



B: arch cast n. 3 after the three month expansion and contention



A: arch cast n. 2 after six months from the removal of the appliance

Fig. 6

Details of the some vertical profiles of the lower casts.

VOLUMETRIC VARIATIONS OF THE PALATE DIRECT COMPARISON FROM THE STEREOSCOPIC MODELS

UPPER ARCH

CAST N.6 (mm)	CAST N.4 (mm)	CAST N.1 (mm)	d C6-C4 (mm)	d C4-C1 (mm)	d C6-C1 (mm)
2.91	7.74	3.63	-4.83	4.11	-0.72
10.46		21.10			-10.64
13.95	23.09	29.13	-9.14	-6.04	-15.18
16.85		30.70			-13.85
20.29		31.91			-11.62
23.24	31.15	34.26	-7.91	-3.11	-11.02
23.90	28.39	33.85	-4.49	-5.46	-9.95
24.82	29.15	34.05	-4.33	-4.90	-9.23
25.05	32.22	36.01	-7.17	-3.79	-10.96

LOWER ARCH

CAST N.5 (mm)	CAST N.3 (mm)	CAST N.2 (mm)	d C5-C3 (mm)	d C3-C2 (mm)	d C5-C2 (mm)
0.58	3.76	1.80	-3.18	1.96	-1.22
6.47	16.15	11.50	-9.68	4.65	-5.03
12.35	17.62	14.92	-5.27	2.70	-2.57
15.95	19.81	20.60	-3.86	-0.79	-4.65
19.58	24.51	28.60	-4.93	-4.09	-9.02
20.01	24.92	29.01	-4.91	-4.09	-9.00
22.94	28.88	37.20	-5.94	-8.32	-14.26
28.92	34.82	40.92	-5.90	-6.10	-12.00

Table 2 - Comparison of the measurements on the casts: front view

In the second part of our work we have tackled the aspects of the visual perception of the analysed problems, always starting from the data acquired photometrically and subsequently worked through other softwares (Thalmann, 1990).

The scientific visualization is a new approach in the area of numerical simulation and it was precisely in this field that, starting from the photogrammetrical data, attempts have been made to use graphic modelling as a support for a better comprehension of the phenomena of volumetric variations of the palate.

The software employed is a Wavefront Technologies Visualizer Series wich includes: a) Advanced Visualizer, which allows graphics professionals to develop maximum-impact 3D computer graphics images with photographic realism and dynamic moving imagery; b) Personal Visualizer an expandable set of 3D visualization tools with an intuitive, point-and-click interface; c) Data Visualizer can turn works with large volumes of non-geometric data, which provides powerful yet easily mastered tools for visualizing and analyzing 3D numeric data.

The Visualizer Series also includes: geometry translators for importing data from external sources; the Visualizer Server for offloading image rendering to other network computing resources; Personal 3D Edit, the Personal Libraries and other products that broaden the scope of the personal visualizer.

The construction of the modular sketch, starting from the existing data in the .DXF size of AutoCad passing through the integration of 4 modules corresponding to the processes for the creatiion and animation of 3D images: a) model - creates 3D objects and applies surface textures and colors; b) preview - animates objects, cameras, and lights; c) medit - edits surface properties like texture, color, reflection, and atmosphere; d) image - renders photorealistic images.

In this first stage of our works of scientific visualization we have tried to stress the volumes of the various casts for a batter interpretation of the deformations. Now we have to ascertain if it is possible to realize a quantitative interpretation of the phenomenon, starting from these elaborations and keeping intact the source of the tridimensional data in terms of accuracy.

4. ACKNOWLEDGEMENTS

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