Elsevier Editorial System(tm) for American Journal of Orthodontics & Dentofacial Orthopedics
Manuscript Draft

Manuscript Number:

Title: A new concept of anatomical lingual arch form

Article Type: Original Article

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A new concept of anatomical lingual arch Form

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Abstract

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Material and Methods: *the study sample comprised 58 pairs of dental casts corresponding to the arches of 58 (37 females and 21 male) adults Southern European subjects with ideal natural occlusion. After the reference points of the dental arches were identified and marked, the dental casts were scanned. The exact position of the models on the scanner was established by means of a specially-created acetate sheet with a Cartesian reference system. These mesaurements were processed using a software to select the polynomial function which best described the shape of the dental arches. Thus three groups SMALL, MEDIUM and LARGE were created by means of a distribution analysis of the x and y values of each tooth in each arch to verify the most appropriate measure of central tendency for our data.*

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INTRODUCTION

The form of the dental arch is considered to be a fundamental element in orthodontic diagnosis and treatment planning due to its ability to influence not only available space and dental and smile aesthetics, but also long-term occlusal stability.[1-7] Furthermore, respecting this important parameter reduces the possibility of crowding relapse and periodontal damage. [5, 8-14] Moreover, definition of the shape of the arch aids the clinician in achieving results in agreement with the natural laws of biological variability.[1, 5] Indeed, Andrews,[15] father of the vestibular straight-wire technique, cited the arch form as the “seventh” of his keys to achieving class I occlusion. Hence, in recent decades, numerous studies have analysed the arch form from anatomical and anthropological perspectives,[16-23] in order to evaluate its implications in orthodontic therapy[24-28] or its modifications induced by orthodontic treatment.[10, 25, 29-33]

Despite the fact that the necessity of individualising each patient’s arch form during treatment is widely recognised,[1, 5] following the evolution of vestibular straight-wire appliances and due to the superelastic properties of the latest generation of arch wires, it would seem to be clinically reasonable to stereotype the constructed arch shapes from subjects with normal occlusion into few sets of pre-formed arches; the most similar to that of the patient before treatment could therefore be selected on the basis of geometrical similarity, ethnicity and type of malocclusion.[1, 3- 5] Nevertheless, no objective demonstration has thus far been provided to elucidate the choice of a particular arch form,[3] although various studies[1-6, 32-33] have sought, using the incisal and occlusal margins of the teeth as anatomical reference points, to represent it graphically from the vestibular side. Numerous authors have used geometric curves to describe the dental arch. Tweed [34] utilized that of Bonwill-Hawley, whose inter-canine arch is represented by a circular arc, while other authorsv[35-37] prefer a catenary curve. Alternative mathematical functions employed are the parabola [38-42], elipse [14, 16, 41-43], hyperbola [41], cubic spline [44], beta function [2], and catenary and polynomial curves [2, 18, 25, 32], each of which gives us an idea of the shape of the dental arch. Other methods used to analyse this are the chi-squared fit [45, 46], particular mathematical algorithms [3] , the Thin-plate Spline Analysis [47] , the Euclidean Distance Matrix Analysis-EDMA [17, 48], the Finite-element Scaling Analysis (FESA), and the MEM method (macroelement method) [49, 50] . According to McAlarney *et al.*[49] the choice of analytical method should be correlated to the type of clinical and statistical information to be gleaned from the research.

Moreover, various authors have observed that polynomial functions are able to simply and symmetrically describe the shape of the dental arch, and have exploited these mathematical equations as an accurate method for its description. [2, 18, 40, 51-56]

A large number of articles dealing with the shape of the dental arch from the vestibular perspective exist in the literature, although nothing has yet been published regarding the lingual side. Many systems for representing the normal arch form have been proposed, including qualitative descriptions, geometric constructions and mathematical curves, but while there is a consensus on the importance of this factor in orthodontics, a definitive geometric shape is elusive, as demonstrated recently by Trivino *et al.* (2008). [2]

However, the introduction of the straight-wire to the lingual technique[57, 58] and the possibility of replacing Fujita's "*mushroom form*"[59] with an arch form without insets has led to the question of which arch form to choose and which criteria to use in lingual straight-wire set-up and treatment planning. Because a 'straight' arch form has not previously been described from a lingual perspective and because this has a fundamental importance in orthodontic treatment planning, in this study, we attempted to describe with an objective, standardised and reproducible methodology, a natural and anatomical arch form obtained from subjects with normal occlusion. This, we hope, could be used, together with other criteria, in the construction of personalised set-ups for the lingual straight-wire technique.

MATERIALS AND METHODS

The sample was carefully selected from among the records in the archives of the University of Ferrara Postgraduate School of Orthodontics and the Department of Orthodontics at the Complutense University of Madrid. It consists of South European Caucasian adults exhibiting the following characteristics: [2, 47]

1. Age of not less than 18 years (range 19.08-70.25 years);
2. No previous orthodontic treatment;
3. Regular arch form with slight to no crowding;
4. Complete dentition up to at least the second molars;
5. Absence of extensive restoration and implants;
6. Presence of at least 4 of the six Andrews' keys for optimal occlusion and bilateral class I molar and canine relationship;
7. Normal (within 2 mm ± 1 mm) overbite and overjet;
8. Absence of deviations of the interincisal lines;
9. Absence of gingival recessions;
10. Absence of muscular and/or joint pathologies;
11. Absence of ectopic teeth, teeth aplasia or anomalies in tooth shape;
12. Absence of supernumerary and congenitally missing teeth;
13. Absence of anterior and posterior cross-bite;
14. Absence of visible intra- and extraoral asymmetry;
15. Minimal diastemas, premolar rotations and incisor irregularities (present in several subjects).

Each subject participating in the study gave informed written consent.

Mandibular and maxillary dental casts of each subject, according to Tweed prescriptions, were obtained, giving a total of 75 pairs. The regularity of these models was first determined clinically, then quantified using Little's Irregularity Index [63]; 9 pairs of models were found to be have a Little index greater than 3 and were therefore excluded, as were a further 8 pairs which, although displaying a Little index of less than 3, were observed to possess spaces of greater than 1 mm or a slightly asymmetrical contraction of the arch in the premolar section. Thus, the definitive sample comprised 58 pairs of dental casts corresponding to the arches of 58 (37 females and 21 male) Caucasian subjects of Southern European ancestry (mainly of Italian or Spanish origin). The mean age of the sample was 29.21 years (SD 8.73), the youngest being 19.08 and the oldest being 70.25 years of age. (*Table 1*)

Reference points for calculation of the shape of the arch were identified and marked on the lingual surface of each tooth (from the left second molar to the right second molar) of each dental cast by a single operator using an indelible marker (Pilot Drawing Pen .08mm, Japan). In the mandibular arch, these points, which trace the Lingual Straight Plane (LS), were situated at the centre of the clinical crown (vertical position) along the central lingual axis (LA), and at the most prominent point on the lingual surface of each tooth (horizontal position) on the molars and premolars and in correspondence to the middle third of the anterior teeth. In the maxillary arch, the reference points were marked at the most prominent point on the lingual surface of each tooth (horizontal position) at the intersection between the middle third and the gingival third of the anterior teeth, along their central axis, and at the centre of the clinical crown of the posterior teeth. Prior to permanently marking these points on the lingual surface, the median axis of the clinical crown of each tooth was traced in pencil to determine their horizontal position, and a gauge was employed to measure the height of the clinical crown to determine their vertical position. It should be noted at this point that, while the same operator carried out this procedure for each tooth, it constitutes an important source of error, as the accuracy of identification of the reference points necessarily influences the tracing of the curves upon which the calculations of the arch shape are based. [33]

After the reference points had been marked, the dental casts were scanned using an EPSON Expression 1680 Pro scanner, and images in TIFF at a resolution of 300 dpi* were obtained. In order to avoid distortion of the image, and hence the reference points, during the scanning procedure, the models were positioned in such a way that both the base and the occlusal plane were parallel to the surface of the scanner. [60] The exact position of the models on the scanner was established by means of a specially-created acetate sheet onto which a sheet of millimetre paper had been photocopied. After making the photocopies, the prepared acetate and millimiter papers were superimposed to verify the lack of distortion in the acetate copy. On this acetate sheet, reference axes, i.e. a horizontal line and a perpendicular vertical line, were drawn using an indelible marker (Pilot Drawing Pen .05mm Japan). The sheet was subsequently placed on the glass surface of the scanner under the plaster models in such a way as to align the posterior margin of the second molars with the abscissa and the median line with the ordinate, thus creating a Cartesian reference system. [2] *(Fig. 1a, 1b)*

For each image, 14 points (x, y), corresponding to the distance between each reference point and the abscissa and ordinate were measured and recorded in order to provide their Cartesian coordinates.

Four weeks later, in order to calculate the method error, 15 of the models were selected at random and the coordinates of each reference point on both arches were re-plotted by the same operator as above. Analysis of the reliability of measurements was performed using Dahlberg's coefficient (1940) [61]:

$$S_e = \sqrt{\frac{\sum d^2}{2n}}$$

S *= Dahlberg coefficient*
d *= difference between 1st and 2nd measurements*
n *= number of repeated measures*

The values corresponding to the coordinates of teeth 1, 2 and 5 were compared singly with their control measurements. Evaluation of the statistical significance was carried out using Student's t-test for paired data. The systematic error of measurement of each value considered was revealed to be not-significant at a p-value of 0.05, thereby confirming the reliability of results. *(Table 2)*

First, the dimensions of the upper and lower dental arches were evaluated via 3 transversal and 3 sagittal measurements, considering the transverse diameters and arch depth at the canines, first molars and second molars, as described by Raberin[6]. The lingual reference points considered were therefore:

- The inter-incisor point;
- The most prominent point on the central axis of the lingual surface of the canine crown;
- The most prominent point on the lingual surface of the first molar at the centre of its clinical crown;
- The most prominent point on the lingual surface of the second molar at the centre of its clinical crown;

Thus, 6 measurements of distance were taken for each arch in order to analyse their width and depth. In order to measure the arch width, the following were considered:

- Inter-canine diameter (D3);
- Inter-molar diameter at the sixths (D6);
- Inter-molar diameter at the sevenths (D7).

In order to measure the arch length, the following were considered:

- Canine depth: distance between the inter-incisor point and the line connecting the canine reference points (L3);

- Molar depth at the first molars: distance between the inter-incisor point and the line connecting the reference points on the first molars(P6);
- Molar depth at the second molars: distance between the inter-incisor point and the line connecting the reference points on the second molars (P7).

Subsequently, the shape of the dental arch was evaluated from the lingual side. The measurements, i.e. the x and y coordinates, of each reference point, were all obtained and processed using Curve Expert software by the same operator. This software (version 1.3; http://curveexpert.webhop.biz) was employed to select the polynomial function which best described the shape of the dental arches.

After the dental arches were viewed and the presence of slight asymmetry was established, despite patients with normal occlusion having been used as models, the reference point coordinates of the 58 dental casts were divided into left and right sides. Each arch half was then 'mirrored' in order to obtain 116 whole upper and 116 whole lower arches with symmetrical curves. [2]

Based on the number of reference points utilised, and after viewing the graphs obtained of the various mathematical functions, the ninth-degree polynomial function was selected for representation of the lingual surfaces of both the upper and lower arches.

This polynomial function yielded the curve most representative of the shape of the lingual dental arch. It was first selected according to visual inspection criteria, [2, 6] then, in order to confirm this choice objectively, we set out to discover which marker could be considered to establish the suitability of the model. With the Residual Analysis we ascertained whether or not the observed values fell outside the trend of the expected curve.

The residual plot graphically depicts the difference between the data points and the model evaluated at the data points. The residual at point i is defined by

$$\text{residual} = yi - f(x_i)$$

where y_i is the measured value at x_i, and $f(x_i)$ is the predicted value at x_i. These distances are shown as bars or points on the residual plot; the magnitudes of the data points are simply replaced by the residual defined above. If the residual is positive, then the data point is above the model's prediction; likewise, if the residual is negative, then the data point is below the model's prediction. The residuals can provide an indication of a particular model's performance. If there are runs of like-signed residuals, then a better model for the data is likely to exist.

Optimally, the residuals should exhibit a random scatter around zero, which indicates that the data points are randomly distributed around the curve. A “run” is a sequence of like-signed residuals, which stand out on the residual plot. A large number of runs indicates that data systematically deviates from the curve.

The critical reference measurement for a residual value is usually 1.96. If this value is exceeded at one or more points, the fit is not acceptable and adaptations must be made. As regards the measurement error, we compared the standard error values of various models to ascertain which model better interpolated the data, namely that characterised by the lowest standard error was considered the best: in our case the ninth-degree polynomial.

The standard error was calculated via minimisation of the so-called Merit Function (http://mathworld.wolfram.com/MeritFunction.html).

Statistical Analysis

The sample was initially subjected to a descriptive statistical analysis including mean, standard deviation, variance, minimum, and maximum values.

The analysis of sexual dimorphism was carried out by means of a comparative analysis of the lingual distances: D3-3, D6-6, D7-7, L3, L6 and L7, in order to verify whether statistically significant differences between the measures of central trend in males and females were revealed. Due to the abnormal distribution of data, the non-parametric U-test Mann-Whitney was applied to compare the two independent groups.[62]

In order to provide a visible representation of a hypothetical ideal arch form curve, first the means and standard deviations of the 14 coordinates of the abscissa and ordinate were calculated respectively for all curves relative to the lingual side of the upper and lower arches. Three groups SMALL, MEDIUM and LARGE were created by means of a distribution analysis of the x and y values of each tooth in each arch to verify the most appropriate measure of central tendency for our data. We verified that all x and y values were characterised by strongly non-normal, asymmetrical and unimodal distribution. This led us to choose the median value as the reference measure of central tendency, and then the values of the 25th (first quartile) and 75th (third quartile) percentiles as measures of variability. Assuming that the median was an adequate representation of the measure of central tendency for the MEDIUM group, we attempted to identify the measures of central tendency for the SMALL and LARGE groups. The objective was to identify three curves, corresponding to the abovementioned three groups, which interpolated the measures of central tendency in a parallel fashion. Considering the large number of anomalous values and the different variability that characterised each tooth, it was not possible to consider the first and third quartiles as measures of central tendency for each tooth in the SMALL and LARGE groups. Hence, we considered the coordinate characterised by the minimum variability (x7, y1), and identified a maximum deviation around the median equal to 1 millimetre in both the upper and lower arches. Thus we obtained the following measures:

- Central tendency for x7 SMALL = median (x7) – 1
- Central tendency for x7 LARGE = median (x7) – 1
- Central tendency for y1 SMALL = median (y1) – 1
- Central tendency for y1 LARGE = median (y1) - 1

We also obtained the central tendency of the SMALL and LARGE groups for the other coordinates, applying the 1 mm displacement to the median of all x and y values. In this way we created constant 'distances' along all points of the mouth between the central tendency measures of the MEDIUM group and those of the SMALL and LARGE groups.

RESULTS

Analysis of dental arch dimensions

The descriptive statistics of each of the six parameters used to measure the depth and width, subdivided by Arch and Gender, are reported in *Tables 3a, 3b, 3c* and *3d*. The values for mean, median, minimum, maximum, 25th percentile, 75th percentile and standard deviation are reported in each table.

The results of the Mann-Whitney non-parametric U-test are reported in *Tables 4a* and *4b*. The p-values imply that there is no significant statistical gender difference as regards the medians measured in the upper and lower arches.

Analysis of the dental arch shape

Initially we set out to provide a simple graphical representation of the lingual side of the arch form, obtaining the mean and standard deviation of the values of the coordinates for the upper and lower arches, respectively. Subsequently, a representation of the variability of the lingual curve of our sample was created, in order to document at least three sizes of the representative curve.

Tables 5a and *5b* document the descriptive statistics of the 14 coordinates corresponding to the reference points used to describe the curves that best represent the shape of the upper and lower arches, respectively. In *Graphs 1a* and *1b,* which depict the data in *Tables 5a* and *5b*, it is possible to observe the difference in variation of the coordinates. Thus, we considered the x and y coordinates which varied the least, as highlighted in *Tables 5a* and *5b*. After identifying 1 mm as the constant measure to be subtracted and added to the median measures, we obtained the central tendencies relative to the SMALL and LARGE groups, as described in *Tables 6a* and *6b*. *Graphs 2a* and *2b* show the three curves: LARGE, MEDIUM and SMALL, superimposed onto the scatter plot.

Graphs 3a and *3b,* display the values of all coordinates relative to the lower and upper arch for each group (LARGE, MEDIUM and SMALL) and the corresponding curves. The values reported in *Tables 6a* and 6*b* were elaborated by Curve Expert 1.3 software, in order to visualise the 9th-degree polynomial curve that interpolates the points relative to groups LARGE, MEDIUM and SMALL, respectively. *Figures 2a, 2b, 2c* illustrate the three representative curves describing the arch form from the lingual side in the lower arch of our sample, and *Figures 3a, 3b, 3c* depict those in the upper arch.

At this point we set out to verify the presence or absence of differences in shape between the upper and lower arches and between males and females, considering the medians as a measure of central tendency. We performed the Mann-Whitney U-test to compare the central tendencies (median) of the two arches (*Table 7*) and of the two genders (*Table 8*). In *Table 7*, the results highlighted in red correspond to significant differences between the medians of the upper and lower arches. For instance, the median of x1 measured in the upper arch (21) was significantly greater ($p < 0.000001$) with respect to the corresponding measurement relative to the lower arch (19). Likewise, the median of y1 measured in the upper arch (4) was significantly lower ($p = 0.002514$) with respect to that measured in the lower arch (4.5), and so on. The results not highlighted in red correspond to non-significant differences between the medians

No statistically significant differences were found between the central tendencies of the two genders, as documented in *Table 8*.

DISCUSSION

The majority of srudies in the literature document analysis of the shape of the dental arches, with different methodologies, of similar samples of healthy subjects in normal occlusion further to obtaining clinical data pertinent to the vestibular edgewise technique. [1-6, 16-23] All of these authors concluded that it is impossible to represent a single ideal human arch form.

However, in the literature there is no evidence of any study reporting reference points for description of the dental arch from a lingual perspective. In fact, the introduction of straight-wire concepts to the lingual technique[57, 58] has led clinicians to pose the important question of which form should be used in setting up indirect bonding, and according to which criteria. Thus, we selected a sample of 58 subjects with normal occlusion and proposed to describe, with an objective, standardised and reproducible method, a natural arch form which could be used as a guide, along with other criteria, for the personalised set-up, which is of fundamental importance in the lingual technique. [57, 64-67] Adults were selected so that the influence of growth on the arch form could be minimised, although not entirely excluded, as the literature suggests that alteration may also occur in adulthood. [22]

In the literature, there is a large diversity in the reference points chosen by authors in evaluation and description of the size and shape of the arches: the majority of previous studies utilised conventional anatomical reference points such as the incisal margin for the anterior teeth and the cusps of the canines, molars and premolars, [6, 18, 41, 44, 55, 68-70] while others chose the contact points, [71] the edge of the alveolar bone, [1, 72] the mesiodistal diameters of the teeth, [73-76] and cranial structures [43, 75]. Despite their anatomical significance, however, these points are unable to provide a clinical representation that could feasibly be used as an arch form guide. In contrast, the use of reference points on the surface of the teeth (FA points) [1- 3, 15, 47, 51, 52] furnishes a direct representation of the clinical arch form which can serve as a template for the manufacture of archwires for use in orthodontic treatment.

After the reference points were identified, an evaluation of the form and dimensions of the lingual side of the arch was performed according to a method previously described by Triviño et al. [2]; likewise, an article by Raberin (2003)[6] was used as a reference for the dimensional evaluation. Unsurprisingly, the results obtained from descriptive analysis of the mean values relative to the width and depth of the arches were lower that those regarding the vestibular side reported by Raberin [6] and other authors [20, 26], due to the fact the reference points considered were on the lingual surface of the arches, which necessarily possess a smaller circumference. Thus, a direct comparison with existing literature could not be made.

The results of our research into possible sexual dimorphism in the diameters between the inter-canine, inter-sixth inter-seventh diameters and the depth of arch on the lingual side revealed no statistical differences between the medians measured in males and females in either arch. These results contrast with the previously published reports [6, 18, 47, 52], which document an evident gender dimorphism in dimension (males have a sensibly wider arch than females, with more marked differences generally seen in the inter-sixth with respect to the inter-canine and inter-seventh diameters). This difference in results is probably due to the choice of reference points on the lingual side of the teeth, which excluded the dimensional differences in the bucco-lingual diameter of the molars that presumably exist between males and females, and have, indeed, been documented in the anthropological studies on the shape of the arch carried out by Ferrario. [17, 18]

In order to obtain an accurate graphical representation of the shape of the lingual arch, in this study we utilized the curves which interpolated the measure of central tendency as precisely as possible. Using Curve Expert software, we interpolated the median values of the x and y coordinates of our sample with various polynomial curves, from the fourth to sixth degree, as described in the literature.[2, 18, 51-56] Determination of the most appropriate curve was first carried out by visual means[2], taking into account the regularity of the shape of the curve and its proximity to the values of the median of the coordinates. Subsequently, in order to confirm this visual assessment objectively, we went on to determine which markers to consider in order to establish the goodness-of-fit of our curve. Residual analysis permitted us to verify whether or not the observed values fell outside the expected curve. The measurement error was calculated using the standard error considered, as per the Comments section of the software manual.

The polynomial function characterised by the lowest standard error was that of the 9th degree, and, despite the fact that it had not previously been described in the literature, it was therefore adopted to represent the shape of the arches from the lingual side. The anterior portion of this curve is considerably flattened in correspondence to the frontal group, and fairly straight towards the posterior; it is reminiscent of both Raberin's "flat" form (1993) [6] and the "Form B" used by Trivino (2008) [2] to describe the vestibular side of the arch. This shape is very probably attributable to the choice of reference points on the lingual surfaces, which annul the difference in bucco-lingual diameter between the teeth in the anterior and posterior sections.

We decided to create the groups SMALL, MEDIUM and LARGE; to this end, a distributive analysis of the x and y values for each tooth was performed in order to determine the measure of central tendency most appropriate for our data. The aim of the research was to identify 3 curves, corresponding to the 3 groups (SMALL, MEDIUM and LARGE), which could interpolate the measures of central tendency in order to represent our sample.

Analysing the presence of differences in shape, we considered the values of the medians of our coordinates and found no significant differences between the upper and lower arches in either males or females. This finding is in agreement with that reported by Ferrario (1993) [17] , who found no sexual dimorphism between the arches when evaluated via Euclidean Distance Matrix Analysis, and that reported by Camporesi (2006) [47], who reached the same conclusions using TPS analysis, a morphometric system. The samples examined in both of these studies were, like ours, comprised of subjects with natural idea occlusion from southern Europe, and thus these studies are comparable. Other investigations [4, 77] have found significant morphological differences in the shape of the vestibular arch among different ethnic groups, a possible topic for future research into the shape of the dental arch from the lingual side. The results of this study should only be considered specific for European populations in the Mediterranean area.

CONCLUSIONS

The present study analysed the shape of the lingual side of the upper and lower dental arches in a sample of adults from the south of Europe with natural ideal occlusion. Analysis of the shape of the arches calculated from the lingual side indicated that:

1. No sexual dimorphism exists as regards the dimensions of the lingual diameter at the inter-canine, inter-sixth or inter-seventh;
2. No significant differences in shape between upper and lower arches and between males and females exist;
3. Three lingual curves, Small, Medium and Large, for the upper and lower arches, representative of the mean values of the selected sample, were developed;
4. The upper curves are coordinate with the lower ones and could be used as a guide for the set-up in lingual straight-wire technique.

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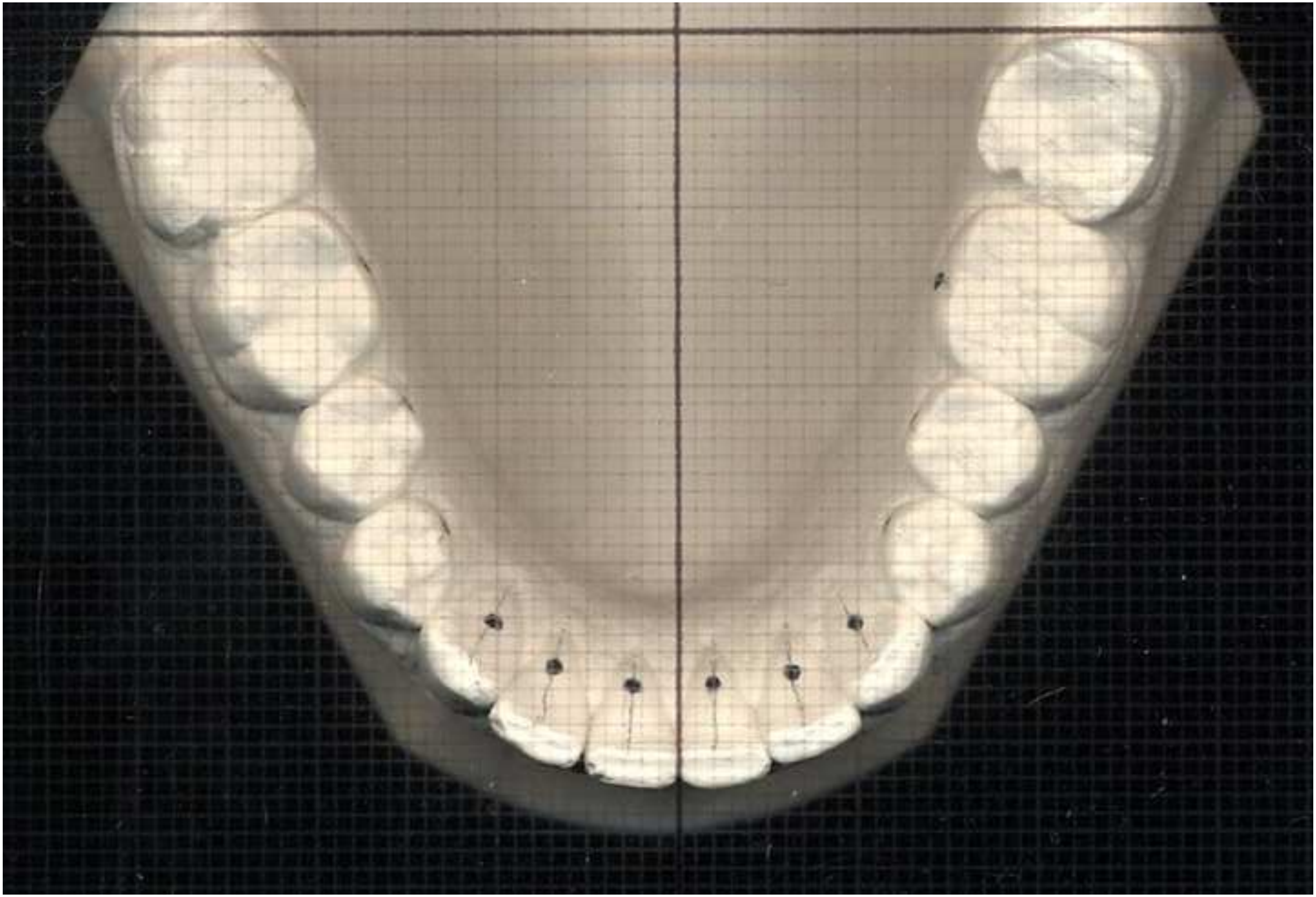

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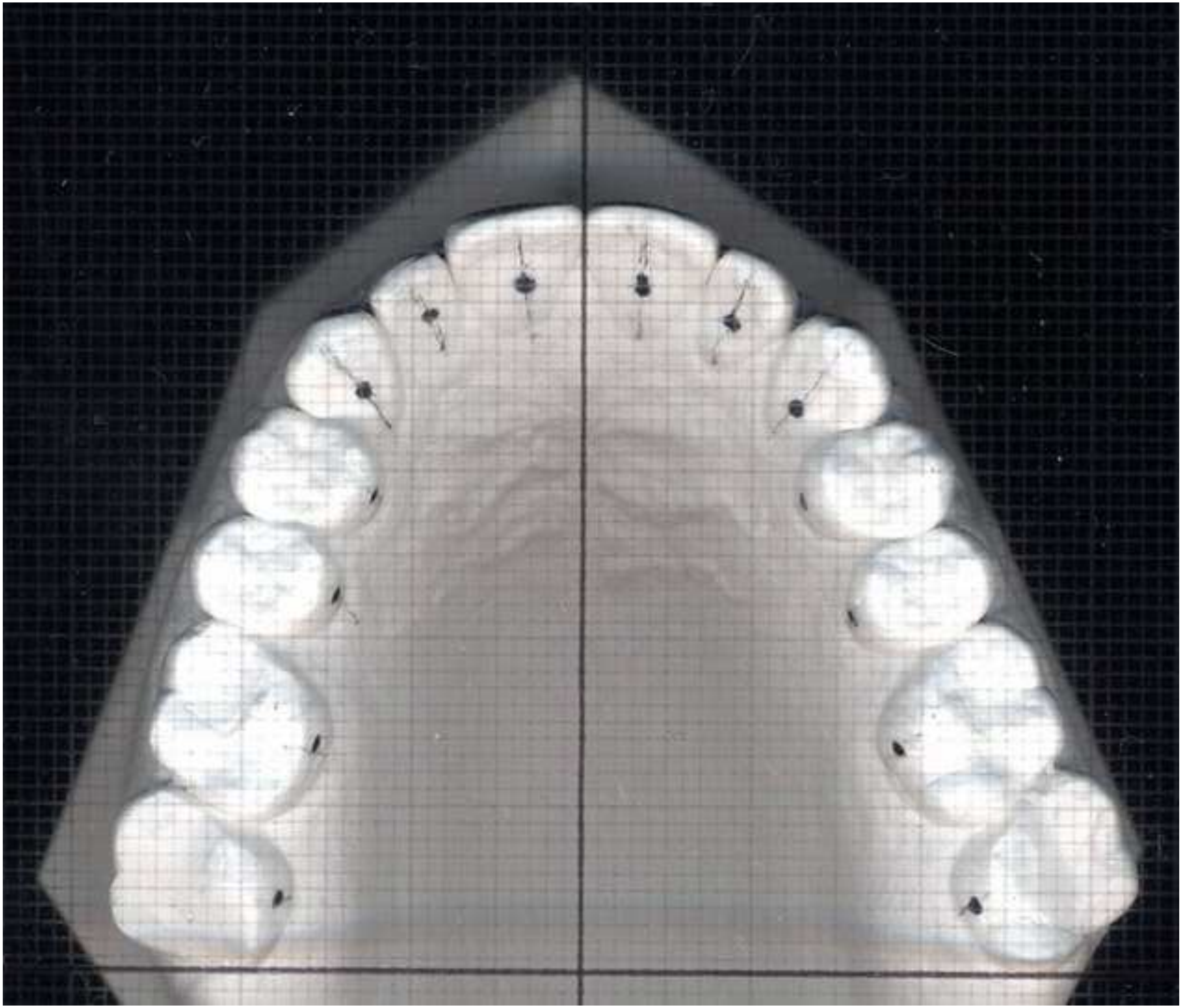

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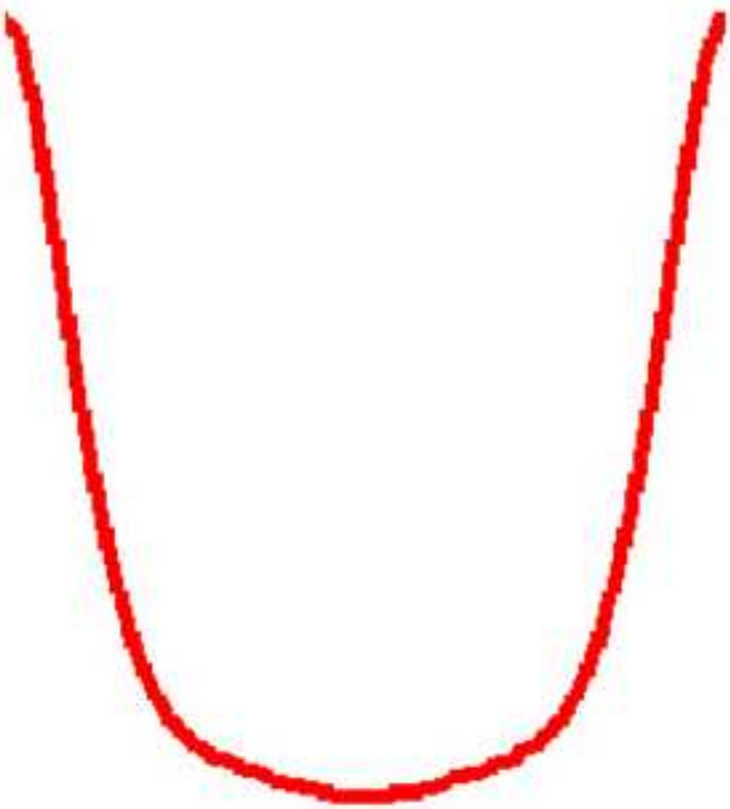

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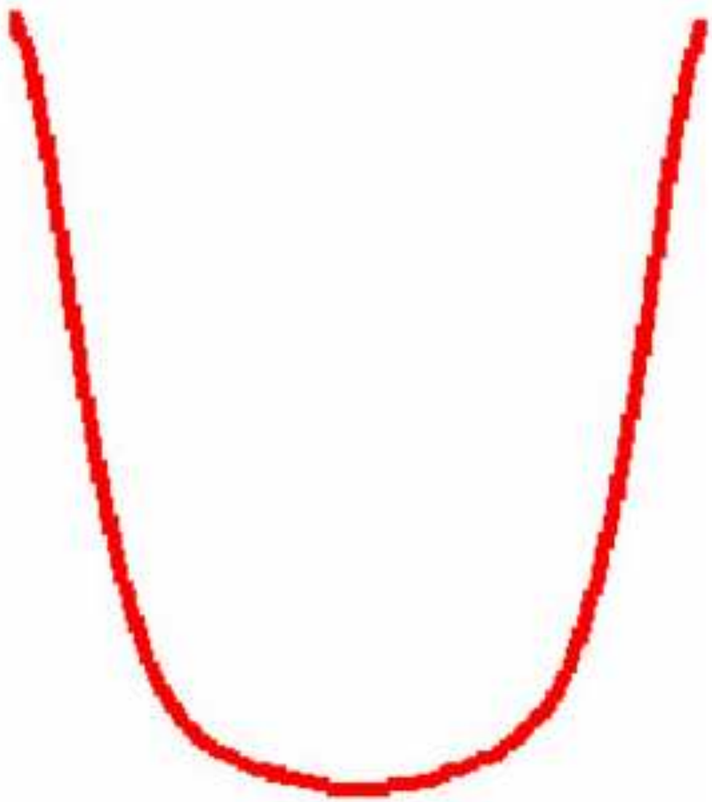

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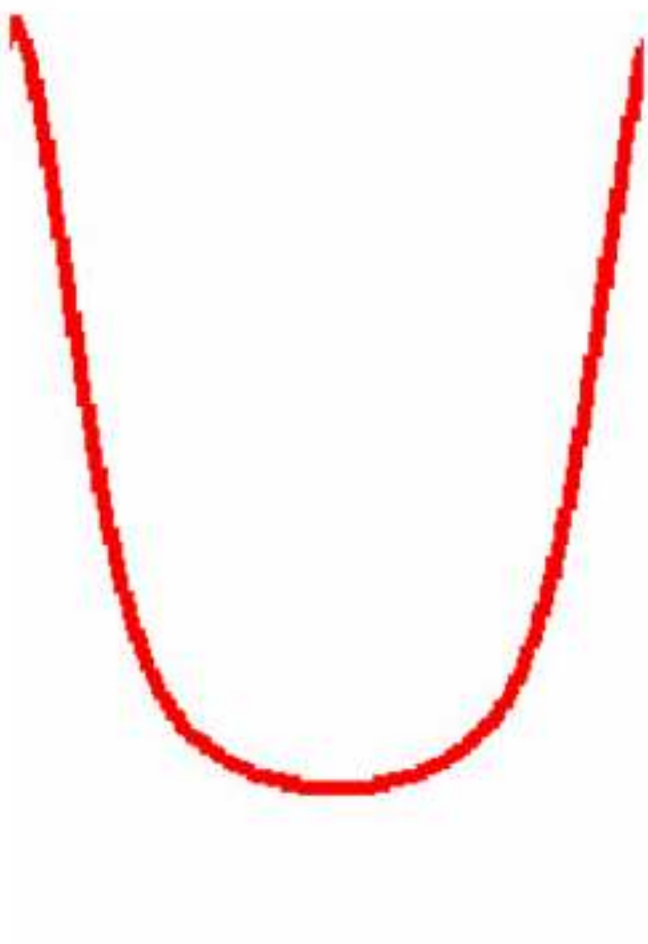

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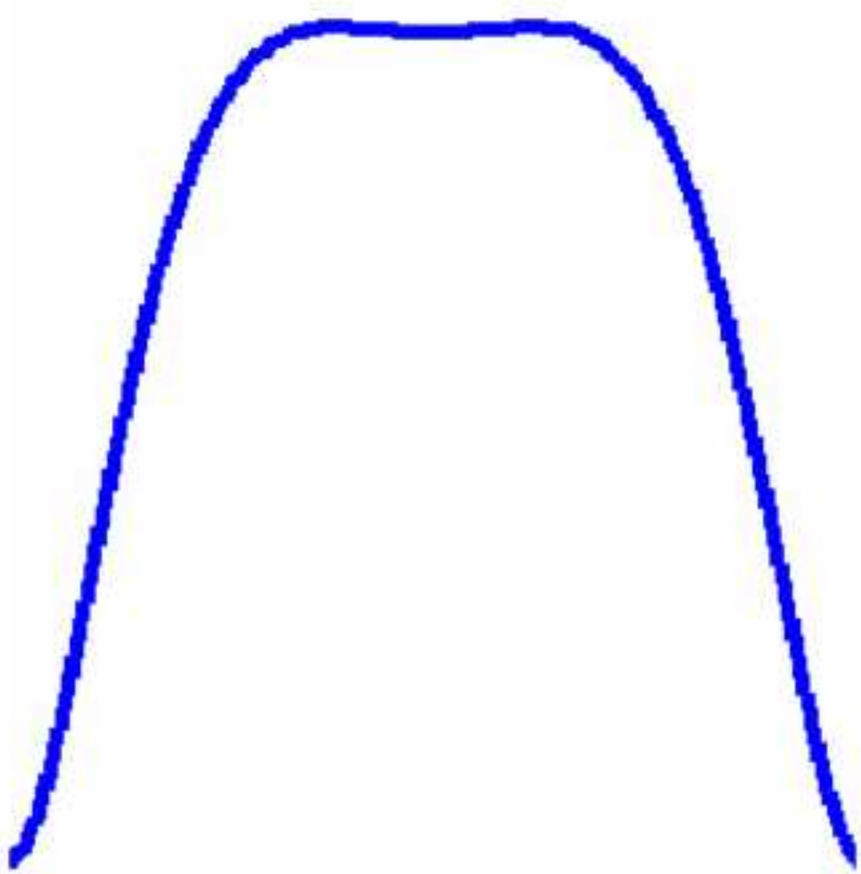

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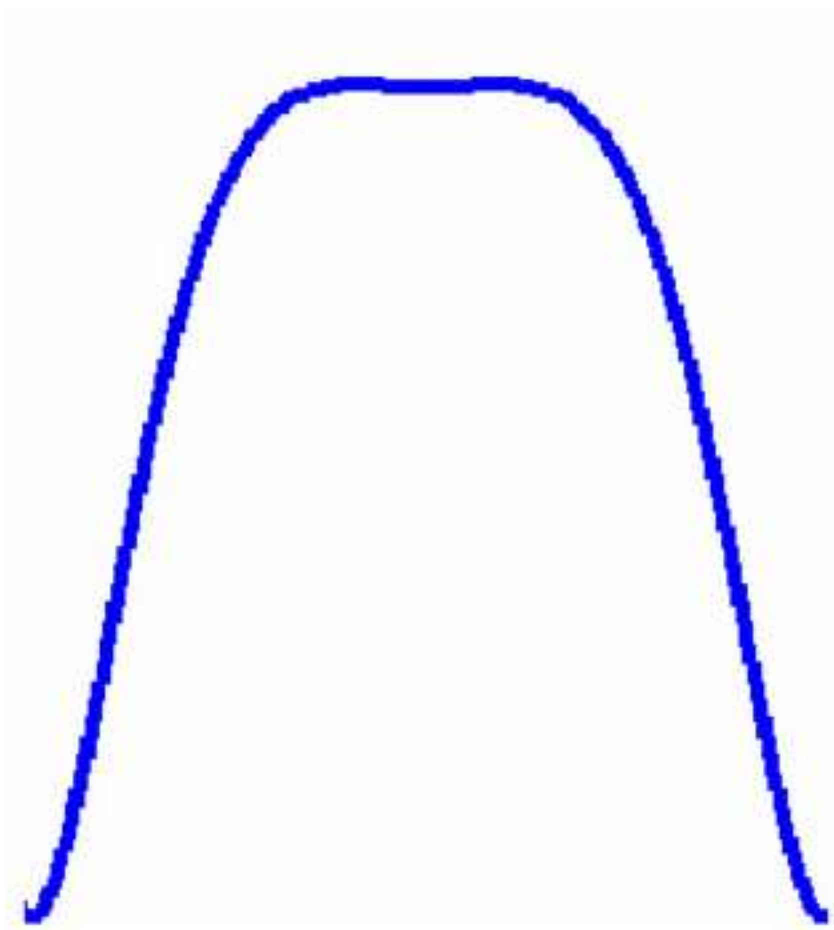

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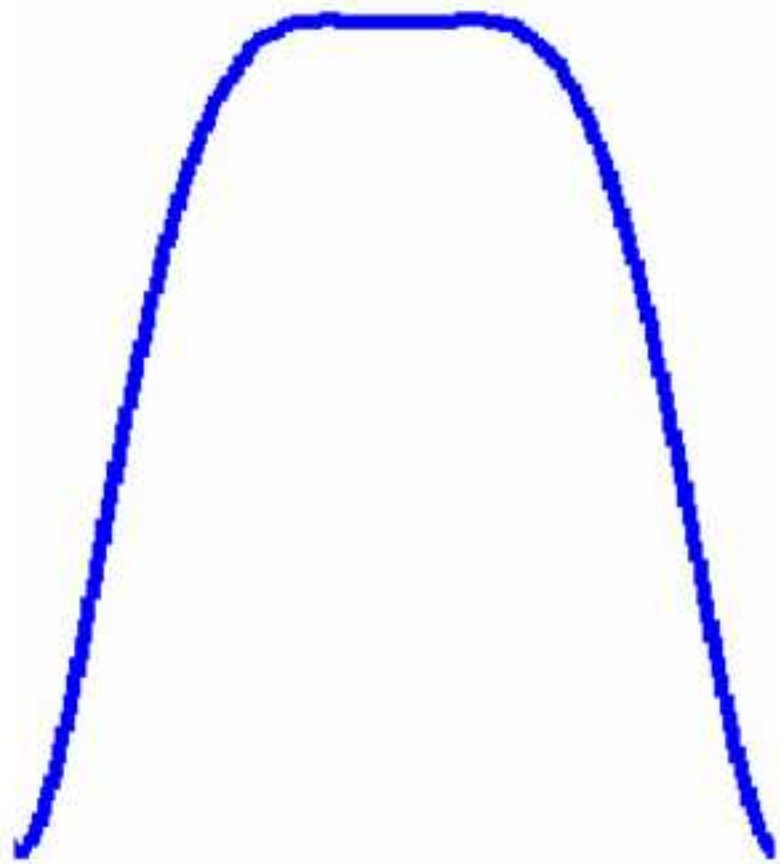


Table

Table 1.

Cod	Gender	Date of birth	Age (Years)	Age (Months)	Age	Little Index
P1	F	15/04/1972	32	11	32,92	1,00
P2	M	14/01/1984	21	2	21,17	0,80
P3	M	16/03/1980	21	7	21,58	1,00
P4	F	22/05/1978	26	10	26,83	1,20
P5	F	15/08/1968	36	7	36,58	0,70
P6	M	13/02/1981	24	1	24,08	1,00
P7	F	12/10/1983	21	6	21,50	0,50
P8	F	06/05/1979	24	11	24,92	0,60
P9	M	05/06/1968	36	10	36,83	1,00
P10	F	19/07/1965	39	8	39,67	0,50
P11	M	04/04/1982	24	0	24,00	0,10
P12	F	10/09/1969	35	5	35,42	1,70
P13	M	04/04/1980	26	0	26,00	0,30
P14	M	02/06/1960	45	0	45,00	0,12
P15	F	01/12/1981	23	3	23,25	0,50
P16	M	05/10/1967	38	5	38,42	2,50
P17	F	04/04/1968	36	10	36,83	0,50
P18	M	12/10/1977	27	4	27,33	1,00
P19	F	06/04/1980	25	0	25,00	0,30
P20	F	01/11/1966	39	5	39,42	0,10
P21	F	01/08/1963	42	0	42,00	1,50
P22	F	06/03/1935	70	3	70,25	2,50
P23	F	24/03/1970	35	3	35,25	2,00
P24	F	20/04/1980	25	9	25,75	2,90
P25	M	21/05/1964	40	11	40,92	0,40
P26	F	20/11/1970	35	3	35,25	0,70
P27	M	30/08/1970	35	5	35,42	1,30
P28	F	14/07/1980	25	6	25,50	0,60
P29	F	12/03/1966	39	11	39,92	0,20
P30	F	21/03/1979	27	0	27,00	1,00
P31	M	26/03/1980	26	1	26,08	0,20
P32	M	14/09/1977	32	10	32,80	0,30
P33	F	25/02/1982	27	5	27,40	2,50
P34	F	14/06/1983	26	1	26,08	2,30
P35	F	09/03/1979	30	4	30,30	1,80
P36	F	29/01/1981	28	6	28,50	0,20
P37	F	25/05/1974	35	2	35,20	0,30
P38	M	12/06/1982	27	1	27,08	2,40
P39	M	24/01/1979	30	6	30,50	0,50
P40	F	22/03/1980	29	4	29,33	1,80
P41	F	13/05/1987	22	2	22,16	0,30
P42	M	21/10/1982	26	9	26,75	1,20
P43	F	04/03/1990	19	1	19,08	0,00
P44	F	08/10/1988	20	6	20,50	1,40
P45	F	28/01/1980	23	6	23,50	2,00
P46	M	03/04/1979	28	1	28,08	1,30
P47	F	12/06/1980	23	0	23,00	1,20
P48	F	06/12/1982	21	6	21,05	2,00
P49	M	22/11/1985	20	9	20,75	1,00
P50	F	09/09/1983	20	11	20,92	0,00
P51	F	14/08/1986	20	5	20,41	0,50
P52	F	18/11/1986	20	8	20,60	1,00
P53	F	24/02/1985	21	11	21,92	2,30
P54	M	12/01/1981	21	10	21,83	1,00
P55	F	22/11/1980	23	5	23,41	2,20
P56	F	03/08/1981	22	2	22,16	2,00
P57	M	28/07/1981	22	1	22,08	1,00
P58	F	07/02/1984	38	9	38,75	1,50
				Mean	29,21	1,08
				SD	8,73	0,77

Table 2.

Variable	Side	Statistics	
		Se	***p-value***
X1 inf	A	0.1	ns
X1 sup	A	0.0333	ns
Y1 inf	A	0	ns
Y1 sup	A	0	ns
X2 inf	A	0.0333	ns
X2 sup	A	0.1	ns
Y2 inf	A	0	ns
Y2 sup	A	0.8667	ns
X5 inf	A	0.0667	ns
X5 sup	A	0	ns
Y5 inf	A	0.0667	ns
Y5 sup	A	0	ns
X1 inf	B	0.0714	ns
X1 sup	B	0.1333	ns
Y1 inf	B	0	ns
Y1 sup	B	0	ns
X2 inf	B	0.0357	ns
X2 sup	B	0	ns
Y2 inf	B	0	ns
Y2 sup	B	0	ns
X5 inf	B	0.0357	ns
X5 sup	B	0.1	ns
Y5 inf	B	0.0357	ns
Y5 sup	B	0.0333	ns

Tables 3a, 3b, 3c, 3d.

Variable	Descriptive Statistics Side=**Inf** Gender=**M**						
	Mean	Median	Minimum	Maximum	Percentile 25.0000	Percentile 75.0000	Std. Dev.
D3-3	21.22222	21.00000	18.00000	26.00000	20.00000	22.00000	1.928895
D6-6	32.77778	32.00000	28.00000	42.00000	30.00000	34.00000	3.034197
D7-7	38.55556	38.00000	30.00000	48.00000	36.00000	40.00000	3.783003
L3	4.13889	4.00000	2.00000	6.00000	4.00000	5.00000	0.899294
L6	25.22222	25.00000	22.00000	30.00000	24.00000	26.00000	1.914025
L7	35.33333	35.50000	31.00000	42.00000	34.00000	37.00000	2.472708

3a

Variable	Descriptive Statistics Side=**Inf** Gender=**F**						
	Mean	Median	Minimum	Maximum	Percentile 25.0000	Percentile 75.0000	Std. Dev.
D3-3	21.08108	20.00000	18.00000	26.00000	20.00000	22.00000	1.826418
D6-6	33.44595	34.00000	30.00000	40.00000	32.00000	36.00000	2.399440
D7-7	39.68919	40.00000	34.00000	48.00000	38.00000	42.00000	3.153279
L3	4.12162	4.00000	2.50000	8.00000	4.00000	5.00000	0.871194
L6	25.29730	25.00000	21.00000	31.00000	24.00000	26.00000	1.960079
L7	35.10135	35.00000	30.00000	43.00000	33.00000	36.00000	2.647019

3b

Variable	Descriptive Statistics Side=**Sup** Gender=**M**						
	Mean	Median	Minimum	Maximum	Percentile 25.0000	Percentile 75.0000	Std. Dev.
D3-3	27.19048	26.00000	24.00000	34.00000	26.00000	28.00000	2.510836
D6-6	36.78571	36.00000	30.00000	50.00000	34.00000	38.00000	3.502861
D7-7	42.28571	42.00000	34.00000	52.00000	40.00000	44.00000	3.769491
L3	6.91667	7.00000	4.00000	9.00000	6.00000	8.00000	1.173470
L6	29.38095	30.00000	22.50000	41.00000	28.00000	30.50000	2.870815
L7	38.58333	39.00000	32.00000	48.00000	37.00000	40.00000	2.987610

3c

Variable	Descriptive Statistics Side=**Sup** Gender=**F**						
	Mean	Median	Minimum	Maximum	Percentile 25.0000	Percentile 75.0000	Std. Dev.
D3-3	26.62162	26.00000	22.00000	34.00000	24.00000	28.00000	2.44783
D6-6	36.94595	36.00000	29.00000	46.00000	34.00000	38.00000	3.36742
D7-7	42.48649	42.00000	34.00000	50.00000	40.00000	46.00000	4.02813
L3	6.68243	7.00000	5.00000	9.00000	6.00000	7.00000	1.03558
L6	28.90541	29.00000	25.00000	34.00000	27.00000	30.00000	2.19382
L7	42.11486	39.00000	33.00000	41.00000	36.00000	40.00000	3.32884

3d

Tables 4a, 4b.

Variable	Test U Mann-Whitney Variable gender Side=**INF** Sign. Lev. p<.05000					
	Rang Sum F	Rang Sum M	U	p-value	N Valid F	N Valid M
D3-3	4273.500	2512.500	1498.500	0.752040	74	42
D6-6	4584.000	2202.000	1299.000	0.143744	74	42
D7-7	4598.000	2188.000	1285.000	0.122974	74	42
L3	4156.000	2630.000	1381.000	0.321717	74	42
L6	4272.000	2514.000	1497.000	0.745508	74	42
L7	4163.000	2623.000	1388.000	0.341744	74	42

4a

Variable	Test U Mann-Whitney Variable gender Side=**SUP** Sign. Lev. p<.05000					
	Rang Sum F	Rang Sum M	U	p-value	N Valid F	N Valid M
D3-3	4158.500	2627.500	1383.500	0.328780	74	42
D6-6	4387.000	2399.000	1496.000	0.741164	74	42
D7-7	4401.500	2384.500	1481.500	0.679161	74	42
L3	4083.000	2703.000	1308.000	0.158455	74	42
L6	4132.500	2653.500	1357.500	0.260194	74	42
L7	4146.000	2640.000	1371.000	0.294463	74	42

4b

Tables 5a, 5b.

Variable	Descriptive Statistics Side=**INF**					
	Minimum	Percentile 25.0000	Median	Percentile 75.0000	Maximum	Mean
1X	-24.0000	-20.5000	-19.0000	-19.0000	-15.0000	-19.6767
2X	-21.0000	-17.0000	-16.0000	-16.0000	-14.0000	-16.5862
3X	-18.0000	-15.0000	-14.2500	-14.0000	-12.0000	-14.6293
4X	-16.0000	-13.0000	-13.0000	-12.0000	-11.0000	-12.7888
5X	-13.0000	-11.0000	-10.0000	-10.0000	-9.0000	-10.5345
6X	-8.0000	-7.0000	-7.0000	-6.0000	-5.5000	-6.8448
7X	-4.0000	-3.0000	-2.0000	-2.0000	-2.0000	-2.4526
1Y	-7.0000	-5.0000	-4.5000	-4.0000	-3.0000	-4.4009
2Y	-17.0000	-15.0000	-14.0000	-13.5000	-11.0000	-14.3190
3Y	-28.0000	-24.0000	-23.0000	-22.0000	-19.0000	-23.0129
4Y	-36.0000	-30.0000	-29.0000	-28.0000	-24.5000	-29.1983
5Y	-44.0000	-37.0000	-35.0000	-34.0000	-30.0000	-35.4224
6Y	-46.0000	-40.0000	-38.0000	-36.0000	-33.0000	-38.1595
7Y	-47.0000	-41.0000	-39.0000	-37.5000	-34.0000	-39.5647

5a

Variable	Descriptive Statistics Side=**SUP**					
	Minimum	Percentile 25.0000	Median	Percentile 75.0000	Maximum	Mean
1X	-26.0000	-22.7500	-21.0000	-20.0000	-17.0000	-21.1207
2X	-25.0000	-19.0000	-18.0000	-17.0000	-14.5000	-18.4612
3X	-22.0000	-17.2500	-16.0000	-15.7500	-13.5000	-16.5517
4X	-20.0000	-15.0000	-14.0000	-13.5000	-12.0000	-14.3319
5X	-17.0000	-14.0000	-13.0000	-13.0000	-11.0000	-13.4052
6X	-12.0000	-10.0000	-10.0000	-9.0000	-7.0000	-9.6595
7X	-5.0000	-4.0000	-4.0000	-3.5000	-2.0000	-3.8578
1Y	3.0000	4.0000	4.0000	3.5000	2.0000	4.0991
2Y	10.0000	13.0000	13.0000	14.0000	17.0000	13.2198
3Y	18.0000	21.0000	22.0000	23.0000	29.0000	22.2500
4Y	24.0000	27.0000	29.0000	30.0000	35.0000	28.7931
5Y	27.0000	34.0000	35.5000	37.0000	44.0000	34.8966
6Y	35.0000	38.0000	40.0000	42.0000	50.0000	40.2500
7Y	37.0000	40.0000	42.0000	44.0000	52.0000	42.3276

5b

Tables 6a, 6b.

Variable	Descriptive Statistics Side=**INF**		
	LARGE Median	MEDIUM Median	SMALL Median
1X	-20.0000	-19.0000	-18.0000
2X	-17.0000	-16.0000	-15.0000
3X	-15.2500	-14.2500	-13.2500
4X	-14.0000	-13.0000	-12.0000
5X	-11.0000	-10.0000	-9.0000
6X	-8.0000	-7.0000	-6.0000
7X	-3.0000	-2.0000	-1.0000
1Y	-5.5000	-4.5000	-3.5000
2Y	-15.0000	-14.0000	-13.0000
3Y	-24.0000	-23.0000	-22.0000
4Y	-30.0000	-29.0000	-28.0000
5Y	-36.0000	-35.0000	-34.0000
6Y	-39.0000	-38.0000	-37.0000
7Y	-40.0000	-39.0000	-38.0000

6a

Variable	Descriptive Statistics Side=**SUP**		
	LARGE Median	MEDIUM Median	SMALL Median
1X	-22.0000	-21.0000	-20.0000
2X	-19.0000	-18.0000	-17.0000
3X	-17.0000	-16.0000	-15.0000
4X	-15.0000	-14.0000	-13.0000
5X	-14.0000	-13.0000	-12.0000
6X	-11.0000	-10.0000	-9.0000
7X	-5.0000	-4.0000	-3.0000
1Y	5.0000	4.0000	3.0000
2Y	14.0000	13.0000	12.0000
3Y	23.0000	22.0000	21.0000
4Y	30.0000	29.0000	28.0000
5Y	36.5000	35.5000	34.5000
6Y	41.0000	40.0000	39.0000
7Y	43.0000	42.0000	41.0000

6b

Table 7.

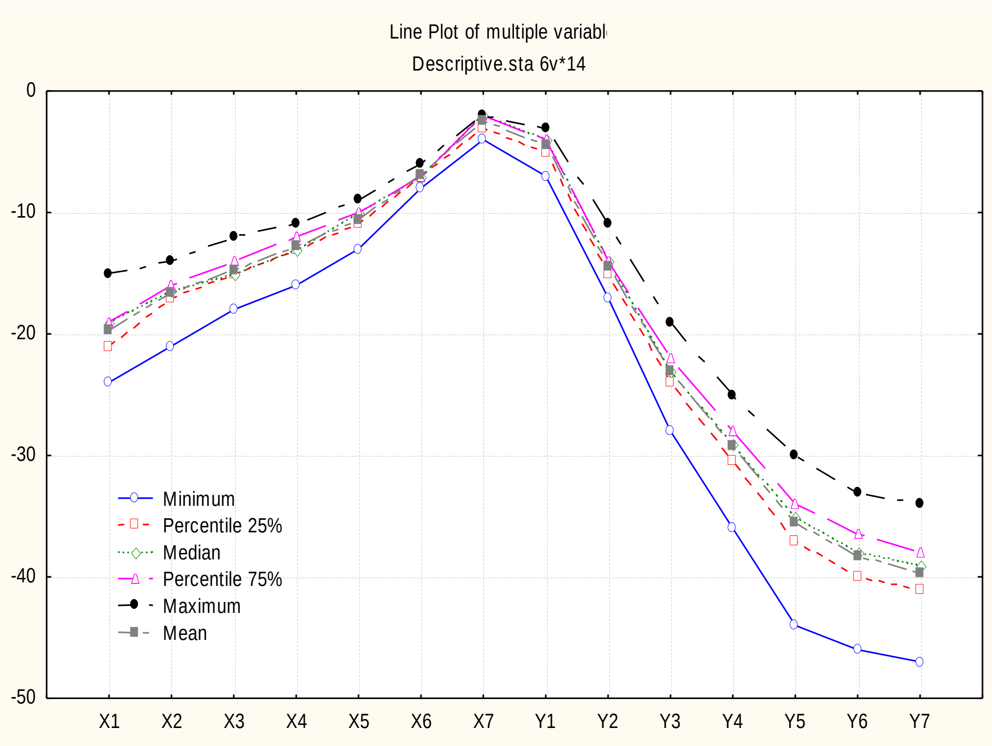
Variable	Test U Mann-Whitney By variable Side Marked tests are significant at p<.05000					
	Median INF	Median SUP	U	p-value	N Valid INF	N Valid SUP
1X	19.00000	21.00000	3817.000	0.000000	116	116
1Y	4.50000	4.00000	5183.000	0.002514	116	116
2X	16.00000	18.00000	2463.500	0.000000	116	116
2Y	14.00000	13.00000	3552.500	0.000000	116	116
3X	14.25000	16.00000	2136.500	0.000000	116	116
3Y	23.00000	22.00000	4968.000	0.000579	116	116
4X	13.00000	14.00000	2358.000	0.000000	116	116
4Y	29.00000	29.00000	6061.000	0.192258	116	116
5X	10.00000	13.00000	420.000	0.000000	116	116
5Y	35.00000	36.00000	6553.000	0.732811	116	116
6X	7.00000	10.00000	108.500	0.000000	116	116
6Y	38.00000	40.00000	3853.500	0.000000	116	116
7X	2.00000	4.00000	750.500	0.000000	116	116
7Y	39.00000	42.00000	3165.500	0.000000	116	116

Table 8.

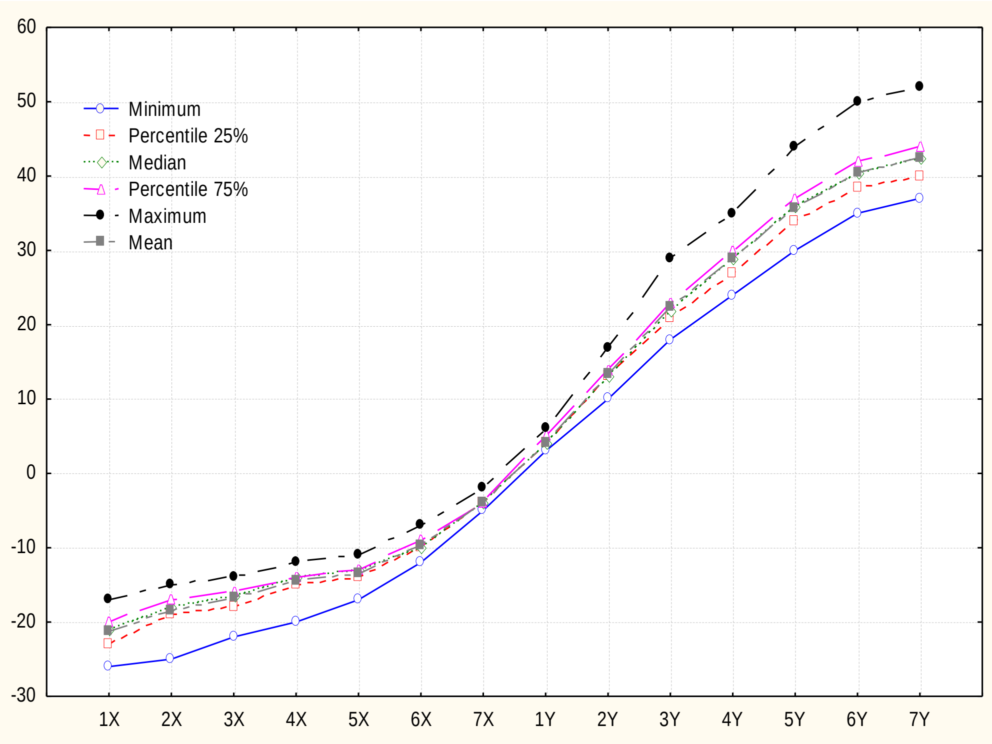
Variable	Test U Mann-Whitney By variable Gender Marked tests are significant at p<.05000					
	Median INF	Median SUP	U	p-value	N Valid F	N Valid M
1X	20.00000	20.00000	5840.000	0.000000	152	80
1Y	4.00000	4.00000	5893.500	0.701877	152	80
2X	17.00000	17.00000	5753.000	0.501624	152	80
2Y	14.00000	14.00000	5661.500	0.389655	152	80
3X	15.75000	15.00000	5770.000	0.524157	152	80
3Y	22.00000	23.00000	5617.500	0.341708	152	80
4X	13.00000	13.00000	5913.500	0.732631	152	80
4Y	29.00000	29.00000	5419.500	0.174375	152	80
5X	12.00000	12.00000	5907.500	0.723357	152	80
5Y	35.00000	36.00000	5561.500	0.286404	152	80
6X	8.00000	8.00000	5885.000	0.688949	152	80
6Y	39.00000	39.50000	5584.000	0.307852	152	80
7X	3.00000	3.00000	6026.500	0.913144	152	80
7Y	40.50000	42.00000	5584.500	0.308341	152	80

Table

Graphics 1a, 1b.

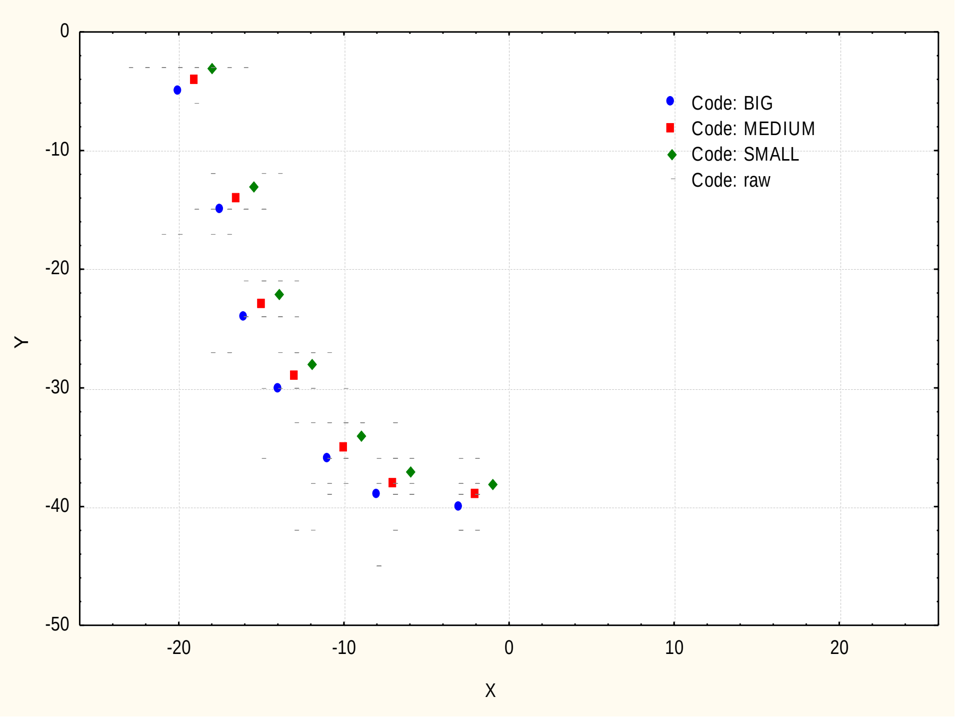


1a

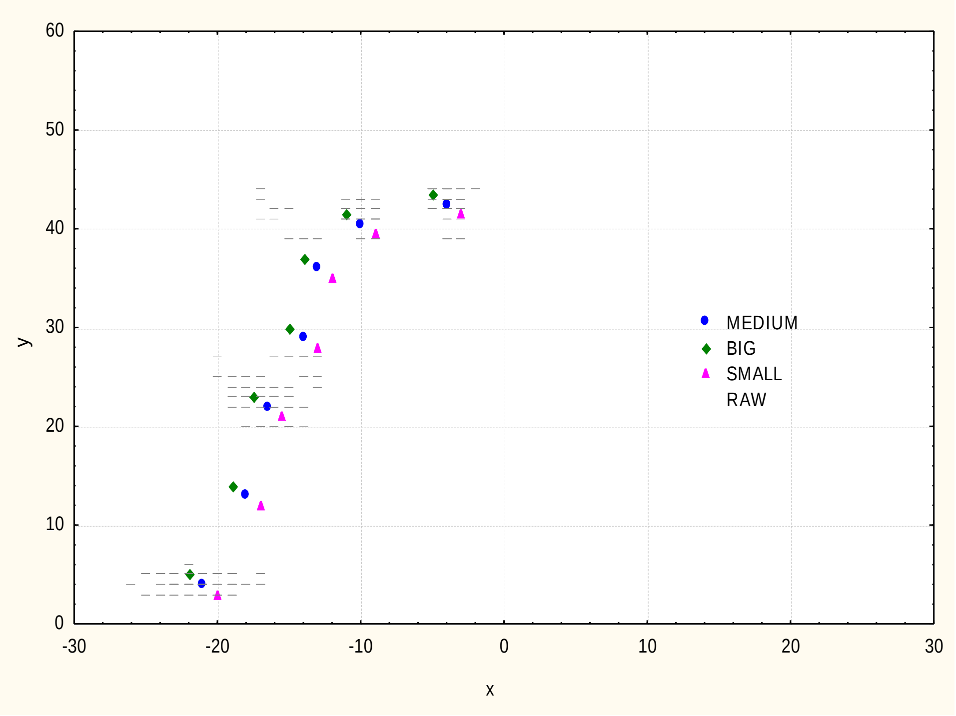


1b

Graphics 2a, 2b.

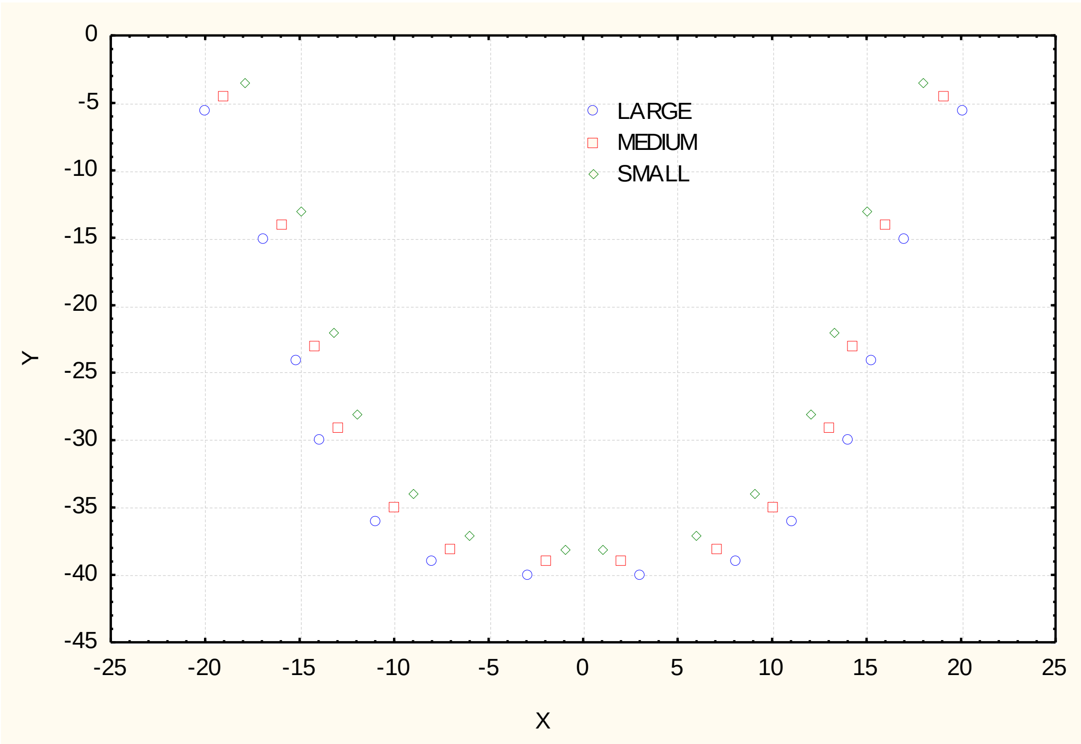


2a

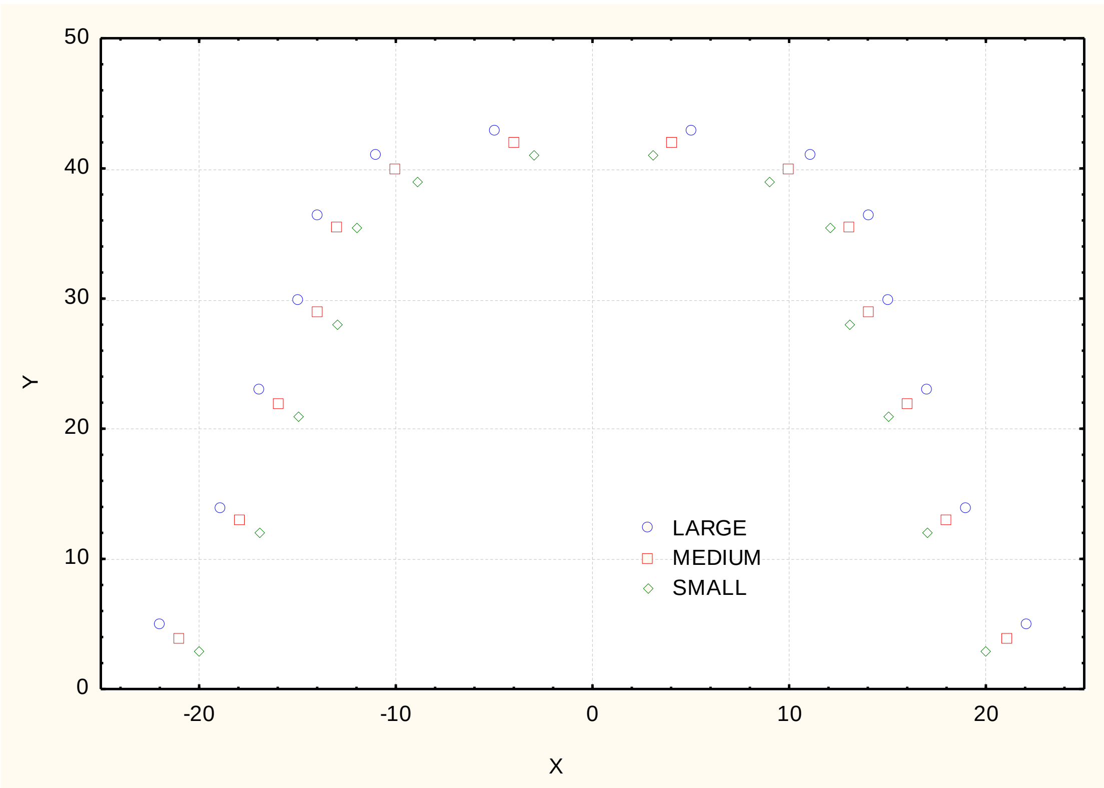


2b

Graphics 3a, 3b.



3a



3b

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