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A comparison of sex identification methods based on lip furrow pattern

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Abstract: The objective of the study was to specify the method with the highest probability of correct sex identification based on lip furrow pattern. Three methods were verified: Vahanwala's method, identification based on the mid-section of lower lip print and our own method. The examined group included 242 persons aged 15- 30 years, 68.6% females and 31.4% males. Cheilograms were taken with the method proposed by Vanahwala, modified in such a way that the prints of lower and upper lips were taken separately. The lip furrow patterns were classified according to Suzuki and Tsuchihashi, modified to include horizontal furrows which were considered by Renaud. In all the quadrants patterns II, III and VI prevailed among males and patterns I, I' and II among females. Females were more frequently diagnosed correctly than males. Our method in which all the lip print was analysed without division into quadrants was the most effective, while Vahanwala's method was the least so.

Key words: cheiloscopy, cheilogram, lip prints

Introduction

A German anthropologist Fischer in 1902 was the first to pay attention to the occurrence of lip furrows, but did not propose any practical use of the trait (Thomas and Van Wyk 1988). Only thirty years later a French criminologist E. Locard recommended taking lip prints for the purpose of identifying persons or confirming their identity (Kasprzak 2000; 2003). A breakthrough in cheiloscopic studies took place in 1966–1971, when Japanese scientists Y. Tsuchihashi and K. Suzuki showed that cheiloscopic prints remained unique and unchangeable during at least 10 years (Suzuki and Tsuchihashi 1970). In this respect they resemble fingerprints and thus can be of practical use in criminology. According to Kasprzak (1991; 2000; 2003), a legible lip print offers even better identification possibilities than a fingerprint, since it has on average 1,100 individual traits, while a fingerprint has only 100. In order to confirm that a lip print belongs to a person it is enough that it has 7 (in Poland) or 9 (in the world) traits in common with comparative material (2). It is also important that a lip print can be taken even 30 days after it has been left (Saraswathi et al. 2009).

There are several classifications of lip furrow patterns. Legible and easily used systems were proposed by Hirth et

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al. (1977) who divided the patterns into 4 categories and by Suzuki and Tsuchihashi **(1970)** who classified them into 6 groups. During analysis, the lip print is usually divided into four quadrants which are then analyzed separately. Renauld (1973) was the only author to consider horizontal furrows in his classification.

Studies on sex identification based on lip prints are few, and based on rather small samples. Besides, the views on the suitability of lip furrow patterns for sex identification are divergent. Hirth et al. (1977) and Vahanwala et al. (2005) demonstrated that the character was sexually dimorphic. Ziółkowska-Łajp (1993) and Kasprzak (1991) maintained that only the mid-section of the lower lip print was suitable for the purpose. Studies limited to the lower lip print were carried out, among other authors, by Sivpathasundaram et al. (2000) and Sandhu et al. (2012) who however failed to demonstrate unequivocally the suitability of that print for sex identification.

The objective of this study was to determine the frequency of occurrence of the various lip furrow patterns in males and females, considering the mid-section of the lower lip, and to attempt to specify the best method of sex identification based on lip prints. Three methods were tested: Vahanwala's method, the method based on the mid-section of lower lip print and our own method.

Material and methods

Lip prints were taken from 76 white males and 166 white females aged 15–30 years, living in Poland. Persons with lip damage or playing brass instruments were excluded from the study. Each cheilogram was placed in a numbered envelope, and the sex of the person was noted separately.

Lip furrow patterns were identified separately for each quadrant of each cheilogram, without determining the dominant type, and furrows in the mid-section of lower lip were also described. In that case only one, dominant, type was determined. Occurrence of more than one type in that section was sporadic.

Sex was identified by 15 well-trained examiners. It is important that each of them was trained only to use one of the three methods of sex identification, in order to avoid their opinion being affected by a different method known to them. Each assessed only 25 randomly selected cheilograms, to avoid fatigue with the task. Sex identification used one of the three methods:

1. According to suggestions of Vahanwala et al. (2005) the upper and lower lips were assessed on their whole length, the print being divided into four quadrants. Then the description was assigned to one of the 6 categories proposed by Suzuki and Tsuchihashi (1970). The sex identification was based on the following assumptions:

a) Female
   - Furrow patterns in all quadrants similar, uniform
   - Pattern I or I' occurs in quadrant I

b) Male
   - Furrow patterns diverse in all quadrants
   - Pattern II occurs in quadrant II
   - Pattern III occurs in quadrant III or IV

2. Only the middle (10 mm) section of lower lip was assessed. Suzuki and Tsuchihashi's (1970) classification was supplemented with horizontal furrows, considered by Renauld (1973). The

identification was based on the following assumptions:
a) Female – dominant types: I, I' or II
b) Male – dominant types III, IV or VI

3. Our own method, like the preceding ones, is based on Suzuki and Tsuchihashi's (1970) system and, like method 2, supplemented with horizontal furrows. The analysis includes the whole lip print, not divided into quadrants. When horizontal furrows are present on the lower or upper lip print (type VI), the print is male. When they are absent, the identification is as follows:

a) Lower and upper lip prints similar, with predominance of patterns I, I' or II–female. Patterns III and IV may appear sporadically, as "background".
b) Lower and upper lip prints similar, of III or V pattern–female.
c) Upper and lower lip patterns in females differ distinctly, but:
   - on lower lip dominant patterns are I, I' or II
   - on upper lip dominant patterns are III or IV
d) Upper and lower lip patterns similar, on lower lip also pattern IV occurs–female.
e) Upper and lower lip patterns in males differ distinctly, but:
   - on lower lip dominant patterns are III or IV
   - on upper lip dominant patterns are I, I' or II
f) Lip damage is much more frequent among males than among females.

The significance of differences between the number of correct and erroneous diagnoses was tested with sign test, calculating the values of
$\chi^2 = [\sum$ correct diagnoses $- \sum$ erroneous diagnoses$]^2 / N$, at $df = 1$. The number of diagnoses for each method was the same, hence the χ^2 values could be directly compared.

The significance of the differences in the frequency of correct and erroneous diagnoses and in the frequency of patterns on the mid-section of lower lip print between the sexes was tested with Góralski's (1975) test, by calculating:

$$F_p = (m/m-1)^* [N_k (p_{śr}-p_k)^2 + N_m(p_{śr}-p_m)^2] / p_k(1-p_k) + p_m(1-p_m)$$

Assuming that $m = 2$, where: m = number of independent samples; N_k = number of females;

N_m = number of males; $p_{śr}$ = mean of pk and p_m $p_{śr} = (N_k * p_k + N_m * p_m) / N_k + N_m$; p_k = ratio of correct female diagnoses to the total number of females;

p_m = ratio of correct male diagnoses to the total number of males

Results

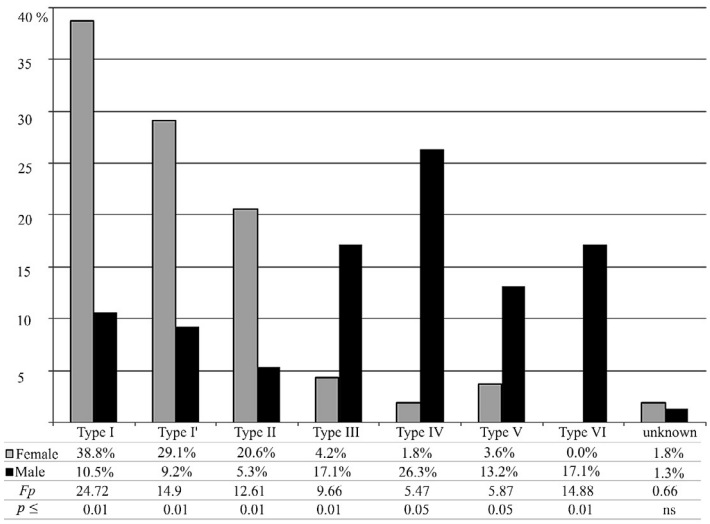
The frequency of occurrence of lip furrow patterns was analyzed separately for each quadrant. Since several (up to four) different patterns could occur in each quadrant, the numbers in Table 1 are larger than the number of quadrants, and the per cents do not add up to 100%.

The most frequent patterns among females were I, I' and II, and their frequency was similar. The most frequent patterns among males were II and III. The least frequent patterns among both sexes were IV and V. The difference in the frequency of occurrence between the sexes was the greatest in the case of pattern VI, which was completely absent in females and appeared in 23.3% of males.

The mid-section of lower lip which Kasprzak (1991) regarded as the most important for individual identification showed considerable differences in the

Table 1. Frequency of occurrence of lip furrow patterns in all quadrants for males and females

Type of patterns	Female (664 quadrants)		Male (304 quadrants)		Total (968 quadrants)	
	N	%	*N*	%	*N*	%
Type I	226	34.0	66	21.7	292	30.2
Type I'	263	39.6	69	22.7	332	34.3
Type II	245	36.9	96	31.6	341	35.2
Type III	110	16.6	97	31.9	207	21.4
Type IV	62	9.3	54	17.8	116	11.9
Type V	63	9.5	41	13.5	104	10.7
Type VI	0	0.0	71	23.3	71	23.3



	Type I	Type I'	Type II	Type III	Type IV	Type V	Type VI	unknown
Female	38.8%	29.1%	20.6%	4.2%	1.8%	3.6%	0.0%	1.8%
Male	10.5%	9.2%	5.3%	17.1%	26.3%	13.2%	17.1%	1.3%
Fp	24.72	14.9	12.61	9.66	5.47	5.87	14.88	0.66
$p \leq$	0.01	0.01	0.01	0.01	0.05	0.05	0.01	ns

Fig. 1. Frequency of occurrence of lip furrow patterns and significance of differences between females and males for mid section of lower lip (ns – statistically insignificant)

frequency of patterns among males and females (Fig. 1). Patterns I, I' and II were more frequent among females, while patterns III, IV and V, as well as IV which was completely absent in females, predominated among males. All the differences were statistically significant.

The proportion of correct identifications among the persons trained to use method 1 varied from 44% to 72% (Table 2). Two persons (numbers 11 and 13) scored more erroneous than correct identifications, but in neither case was the difference statistically significant. Considering the whole team, correct identification was more frequent and the difference was statistically significant.

All the persons using method 2 more often identified sex correctly. The mean proportion of correct identifications

Table 2. Sex identification (method 1) – assessment of well-trained examiners

N° of examiners	Correct diagnoses		Erroneous diagnoses		No diagnoses	
	N	%	*N*	%	*N*	%
1	16	64	9	36	0	0
2	12	48	11	44	2	8
3	18	72	7	28	0	0
4	14	56	10	40	1	4
5	16	64	7	28	2	8
6	15	60	10	40	0	0
7	15	60	10	40	0	0
8	11	44	13	52	1	4
9	15	60	10	40	0	0
10	13	52	9	36	3	12
11	14	56	9	36	2	8
12	13	52	12	48	0	0
13	12	48	13	52	0	0
14	15	60	9	36	1	4
15	16	64	8	32	1	4

$\sum$ correct diagnoses = 215; $\sum$ erroneous diagnoses = 147; $\chi^2 = 12.77$; df= 1; $p \leq 0.001$

among the team was 73.0%, and the difference in frequency of correct and erroneous diagnoses was statistically significant (Table 3).

In the case of method 3, as with the preceding two methods, most (79.8%) persons identified sex correctly, and the correct identifications were statistically significantly more frequent than misidentifications, but the significance of the difference (χ^2 value) was the greatest among all three methods (Table 4).

The best method of sex identification based on lip prints should produce a high difference between the correct and the erroneous diagnoses (χ^2 value), that is correct identifications should be distinctly more frequent. In this respect method 3 proved to be the best, method 1 – the worst.

At the same time, with a good method the difference between the proportion of correct/incorrect diagnoses pertaining to males and females should be statistically insignificant (Góralski's test) (1975), which means that the method could be applied to both sexes with equally good results. In this respect also method 3 proved to be the best ($p>0.05$), and method 1 not much inferior ($p=0.05$). None of these methods "favored" either sex in any significant way. Method 2 ($p \leq 0.05$) proved to be significantly more reliable in the case of females, and of little reliability for males.

Discussion

Though many cheiloscopic studies deal with the frequency of occurrence of lip furrow patterns in both sexes, we have failed to find any studies comparing the reliability of the existing methods of sex identification based on such patterns.

Sex identification based on lip prints

Table 3. Sex identification (method 2) – assessment of well-trained examiners

Nº of examiners	correct diagnoses		erroneous diagnoses		no diagnoses	
	N	%	*N*	%	*N*	%
1	18	72	7	28	0	0
2	16	64	8	32	1	4
3	19	76	4	16	2	8
4	14	56	8	32	3	12
5	20	80	3	12	2	8
6	18	72	6	24	1	4
7	20	80	5	20	0	0
8	21	84	3	12	1	4
9	14	56	9	36	2	8
10	16	64	7	28	2	8
11	20	80	3	12	2	8
12	21	84	3	12	1	4
13	19	76	4	16	2	8
14	21	84	4	16	0	0
15	17	68	5	20	3	12

$\sum$ correct diagnoses = 274; $\sum$ erroneous diagnoses = 79; $\chi^2 = 107.7$; df= 1; $p \leq 0.001$

Table 4. Sex identification (method 3) – assessment of well-trained examiners

Nº of examiners	correct diagnoses		erroneous diagnoses		no diagnoses	
	N	%	*N*	%	*N*	%
1	18	72	4	16	3	12
2	16	64	6	24	3	12
3	22	88	3	12	0	0
4	22	88	2	8	1	4
5	19	76	5	20	1	4
6	21	84	4	16	0	0
7	20	80	5	20	0	0
8	17	68	7	28	1	4
9	23	92	2	8	0	0
10	19	76	6	24	0	0
11	17	68	6	24	2	8
12	22	88	3	12	0	0
13	22	88	2	8	1	4
14	20	80	1	4	4	16
15	21	84	3	12	1	4

$\sum$ correct diagnoses = 299; $\sum$ erroneous diagnoses = 59; $\chi 2 = 160.9$; $df = 1$; $p \leq 0.001$

is currently under debate. The Polish scientists: Kasprzak (1991), Ziółkowska-Łajp (1993) and Łęczyńska (2001), are of opinion that there is not enough evidence to justify regarding lip furrows as sex-distinguishing character. According to Vahanwala et al. (2005), Augustine et al. (2008), Bindal et al. (2009), Saraswathi et al. (2009), Singh et al. (2011) and Sandhu et al. (2012) it is possible to identify sex based on lip prints.

Our studies suggest that the identification is more often correct in the case of females which is in agreement with the results of Vahanwala et al. (2005) and Gondivkara et al. (2009).

Sex identification based on the analysis of the mid-section of lower lip yielded 73.1% correct diagnoses. The assumptions of the method are clearly specified; hence the results are more objective.

The situation is different when using Vahanwala's method, since some of his assumptions can be mutually exclusive. The lip furrow patterns are very diverse, and one quadrant usually contains more than one pattern. Because of this in our opinion sex identification with this method is very subjective in cases when, among others, type I appears in quadrant I (female), and type II in quadrant II (male). Besides, as shown by the earlier analysis of the occurrence of the patterns in individual quadrants, type III appears also on the lower lip in females, and thus one of Vahanwala's assumptions is practically invalid. Despite these inconsistencies, the test team using this method diagnosed correctly on average 57.3% of the cases, and the best juror estimated correctly as much as 72.0% of the prints. We regard this method as inexact and, compared to the other methods, subjective.

The third method, with its seven assumptions based on our own observations of the frequency of the lip furrow patterns, yielded correct identification of 79.8% of the prints, and the best juror identified correctly 92.0% of the prints.

According to Vahanwala et al. (2005), their method is reliable for females and less so for males. Such conclusions may be a result of the small size of their sample. Our observations indicate that it is not reliable for any sex.

Using the three methods of sex identification provided a picture of potential of cheiloscopy in sex identification. Studies using large and ethnically varied samples are worth continuing; the results would be more objective and reliable.

Conclusions

1. Our own method offers the greatest probability of correct sex identification; with Vahanwala's method such probability is the smallest.
2. The attempt at sex identification based on lip furrow pattern shows that each of the three methods is more reliable in the case of females.

Authors' contributions

AT designed the study; AT, KB acquired the data, analysed and interpreted the data; KB, AT drafted the manuscript; DN, KB is the co-author of the final version of the manuscript; DN is the correspondence author. All authors critically read and approved the final manuscript.

Conflict of interest

The authors declare no conflict of interests.

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