Digital method for lip print analysis: A New approach

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Abstract

Aim: To evaluate the uniqueness and to define a standard method for the analysis of lip prints. **Materials and Methods:** Lip prints of 100 students were taken using Scotch tape without any distortion. These prints were then scanned for the digital analysis. Using Adobe Photoshop 7 software an attempt was made to trace each and every line using Suzuki and Tsuchihashi's classification. Weighted value scoring system was used to check for the uniqueness of the lip prints. **Results:** No two lip prints had exactly matching scores in all four Quadrants. No statistically significant difference was found in the change of pattern in lip print images collected after 12 months from the same individual. With digital analysis, up to 15 lines were traceable in 66%, 71%, 52% and 51% of Quadrant I, II, III and IV respectively. **Conclusion:** Lip prints are unique to an individual. The digital method of analyzing lip print images serves better visualization, ease in identification and recording of the lip print pattern. Weighted Value Scoring system can be considered as a standard method for determining the uniqueness of the lip prints.

Key words: Cheiloscopy, digital analysis, lip prints, lip score, weighted value

Introduction

Identification is a matter of paramount importance in any crime investigation. Even though DNA and fingerprints are the time-tested methods, these evidences are not always available at the investigation sites. In such circumstances, it is necessary to apply different and less-known techniques. A new area of investigation in the detection of crime is the use of wrinkles on the lips. Cheiloscopy (Quiloscopy) is a method of identification of a person based on characteristic arrangement of lines appearing on the red part of lips. Very little has been said or written about the application of lip prints in these days of advanced scientific crime detection. In view of the need of forensic dental services in the different parts of our country it was found necessary to do research on the use of lip prints for person identification. It was therefore decided to carry out a pilot study to evaluate the uniqueness of the lip prints and their stability over a period of time. The authors have introduced the Weighted Value Scoring system for the first time to calculate the LIP SCORE for each lip in an intention to settle once and for all the question of the uniqueness of the lip print. It was felt that such a study would prevent one of the most important forms of evidence from being overlooked.

The studies done so far[1-9] depended on the manual method for the lip print analysis which has its own demerits. The information that is lacking in the research of cheiloscopy is an accurate methodology for lip print collection and a standard method for its analysis. The present study was also aimed to develop an ideal methodology for lip print collection that provides minimal distortion and greater clarity of the image. The study has been designed to carry out the analysis of the lip prints using computer software program, 'Adobe Photoshop 7.0' for the first time.

Materials and methods

A pilot study was conducted at the Oral Medicine, Diagnosis, and Radiology Department of the Goa Dental College and Hospital, Bambolim, Goa – 403 202, India. The study comprised 100 subjects selected from amongst the students of the Goa Dental College and Hospital, Bambolim, Goa, India, whose ages ranged between 19 to 28 years. Subjects with inflammation, ulcers, trauma, congenital developmental defects and malformation, deformity and surgical scars (e.g. operation for cleft lip) and other abnormalities of lips were excluded because of their unsuitability for this investigation either because the defect itself was enough for identification or the clinical condition precluded from enrolling the individual in this study. Subjects with allergy to cosmetics (lipstick) were also excluded from the study. Informed consent of the subjects was taken and they were explained that they would be a part of a Research Program wherein cosmetics had to be used for recording the lip prints. The object being the human mouth, special attention was paid to the cleanliness and hygiene while recording the lip prints by giving a prophylactic antiseptic mouth rinse followed by cleansing of the upper and lower lips with Povidone-Iodine cleansing solution. Lipstick application was done stepwise. Firstly the boundaries of the lips were marked with a red-colored (Lakme) lip liner to confine the lipstick application within the marked area. The tip of the lip liner was later cleansed with a cotton ball dipped in 'Pure Hands', a herbal hand cleanser, prior to using it on the next person. Lipstick was then uniformly applied with the help of a lipstick application brush in a systematic manner to avoid the smudging of the lipstick in the grooves. Once the application of the lipstick to one lip e.g. upper lip, was over, the subject was made to wait for 30 sec for drying of the lipstick. He or she was told to keep the teeth in occlusion and gently retract the opposing lip when the print of the concerned lip was being taken. Lip print was then obtained using 14-mm wide and 50-mm long Scotch tape with gentle pressure on either side. Since the human lips are so mobile that the strength or the direction of the pressure applied and even the minimal movement of the lip can affect the accuracy of the lip print taken, the subject was strictly advised not to change the position and avoid any movement of the lips during the procedure of recording the lip print. The Scotch tape was then stuck onto a plain white A4 size bond paper, with the details like the Serial No., the Name of the Subject and the Date of recording of the Lip Print mentioned on the page. The same procedure was then repeated to record the print of the lower lip. Recording of the upper and lower lip prints together was also done using Cellophane Tape (Width: 50 mm and Length: 50 mm), to aid in confirming the midline of the upper and the lower lip. Cleansing agent (Lakme) was used to clean the lips after the procedure. The used lipstick application brush was washed with water and the tips were immersed in diluted 0.5% Sodium Hypochlorite solution for 30 min and washed with water again prior to reuse. Each time while taking the lipstick with the application brush, a separate chemically sterilized brush was used in order to avoid the cross-contamination of the lipstick.

The lip print was then scanned (256 gray shades at a resolution of 300 dpi) for the digital analysis. Using various applications of Adobe Photoshop 7 software an attempt was made to trace each and every line. K. Suzuki and Y. Tsuchihashi's classification was followed to define the patterns of the grooves.[1,2] Strict criteria were followed to define Type II, III and IV pattern. While recording Type II pattern, only those lines that bifurcate, with the bifurcating lines not in the same straight line as the leg of the 'Y' were considered whereas lines showing trifurcation and multiple branching appearance were considered as Type V. Lines that intersect forming an 'X' pattern, without having any superimposition and the length of the arms of 'X' being almost equal from the point of intersection were considered as Type III pattern. Lines showing multiple interconnections and difficult to categorize in Type I to IV were directly considered as Type V. Each type of pattern was given a color code while recording it digitally as pink, blue, green, red, yellow and orange for Type I to V respectively.

Upper and lower lip print images were categorized into two quadrants each, thus producing a total of four quadrants. The four quadrants were named as follows: Upper Right as Quadrant I, Upper Left as Quadrant II, Lower Left as Quadrant III and Lower Right as Quadrant IV. Classified groove patterns were recorded by employing the dental formula generally used. Thus by noting the classified types of grooves, the individual's lip print pattern was recorded [Figure 1].

In each quadrant, the first 15 lines appearing from the midline to the periphery were recorded in 15 columns. Each pattern was given an Arabic numeral scoring in the following manner and as shown in Table 1. Weighted values
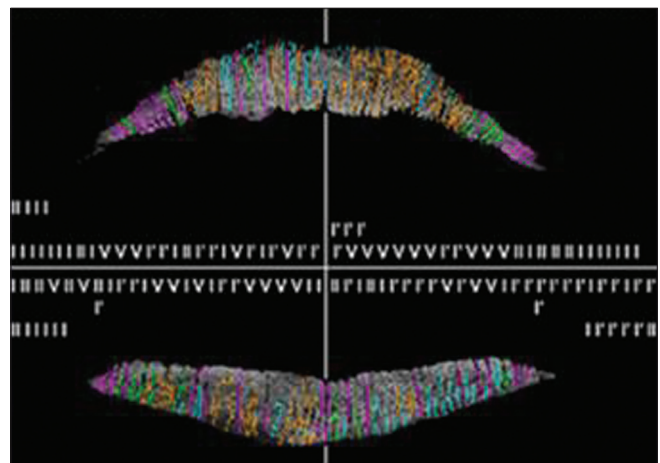

Figure 1: Lip print image with various color-coded grooves

were given for the lip lines in the descending order from 15 to 1 with reference to their position from the midline. The product of the Arabic Numeral Score of the line and the weighted value of the line vis-à-vis its position from the midline was given as the lip line score. More weightage was given for the lines appearing in the center than at the periphery because this is the part of the lip which comes more in contact with any surface, and is the part often recorded without much distortion and smudging. By summing the weighted lip line score values, lip score in each quadrant for an individual subject was calculated. By adding the scores of all the four lip quadrants the LIP SCORE for each person was calculated to check for the uniqueness of the lip prints.

Subject and quadrant-wise display of lip scores including subject and upper lip (Quadrant I, II, I +II) and lower lip (Quadrant III, IV, III + IV) and total lip score for an individual (Lip scores of Quadrant I + II + III + IV) was also charted.

The same procedure was repeated after a one-year interval to evaluate the stability of the lip prints.

Results

It was observed that no two lip prints had exactly matching scores in all four quadrants. There were a number of cases where the lip score in a particular quadrant was the same but their lip scores in other quadrants differed and consequently so did their total lip score [Table 2A-D and Table 3].

The total lip score i.e. Quadrant I + II + III + IV was unique for individual lips except for A – 70 and A – 74 having the score of 2352 and A – 77 and A – 80 sharing the same score of 2118 [Table 3].

Wilcoxon Sign Rank Test was used to check the stability of the lip prints over a period of time. No statistically significant difference was found in the change of pattern in lip print images collected after 12 months from the same individual, even after exposure of the lips to the seasonal variations and minor or superficial trauma.

The technique followed for collection of the lip prints using lipstick as a recording media and Scotch Tape as a transferring media provided clear and definable lip print image.

Digital method provided better visualization of the image and was convenient for analyzing the lip print pattern.

Various Type V patterns encountered in the current

Table 1 Arabic Numeral Scoring for the Individual Pattern

Suzuki & Tsuchihashi's Lip Print Pattern	Arabic Numeral Scoring
Type I	1
Type I	2
Type II	3
Type III	4
Type IV	5
Type V	6

Table 2: - lip score in quadrants I, II, III, IV, I + II, III + IV, I + II + III + IV

Part – 'A' lip score in quadrants

Subj	I	II	I + II	III	IV	III + IV	I + II + III + IV
1	559	558	1117	159	159	318	1435
2	343	397	740	278	306	584	1324
3	601	548	1149	436	313	749	1898
4	476	483	959	187	317	504	1463
5	450	468	918	504	450	954	1872
6	426	371	797	451	282	733	1530
7	867	627	1494	390	504	894	2388
8	552	504	1056	410	552	962	2018
9	426	552	978	387	525	912	1890
10	298	366	664	223	389	612	1276
11	533	338	871	252	329	581	1452
12	537	497	1034	327	268	595	1629
13	366	258	624	429	233	662	1286
14	450	584	1034	328	215	543	1577
15	395	606	1001	323	272	595	1596
16	433	553	986	504	450	954	1940
17	909	1007	1916	90	90	180	2096
18	481	297	778	450	448	898	1676
19	552	450	1002	282	324	606	1608
20	534	405	939	277	439	716	1655

Cont........

Table 2: - lip score in quadrants I, II, III, IV, I + II, III + IV, I + II + III + IV

Part – 'A' lip score in quadrants

Subj	I	II	I + II	III	IV	III + IV	I + II + III + IV
21	232	198	430	344	187	531	961
22	579	579	1158	357	487	844	2002
23	531	562	1093	233	321	554	1647
24	405	476	881	168	486	654	1535
25	229	281	510	297	245	542	1052
26	508	342	850	235	100	335	1185
27	496	500	996	448	461	909	1905
28	384	528	912	471	591	1062	1974
29	467	389	856	422	420	842	1698
30	672	700	1372	720	720	1440	2812
31	318	501	819	543	585	1128	1947
32	493	588	1081	609	414	1023	2104
33	579	537	1116	504	552	1056	2172
34	249	207	456	179	177	356	812
35	164	211	375	361	364	725	1100
36	330	262	592	337	339	676	1268
37	357	469	826	258	298	556	1382
38	424	295	719	168	285	453	1172
39	454	281	735	594	552	1146	1881
40	687	605	1292	324	405	729	2021
41	199	360	559	216	139	355	914
42	0	0	0	0	0	0	0
43	361	476	837	544	554	1098	1935
44	507	601	1108	403	392	795	1903
45	330	295	625	450	450	900	1525
46	540	588	1128	390	324	714	1842
47	630	470	1100	230	446	676	1776
48	556	635	1191	542	608	1150	2341
49	531	596	1127	609	468	1077	2204
50	580	559	1139	642	642	1284	2423
51	318	265	583	434	499	933	1516
52	512	481	993	521	651	1172	2165
53	302	357	659	378	297	675	1334
54	458	551	1009	543	436	979	1988
55	398	362	760	0	554	554	1314
56	0	0	0	0	0	0	0
57	529	499	1028	675	660	1335	2363
58	401	493	894	222	204	426	1320
59	334	374	708	277	246	523	1231
60	594	614	1208	476	464	940	2148
61	516	624	1140	281	430	711	1851
62	485	475	960	537	479	1016	1976
63	705	672	1377	630	630	1260	2637
64	639	694	1333	503	397	900	2233
65	505	475	980	627	714	1341	2321
66	726	605	1331	385	660	1045	2376
67	660	552	1212	594	476	1070	2282
68	282	350	632	426	552	978	1610
69	314	662	976	293	433	726	1702
70	618	642	1260	542	550	1092	2352
71	1033	1014	2047	310	341	651	2698

Cont........

Table 2: - lip score in quadrants I, II, III, IV, I + II, III + IV, I + II + III + IV

Part – 'A' lip score in quadrants							
Subj	I	II	I + II	III	IV	III + IV	I + II + III + IV
72	0	0	0	0	0	0	0
73	684	660	1344	702	684	1386	2730
74	702	450	1152	627	573	1200	2352
75	0	0	0	0	0	0	0
76	714	720	1434	696	681	1377	2811
77	435	522	957	684	477	1161	2118
78	694	660	1354	636	639	1275	2629
79	194	399	593	555	492	1047	1640
80	714	645	1359	375	384	759	2118
81	513	435	948	222	330	552	1500
82	314	307	621	224	120	344	965
83	687	669	1356	660	594	1254	2610
84	690	587	1277	390	390	780	2057
85	0	0	0	301	239	540	540
86	306	213	519	0	0	0	519
87	702	660	1362	630	552	1182	2544
88	552	660	1212	157	206	363	1575
89	450	552	1002	288	321	609	1611
90	365	397	762	247	219	466	1228
91	244	350	594	433	223	656	1250
92	565	509	1074	654	594	1248	2322
93	313	506	819	444	496	940	1759
94	314	340	654	318	233	551	1205
95	594	612	1206	394	412	806	2012
96	312	418	730	159	390	549	1279
97	573	457	1030	317	333	650	1680
98	243	548	791	269	427	696	1487
99	366	414	780	392	393	785	1565
100	542	504	1046	159	159	318	1364

study included Cartwheel Appearance, Pineapple Skin Appearance, Trifurcations, Bridge or 'H' pattern, Horizontal Lines (predominantly found in the centre of the upper lip), and Multiple Branching Appearance (predominantly found at the lateral or peripheral aspect of the lower lip).

Discussion

Cheiloscopy (Quiloscopy) can be defined as a method of identification of a person based on the characteristic arrangement of lines appearing on the red part of lips, or as a science dealing with the lines appearing on the red part of lips.[10] It was first described by R. Fischer[10,11] in 1902. Since 1950 the Japanese have carried out extensive research in the matter.[1-3] Lip prints can be used with equal reliability in identification as fingerprints since it is claimed that no two individuals have identical lip prints.[1,3] Apart from identification and evidential use, lip prints may also be used in detection work, being the source of tactical and criminalistic information. A lip print at the scene of crime can be a basis for conclusions as to the character of the event,

the number of the people involved, sexes, cosmetics used, habits, occupational traits, and the pathological changes of lips themselves.[11] Criminals make attempts to conceal their identity and try to destroy the finger skin pattern by self-inflicted wounds, by application of corrosives or by abrading the skin. These kinds of manipulations are unlikely to be inflicted by the criminals on their lips. Hence taking lip prints of all the suspected individuals and comparing them with the items found at the scene of crime could give conclusive evidence about the presence of a person at the crime scene. The other investigations become easier once the involvement of a suspect at the scene is confirmed.

Collection and recording of the lip prints

The lip crease pattern is on the vermilion border of the lip, which is quite mobile and lip prints may vary in appearance according to the pressure, direction and method used in making the print. If lipstick is used as a recording medium the amount applied may also affect the print. Hence a good method is required for the collection of the lip prints with suitable transferring and recording media. Various

Table 3: Subjects with the same lip score Quadrant I, II, III, IV, I + II, III + IV and I + II + III + IV.

Quadrant	Subjects	Scores	Quadrant	Subjects	Scores
I	A − 69, 82, 94	314	II	A − 25, 39	314
	A − 31, 51	318		A − 38, 45	318
	A − 36, 45	330		A − 68, 91	330
	A −13, 99	336		A − 2, 90	336
	A − 6, 9	426		A − 19, 74	426
	A − 5, 14, 89	450		A − 62, 65	450
	A − 23, 49	531		A − 24, 43	531
	A − 8, 19, 88	552		A − 8, 100	552
	A − 22, 33	579		A − 3, 98	579
	A − 60, 95	594		A − 9, 67, 89	594
	A − 40, 83	687		A − 40, 66	687
	A − 76, 80	714		A − 73, 78,87, 88	714

Quadrant			Quadrant		
III	A − 1, 96, 100	159	IV	A − 1, 100	159
	A − 24, 38	168		A − 13, 94	233
	A − 58, 81	222		A − 23, 69	321
	A − 20, 59	277		A − 84, 96	390
	A − 7, 46, 84	390		A − 5, 16, 45	450
	A − 18, 45	450		A − 8, 33, 39, 68, 87	552
	A − 16, 33	504		A − 43, 55	554
	A − 48, 70	542		A − 83, 92	594
	A − 31, 54	543		A − 57, 66	660
	A − 39, 67	594			
	A − 32, 49	609			
	A − 65, 74	927			
	A − 63, 87	630			

Quadrants			Quadrants		
I + II	A − 31, 93	819	III + IV	A − 1, 100	318
	A − 12, 14	1034		A − 23, 55	554
	A − 67, 88	1212		A − 12, 15	595
				A − 36, 47	676
				A − 45, 64	900
				A − 60, 63	940
				A − 5, 16	954

Quadrants			Quadrants		
I + II + III + IV	A − 77, 80	2118	I + II + III + IV	A − 70, 74	2352

Table 4: Number of lines recorded in Quadrant I, II, III and IV

No. of lines recorded	Subjects			
	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
≥ 15 Lines	25	33	11	13
10 − 14 Lines	41	38	41	38
5 − 9 Lines	27	22	35	37
1 − 4 Lines	2	2	7	7
0 Lines	5	5	6	5

methods have been followed till today for recording the lip prints. [3-5,12] The method that was preferred in the present study was using a Scotch tape.

The authors tried using cellophane tape, paper roller, dabbing of the lips against the paper and Scotch tape for recording the lip prints. Conventional powder method and photography were also tried. The lip prints are on the zone of transition of the lips which are extremely mobile. Smudging of the prints due to excessive or uneven pressure was noticed in subjects with prominent upper and/or lower lip when cellophane tape or paper roller was used to collect upper and lower lip print together. When the subject is asked to press his or her lips against the folded paper, there is a possibility of only the central area coming in contact with the paper and in doing so the rest or the relaxed position of the lips is not achieved which invariably

leads to distortion of the prints. In conventional powder methods the brush tends to smear or leave streak marks on the print. These streak marks may then be interpreted as false characteristics by the comparer. Photographing of the lips was found to be very tricky and subject to errors as the central area of the lips and the angles of the lips are never in the same plane which leads to focusing errors resulting in blurred or partial images of the lips. This invariably calls for recording the lip prints and then photographing them and then comparing the two photographs. Thus in spite of being a reliable method in other areas of forensics, in the recording of lip print images it adds to the cost but does not enhance the clarity in the same rising proportions.

Since recording of the lip print becomes the fundamental exercise, the method adopted in the present study could be advantageous. Firstly, clear prints can be obtained including the peripheral grooves. Smaller width of the tape helps in its application along the curvature of the lip without any interference of the opposing lip (if properly retracted) and nose. Upper and lower lip print images can be recorded separately with minimal distortion in subjects having either one or both, upper-lower prominent lips or excess curvature of the lips. It is convenient to learn and easy to master the technique. The cost of the tape is also less.

Classification of the lip prints

The classification that was followed in the present study was Suzuki and Tsuchihashi's classification which is generally followed by most of the authors because of its accuracy and simplicity. Strict criteria were followed while considering all the types of patterns to avoid intra-observer bias. The authors would like to suggest some modifications with respect to the classification to make it more precise and accurate and standardize the readings of the various studies conducted by other workers in the country and elsewhere. This will help us in comparison of the various parameters in a greater sample size by following a standard classification. The following modifications are suggested, especially for Type I', Type II and Type V pattern. According to Suzuki and Tsuchihashi's classification Type I' is a straight groove that disappears halfway into the lip instead of covering the entire breadth of the lip. This pattern can be further classified into: Type I'A-A straight groove appearing from the outer margin of the lip to the inner aspect and Type I'B-A straight groove appearing from the inner margin of the lip to the outer aspect. Type II is grooves that fork or bifurcate in their course or a branched groove. This pattern can be further classified into: Type II A – grooves that bifurcate in the outward direction and Type II B—grooves that bifurcate in the inward direction. Type V—grooves that do not fall into any of the above categories and cannot be differentiated morphologically. Instead of just giving a generalized term as Type V pattern, it is found necessary to sub-classify the Type V pattern wherever possible, so as to give a more

defined term that will further add to the accuracy of the classification. The current study reports six new patterns which are considered as Type V pattern.

Analysis of the lip prints

Various studies[3-5] have used magnifying lens to record lip prints. The current study has adopted an indirect digital method by scanning the lip print images in Adobe Photoshop 7 with 256 gray scale, 300 dpi resolution for better visualization of the image and recording each type of the groove patterns with assigned color code as mentioned thus ensuring the recording of each line without missing a single one and also eliminating an error of recording the same groove twice which is most likely to occur with manual recording.

The digital method adopted in the present study has various advantages due to its features like zooming, enhancement, layers and drawing tool. Adobe Photoshop is a popular software program, which allows for a multitude of imaging features, functions, enhancements and metric analysis. The initial working image can be enlarged using the zoom tool. The only limitation is the very high resolution of the image (300 dpi) required to avoid pixellation (fuzziness) of the magnified picture. Regardless of the method by which an image is captured, once it has been digitized, several computerized enhancements can be performed on the image. Brightness and contrast can both be altered. This gives us the chance to "salvage" an image that is either too dark or too light. There is a limit to the ability of salvaging poor images. An image in which all of the pixels have been saturated (too dark) or where the noise (useless information) in the system overwhelms the signal (useful information), cannot be saved. Image contrast can also be manipulated by altering the gradient of the gray levels in the image. Again, there is a limit to how much contrast can be altered. Manipulating the image contrast cannot salvage an image in which the subject contrast is inadequate. With layers, we can work on one element without disturbing others. To rearrange elements, simply shift the order in the layers palette. We can lock layers to prevent accidental changes, hide them to get a clear view of the element we are working on, and link layers to move them as a group. The layers palette also makes it easy to apply instant, editable effects including blending modes, adjustment layers, and layer effects. Resolution-independent vector shapes can be drawn instantly with the line, rectangle, ellipse, polygon, and custom shape tools. This method also has certain disadvantages.

Direct digital imaging indicates that the original image is captured in a digital format, i.e., the image is made up of discrete packets of information called pixels (picture elements).On the other hand, indirect digital imaging implies that the image is captured in an analog or continuous format and then converted into a digital format. As with any data conversion, this analog to digital conversion (ADC)

results in the loss and alteration of information. Instead of capturing the border that traverses a particular pixel, the pixel value is averaged. This is called partial volume averaging. Consequently, many edges are lost or distorted in an analog to digital conversion.

Total recorded lip lines

Sivapathasundharam B. and Prakash P. A.[5] have taken the middle part of the lower lip, (10-mm wide) as a study area, since this fragment is almost always visible in any trace.

The current study has made an attempt to record each and every line of the entire lip starting from the midline to the periphery. In some subjects, the lip lines were very clear and were easily identified but in some lips only a few lines could be recorded and in others, the lines were not identifiable because of the poor quality of the image. The number of the lines recorded quadrant-wise is shown in detail in Table 4. With the help of digital analysis, up to 15 lines were traceable in 66% of Quadrant I, 71% of Quadrant II, 52% of Quadrant III and 51% of Quadrant IV images. The reason for some of the images showing very few or non-recordable lines can be attributed to the inherent anatomy of the lips, technical error and processing error. Thin lips, recessive lips, inverted lips, excessive prominence either in the center or lateral portion of the lips, excessive curvature of the lips, fine groove pattern on the lips, all these factors can affect the quality of the lip print image. The lips are two highly mobile fleshy folds surrounding the orifice of the mouth. The anatomy of the lips varies from person to person. They may be full or thin, wide or narrow, short or long, generally in response to genetic data and the form of the teeth. The inclination of the teeth may cause the lips to be excessively prominent or recessive. In the edentulous person the lips recede, increasing the prominence of the nose and chin, since the inter-arch distance may be reduced and the nose and chin tend to approximate each other. With thin, recessive and inverted lips it is difficult to record the lip print using any of the above methods. Excessive prominence in any part of the lips or excessive curvature of the lips leads to pressure areas resulting in distortion of the image. In such cases a compromise has to be made over the lateral areas so as to clearly record the central area with minimal pressure. With fine groove pattern on the lips, there is all possibility of excess lipstick getting smudged in the grooves resulting in a distorted image.

Excessive application of the lipstick leads to smudging of lipstick in the grooves and thus unclear groove pattern. Lips being highly mobile, minimal variation in the pressure application while recording the lip print using Scotch tape or any other method can lead to distortion of the image. Variation in the posture of the lip i.e. contraction or stretching of the lips during the procedure of recording can either lead to overlapping of the grooves or clear area without any groove pattern, thus causing distortion of the image.

Mobility of the lips is nature's creation, and an error caused because of this nature of the lips could not be avoided. But an effort was made to minimize the technical error and to standardize the technique of recording the lip prints. For uniform application of the lipstick, a lipstick application brush was used with vertical strokes of the brush starting from the outer to the inner aspect of the lip. Care was taken to evenly apply the pressure while recording the lip prints with Scotch tape. For standardizing the posture of the lips while recording, the subject was advised to keep his/her teeth in occlusion and lips relaxed and strict instructions were given to stabilize this posture during the procedure of recording the lip print. A set of images were recorded and the image with minimal distortion and clear groove pattern was selected for analysis.

Processing errors are the errors expected to occur in Indirect or Scanned Digital Method as described above. The data loss that occurs due to the averaged pixel value in an analog to digital conversion leads to decreased contrast between the creases (white areas) and the ridges (dark areas) and thus may lead to a decreased contrast or an image with minimal recordable grooves.

Uniqueness of the lip prints

No two lip prints were found to have similar characteristics which was in agreement with the previous studies reported. [3,4] The combination of the six types of grooves is, theoretically, 6^6 X 4, and if they are entered in the dental formula the advisable method is to select the first groove from the median line, and then, focusing on the chief construction of the second group of grooves, to compare the peculiarities and the details with the control.[13]

To determine the uniqueness, the current study adopted a scoring method wherein weighted value in descending order from 15 to 1 was given for the lip lines starting from the midline to the periphery. Total lip score for each quadrant i.e. Quadrant I, II, III, and IV was then calculated along with the score of the individual lips i.e. Quadrant I + II, Quadrant III + IV and the total score of the lip i.e. Quadrant I + II + III + IV. These scores were then compared to check the uniqueness of the individual lip prints.

It was found that the total lip score i.e. Quadrant I + II + III + IV was unique for individual lips except for A–70 and A–74 having the score of 2352 and A–77 and A–80 sharing the same score of 2118. Although the total lip score in above cases was matching, they differed in the individual quadrant score viz. scores of A-70 in Quadrant I - 618, Quadrant II – 642, Quadrant I + II – 1260, Quadrant III – 542, Quadrant IV – 550 and in Quadrant III + IV – 1092 whereas scores of A–74 in Quadrant I - 702, Quadrant II – 450, Quadrant I + II – 1152, Quadrant III – 627, Quadrant IV – 573 and in Quadrant III + IV – 1200. Scores of A -77 in Quadrant I - 435, Quadrant II – 522, Quadrant I + II – 957, Quadrant III – 684,

Quadrant IV – 477 and in Quadrant III + IV – 1161 whereas scores of A–80 in Quadrant I - 714, Quadrant II – 645, Quadrant I + II – 1359, Quadrant III – 375, Quadrant IV – 384 and in Quadrant III + IV – 759.

There were a number of cases where the lip score in a particular quadrant was the same but their lip scores in other quadrants differed and consequently so did their total lip score [Table 2 and Table 3].

It was observed that no two lip prints had exactly matching scores in all four Quadrants. The scores were differing either in the individual Quadrants i.e. I, II, III or IV or in the sum of the two Quadrants I + II or III + IV or in total lip score i.e. Quadrant I + II + III + IV.

Our method appears to settle once and for all the question of uniqueness of the lip print as it employs whole numbers and thereby is an open-ended method since the last 'whole number is yet to be written, whole numbers being infinite'. Thus each individual is assured with his or her own lip identity card number!

Stability of the lip prints

Injuries to the skin, such as cuts, burns and abrasions, may affect the alignment of ridges and may even result in the destruction of some. Superficial injuries cause only temporary damage; on healing, the patterns and details of the ridges appear as before. When, however, the skin is injured causing destruction of the dermal papillae, scars are formed which result in permanent distortion of the ridges.[14]

However, the author has not come across any such detailed studies being done on the lips. Histologically the lip can be divided into three parts, outer skin of the lip that consists of keratinized stratified squamous epithelium in which hair follicles, sweat glands and sebaceous glands can be seen, the vermilion border or the red margin of the lip which is very thin keratinized epithelium with no hair follicles or sweat glands and the submucosa of the lip, composed of dense connective tissue containing blood vessels, nerves and mixed seromucous glands. Being an intermediate zone, the lip is composed of the histologic features of the skin as well as the oral mucosa. Healing response depends upon the depth of the wounds even in the case of lips. But whether the destruction of the dermal papillae leads to scar formation in lips like in the case of skin cannot be said with certainty. Also, the depth of injuries leading to scar formation in lips is yet to be investigated. TsuchihashiY[13]studied lip prints by recording them routinely once a month for three years for comparative study. No change was observed during this time. The author also studied the samples of the lip prints of the same individual taken at six-monthly intervals. He has illustrated the serial observations made on the lip print every day (except Sundays and holidays) for nine weeks which revealed no changes.

Vahanwala S. P. and Parekh B. K.[4]confirmed that the labial wrinkles and grooves of each individual were identical with the ones taken four months earlier.

To determine the stability of the lip prints, the current study collected the lip prints 12 months (Part B) after the initial collection (Part A). An interval of 12 months was kept to check the effect of any seasonal variation or healing response of the lips to inflammation on the groove pattern if present. None of the subjects gave history of any deep injuries to the lips, but there was history of cracking or chapping of the lips in the winter.

Lip print images of all the subjects were collected after 12 months in a similar manner as in Part A. Nine subjects dropped out of the study, hence their lip prints could not be recorded. The author has considered equal number of lines for comparison of Part A and Part B of the study. Using Wilcoxon Sign Rank Test, each line in Part A was compared to that of Part B for determining any statistically significant changes in the groove pattern that had occurred after 12 months. The statistical results of comparison showed no significant changes in the first 15 lines in all four quadrants in a study repeated after one year.

Further studies are required to be carried out on a larger population to evaluate the uniqueness using the digital method for analyzing the lip prints. Studies in the field of healing pattern and the effect of deep injuries over the groove pattern on the lips are recommended.

Conclusions

The following conclusions can be drawn from the observations of the current study:

Lip prints are unique to the individual which can be explained on the basis that no two individuals in the studied group had an exactly matching lip score in all four quadrants.

Lip prints remain stable over a period of time. No statistically significant difference was found in the change of pattern in lip print images collected after 12 months from the same individual, even after exposure of the lips to the seasonal variations and minor or superficial trauma.

Thus from the above statements, it can be concluded that lip prints can be used as an evidence or a positive means of person identification just like fingerprints.

The technique followed for collection of the lip prints using lipstick as recording media and Scotch tape as transferring media with proper stabilization of the lips while recording can be adopted as a good technique to obtain a definable lip print image.

The digital method of analyzing the lip print images using Adobe Photoshop 7 software serves as a convenient method that provides better visualization and ease in recording and identification of the lip print pattern. It also serves as an ideal method of permanently storing the data which will help in keeping an ante- mortem record of an individual.

Weighted Value Scoring system used for the first time to calculate the lip score (quadrant-wise, lip-wise, and the total score), appears to settle once and for all the question of the uniqueness of the lip print as it employs whole numbers and thereby is an open-ended method since the last 'whole number is yet to be written, whole numbers being infinite'.

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