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Quantitative Analysis on Facial asymmetry: A Review

Aida Khairunnisaa[1], Hassrizal Hassan Basri[2], Shafriza Nisha Basah.
School of Mechatronic Engineering, University Malaysia Perlis
[1]aidakhairunnisaa@yahoo.com, [2]hassrizal@unimap.edu.my

Abstract- A quantitative analysis is steadily rising in clinical application either in diagnostic system or rehabilitation system. Currently, the three-dimensional digital models have been the main focus among researchers in the application of image processing area. The purpose of the review is to focus on evaluating the researches on craniofacial deformities applications as a guideline for facial paralysis diagnostic system. The subject data of the review was searching using Pud Med, Springer, IEEE, Elsevier, NIH Public Access, PMC, Scielo, Pub Facts and Cite Seer. From published articles, 35 articles were selected and satisfied the criteria of the studies. The data extracted into five categories: Year of publication, disease approach, system used, reference points or areas used and size of the sample.

Keywords- Facial asymmetry, quantitative analysis, 2D images, Points of face,

1. Introduction

Usually, facial asymmetry happens in two ways, either by external factors like expression, lighting direction and angle of view, or by internal factors like craniofacial deformities, injury and age-related changes [39]. Based on Farkas's research, facial asymmetry is a common difference as long as the average measurement between left and right of face about 3mm or 3% [40].

Practically, the specialist doctor and a medical practitioner will observe the condition of the asymmetry of patients face based on measuring certain different points between the two sides of face manually before recommending suitable treatment for their patients[36]. However, the evaluation made has a low degree of consistency and potentially prone to diagnostic error due to its dependency of subjective memories and experiences of an expert. Because of that, a lot of research has shown their effort in diagnosis and rehabilitation field using various approaches in order to help the specialist doctor and a medical practitioner doing their work. This review is to gather the discovery of other researchers in order to evaluate their performance and achievement in each type of approach for the treatment applications.

FP diagnosis is about quantifying the asymmetry of important features on the face such as eyes, nose and mouth. Based on this fact, this review has gathered a few researches which related to any Craniofacial deformity treatment in term of their disease approach, system used, reference points, and size of their sample.

2. Methodology

A. Search Strategy

The review process started on January 21, 2013 to search for articles and possible reviews on quantitative analysis in craniofacial deformities specifically for facial paralysis and cleft lip and palate in Pud Med, Springer, IEEE, Elsevier, NIH Public Access, PMC, Scielo, Pub Facts and Cite Seer databases. The terms used for the search strategy are concerning about Facial Paralysis and Cleft Lip and Palate (CLP).

B. Selection Process

The records for articles found through the database are 171 articles. Based on abstracts of the articles found, there were duplication of articles were identified. Besides that, after going through all the articles, some of them do not meet the inclusion criteria. The criteria mention included the study case in the field of craniofacial and using the image processing system in face area. For the articles that focus other than face area, using a system like EEG or EMG and the study case is psychology area has been removed from this review.

After the screening process, the number of articles is 118 articles. Then, for the eligibility of the articles for this review, the selection is based on the craniofacial deformities study, quantitative analysis for treatment application based on symmetry of the face. Finally, the selected articles those qualified for this review are 35 articles.

3. Result

A. Publication Year

The selected articles were published from 1994 to 2014:

- 2014: 2 article published[16,33];
- 2013: 1 articles published[19];
- 2012: 5 articles published[11,17,23-25];
- 2011: 1 articles published[10];
- 2010: 8 article published[6-9,15,21,26,34];
- 2009: 3 article published[22,27,28];
- 2008: 2 article published[14,29];
- 2007: 2 article published[5,35];
- 2006: 2 article published[13,32];
- 2004: 2 article published[20,30];
- 2003: 3 article published[4,18, 31];
- 2001: 1 articles published[12];
- 1995: 2 article published[2,3];
- 1994: 1 articles published[1];

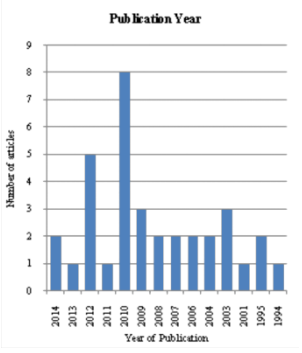


Fig. 1: Articles distribution according to year of publication.

B. Disease Approached

Disease distribution according to the number of articles that focus on each condition, as follows:

- Cleft lip and palate – addressed by 16 articles (13 articles: UCLP [1-8,10-14], 1 article: BCLP [6], 3 articles: ICP [6-8],2 articles: RCLP [9,15],2 articles: CLP [21,22],1 article: CL[21]);
- Facial Paralysis – addressed by 16 articles (5 articles: Bell's Palsy[16,18,19,27,31],1 article: Ramsey Hunt Syndrome [27],1 article: Trauma [27], 11 articles: Disease are not specific [17,20,23-26,28-30,32,33]);
- Class III Malocclusion – addressed by 3 articles[7-8,34];
- Acoustic Neuromas– addressed by 1 article[18];
- Facial Neuromas– addressed by 1 article[18];
- Dysmorphology (DSM-IV) for Schizophrenia – addressed by 1 article[35];

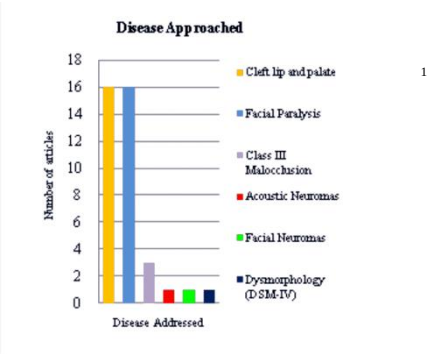


Fig. 2: Diseases distribution according to the number of articles that focusing on them.

C. System Used

In the 35 articles selected, the system used was divided into 3 groups:

• Passive vision

i Stereophotogrammetry- used by 10 articles; [4-11,21,21]

ii 2D image- used by 10 articles; [1-3,13,14,17,24-26,29,32]

iii Video image- used by 9 articles; [9,12,15,18,23,27,28,30,33]

• Active vision

iv Scanner imaging- used by 2 articles [16,34];

v Laser imaging- used by 2 articles [31,35];

• Other: Digital measuring caliper- used by 1 article[19].

Note: 1 article not mention their system used[20].

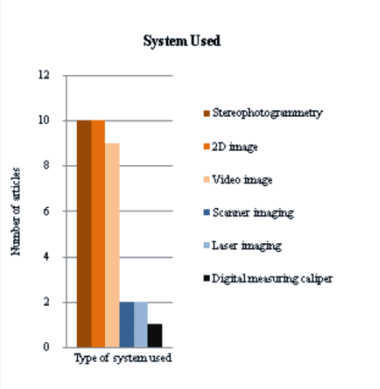


Fig. 3: Articles distribution according to the system used.

D. Reference Points used

Table 1: Distribution of reference points analysed in 3D images of craniofacial deformities.

No.of Point (R-L)	Reference Points	n(%)
1-2	Cheilion (ch)[1-3,5-9,11,13,16,19,21-23,25-27,29-31,33,34,35]	24 (68.6)
3	Nasion (n)[1,3,5-9,11-13,16,20,22,23,31,33,34,35]	18 (51.4)
4-5	Exocanthion (ex)[1-3,5-9,11,16,19,20,21,25,29,31,34,35]	18 (51.4)
6	Subnasale (sn)[1,3,5-12,20-22,24,31,34,35]	17 (48.6)
7-8	Endocanthion (en)[1-3,5-9,11,13,16,19,22,29,31,34,35]	17 (48.6)
9	Pronasale (prn)[1,3,5,6,10,11,13,16,20,22,31,34,35]	13 (37.1)
10	Labiale superius (ls)[1,3,5,6,9,11,13,16,23,24,31,34,35]	13 (37.1)
11-12	Crista philtri (cph)[1-3,5,6,11,13,22-24,33,34,35]	13 (37.1)
13-14	Alare (al)[1-3,5-8,10,11,16,21,22,35]	12 (34.2)
15	Labiale inferius (li)[1,3,6,9,11,12,23,31,34,35]	10 (28.6)
16	Menton (me)[1,3,6-8,11,16,22,31,34]	10 (28.6)
17-18	Alar curvature (ac)[6,10,13,19,23,29,31,34,35]	9 (25.7)
19-20	Apex of columela (c)[5,6,10,12-14,20,35]	8 (22.9)
21	Stomion (sto)[9,11,13,22,31,34,35]	7 (20.0)
22-23	Alare' (al')[1-3,5,6,10]	6 (17.1)
24-25	Pupila (pu)[1-3,21,27,30]	6 (17.1)
26-27	Subalare (sbal)[6,10,11,13,22,34]	6 (17.1)
28	Pogonion (pg)[1,3,6,34,35]	5 (14.3)
29-30	Base of columella (c')[6,10,12,13,14]	5 (14.3)
31	Sublabiale (sl)[6,11,22,35]	4 (11.4)
32-33	Subnasale' (sn')[1,3,6,10]	4 (11.4)
34-35	Gonion (go) [7,8,11,31]	4 (11.4)
36-37	Palpebrale Inferius (pi)[23,25,29,31]	4 (11.4)
38-39	Superciliare (sci) [23,25,29,31]	4 (11.4)
40	Glabella[5,7,8,34]	4 (11.4)
41	Tragus/ Tragion [9,11,19,35]	4 (11.4)
42	Subtragion[6,11,31]/ Pre (preaureculare)	3 (8.6)
43	Otobasion inferiorus[6,11,35]	3 (8.6)
44-45	Palpebrale Superius (ps)[23,29,31]	3 (8.6)
46-47	Superalare (sa)[1,2,3]	3 (8.6)
20	Stomion superius (stos)[1,3,6]	3 (8.6)
20	Stomion intferius (stoi)[1,3,6]	3 (8.6)
48-49	Frontotemporale (ft)[26,31,33]	3 (8.6)
50-51	Lower lip boarder [23,33,34]	3 (8.6)
52	Intersection of forehead axis with the exocanthioncircle[7,8]	2 (5.7)
53-54	Inner of Eyebrows[26,31]	2 (5.7)
55-56	Upper lip boarder[23,34]	2 (5.7)
57	Trichion[16]	1 (2.9)
58	Superior labial sulcus (sls)[6]	1 (2.9)
59	Intertragic notch[16]	1 (2.9)
60-61	Orbitale Superius (os) [31]	1 (2.9)

Note: 6 articles were not counted in the percentages because their lack of information details. Information details mention are:-

- Not specify the reference points : 2 articles[4, 32]
- Use only the region of face: 2 articles[18,28]
- Landmark given is not label properly:1 article[15]
- Size of marker is big: 1 article[17,]

Table 2: Descriptions of the soft tissue for the selected landmarks used in the study [6,9,11,16,34]	
Names of reference point	Definitions
Cheilion (ch)	Point positioned at the lateral most point lips angle
Nasion (n)	Point positioned at the deepest concavity on the nose bridge
Exocanthion (ex)	Point positioned at the outer end of upper and lower eyelid meet
Subnasale (sn)	Point positioned at midpoint of the columella base and upper lip skin meet.
Endocanthion (en)	Point positioned at the inner end of upper and lower eyelid meet
Pronasale (prn)	Most protruded point on the nose tip
Labiale superius (ls)	Point positioned at the midline of vermilion of upper lip
Crista philtri (cph)	Point positioned at the junction between upper lip vermillion and philitral peak
Alare (al)	The most lateral point on every alar contour of the nose
Labiale inferius (li)	Point on the midline of lower vermilion point
Menton (me)	Lowest midline point on the chin, also called as Gnathion (gn)
Alar curvature (ac)	Most lateral point in the curved base line of every alar of the nose
Apex of columella (c)	Top point on the columella crest
Stomion (sto)	Point between the most bottom point on the upper lip vermilion and top point on the lower lip vermilion
Alare' (al')	Surface marking level at the midportion of the alar where the thickness of every nose alar is measured
Pupila (pu)	Pupil reconstructions point where the midpoint between endocanthion and exocanthion are.
Subalare (sbal)	Point at the upper lip skin and lower limit ofevery alar base meet
Pogonion (pg)	The most prominent midpoint of the chin
Base of columella (c')	Most bottom point on the columella crest
Sublabiale (sl)	Point positioned at the deepest concavity on the anterior profile of the mandible
Subnasale' (sn')	Midpoint of columella on every side at the lowest line where the thickness of the columella is measured
Gonion (go)	The most everted point of the soft-tissue outline of the angle of the mandible
Palpebrale Inferius (pi)	Most lowest point in the middle of the bottom eyelid margin
Superciliare (sci)	Top point on the upper margin of the eyebrow middle portion
Glabella	The most protruded midline point between the eyebrows
Tragus	The notch on the upper margin of the right ear tragus, also called as Tragion
Subtragion	The most lateral point of the soft tissue facial outline in front of tragus, also called as Pre (preaureculare)
Otobasion inferiorus	Most inferior point on the ear lobe at the attachment to the cheek
Palpebrale Superius (ps)	Highest point in the middle of the bottom eyelid margin
Superalare (sa)	Deepest point between alar nostril sill and sidewall of nose.
Stomion superius (stos)	Midpoint on the lowest point on the top lip vermilion
Stomion intferius (stoi	Midpoint on the highest point on the bottom lip vermilion
Frontotemporale (ft)	Point located at the outer end of upper and lower eyebrows meet
Lower lip boarder	Point on the line between red colour of lower lip and the chin skin.
Intersection of forehead axis with the exocanthioncircle	Point on the junction of exocanthion circle and vertical line from pronasale to trichion.
Inner of Eyebrows	Point located at the inner end of upper and lower eyebrows meet
Upper lip boarder	Point on the line between red colour of upper lip and the skin below nose.
Trichion	Point where the hairline meets the midpoint of the forehead
Superior labial sulcus (sls)	Deepest concavity point on the upper lip skin
Intertragic notch	The small groove between the bump of cartilage between the ear and temple and earlobe
Orbitale Superius (os)	Top point on the bottom margin of the eyebrow middle portion

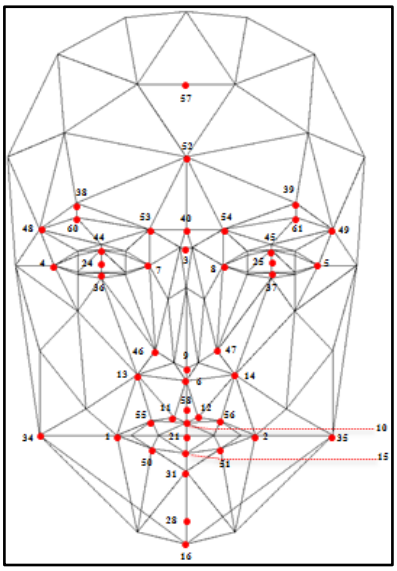
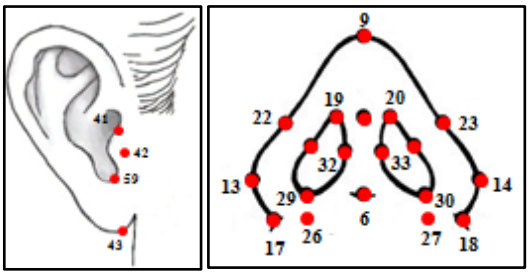


Fig. 4: Mapping points of the reference points in the face mesh.



(a) (b)

Fig. 5: Schematic picture of facial soft tissue,(a) ear, (b) nose.

E. Sample size

Sample size being used according to the reference selected articles, as shown in Fig.6.

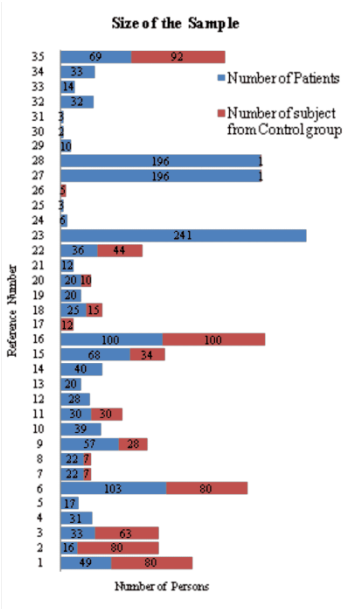


Fig. 6: Size of the sample used in 35 articles selected.

4. Discussion

The majority disease of the review concerning on Facial Paralysis and Cleft Lip and Palate about (42.1%) for each of them. Besides that, the distributions for the minority disease like Class III Malocclusion about (7.9%) and other 3 diseases Acoustic Neuromas, Facial Neuromas and Dysmorphology (DSM-IV)for Schizophrenia only about (2.6%) for each of them. Based on this result, this review can be very helpful for other research in the field of quantitative analysis on Facial paralysis and Cleft Lip and Palate.

There are many systems have been used found in this review such as stereophotogrammetry, video imaging, 2D image capture, 3D scanner and laser imaging. All of this system has been categorized as optical technology. From this category, there are further subdivided categories into passive vision and active vision [37]. In the passive vision, there are 2 different ways. First, a good optical sensor moves to identify the relative positions in the scene. Second, two or more optical sensors tend to be fixed in known positions. For the active vision, only one camera is used to image the projection of a provided pattern on the measuring area [38]. Based on this definition, this review has grouped the stereophotogrammetry, video imaging and 2D image capture into passive vision.

The highlight of this review is about the reference points being used in order to quantify the asymmetry of patients face. The main problems faced in extracting all the data on the reference point used in each selected articles was the jargon of the names used to mention the same facial landmark and the variation names of the reference points. Because of that, this review has shown all the reference points being used with picture (Fig. 4 and Fig. 5) and explains all definitions for each point (Table 2) to help readers have a better understanding.

Among these reference points being used, there are difference distribution points based on their disease approach. For the facial paralysis approach, most the reference points used are related to the eyes, nose and mouth: endocanthion, exocanthion, nasion, subnasale, pronasale, cheilion, labiale superius and crista philtri. For the Cleft lip and palate approach, some of them used the same distribution points as facial paralysis, but some of them more to focus and details on the nose and mouth only.

In order to prove the quality and validity of each research, the number of sample size and the subject being selected is the important aspects that need to be focused. Based on all selected articles, the majority of their research used 2 groups of subject which is a control group and patients. Both of these groups are important during the experimental process in order to respect the patients feeling and their emotional.

5. Conclusion

The success of a quantitative analysis of facial asymmetry depends on the selection of reference points used in the analysis. From these points, the next analysis such as measurement and comparison can be carried out for the overall result. In addition, the selection system used will ensure the accuracy of each point obtained and determine the total cost of a research. Finally, the total sample size became evident the accuracy and validity of a research.

6. References

[1] Ras F, Habets LLMH, Van Ginkel FC, Prahl-Andersen B.“Three-dimensionalevaluation of facial asymmetry in cleft lip and palate.,” Cleft PalateCraniofac J, vol.31, pp. 116-121. 1994.

[2] Ras F, Habets LL, van Ginkel FC, Prahl-Andersen B. “Methodforquantifying facial asymmetry in three dimensions using stereophotogrammetry,” Angle Orthod, vol, 65, pp. 233-239, 1995.

[3] Ras F, Habets LLMH, Van Ginkel FC, Prahl-Andersen B. “Longitudinalstudy on three-dimensional changes of facial asymmetry in children between 4 to 12 years of age with unilateral cleft lip and palate,” Cleft Palate Craniofac J, vol. 32, pp. 463-468, 1995.

[4] Al-Omari I, Millett DT, Ayoub A, Bock M, Ray A, et al. “An appraisal ofthree methods of rating facial deformity in patients with repaired completeunilateral cleft lip and palate,” Cleft Palate Craniofac J, vol. 40, pp. 530-537, 2003.

[5] Devlin MF, Ray A, Raine P, Bowman A, Ayoub AF. “Facial symmetry inunilateral cleft lip and palate following alar base augmentation with bone graft: a three-dimensional assessment,” Cleft Palate Craniofac J, vol. 44, pp. 391-395, 2007.

[6] Bugaighis I, O’Higgins P, Tiddeman B, Mattick C, Ben Ali O, et al.. “Three-dimensional geometric morphometrics applied to the study of childrenwith cleft lip and/or palate from the North East of England,” Eur J Orthod, vol. 32, pp. 514-521. 2010.

[7] Hoefert CS, Bacher M, Herberts T, Krimmel M, Reinert S, et al. “3D softtissue changes in facial morphology in patients with cleft lip and palate andclass III mal occlusion under therapy with rapid maxillary expansion and delaire facemask,” J Orofac Orthop, vol. 71, pp. 136-151, 2010.

[8] Hoefert CS, Bacher M, Herberts T, Krimmel M, Reinert S, et al. “Implementing a superimposition and measurement model for 3D sagittalanalysis of therapy-induced changes in facial soft tissue: a pilot study,” J OrofacOrthop, vol. 71, pp. 221-234, 2010.

[9] Tanikawa C, Takada K, van Aalst J, Trotman CA. “Objective three-dimensionalassessment of lip form in patients with repaired cleft lip,” CleftPalate Craniofac J, vol. 47, pp. 611-622, 2010.

[10]Sander M, Daskalogiannakis J, Tompson B, Forrest C.“Effect of alveolarbone grafting on nasal morphology, symmetry, and nostril shape of patientswith unilateral cleft lip and palate.,” Cleft Palate Craniofac J, vol. 48, pp. 20-27, 2011.

[11]Zreaqat M, Hassan R, Halim AS. “Facial dimensions of Malay childrenwith repaired unilateral cleft lip and palate: A three dimensional analysis,” Int J Oral Maxillofac Surg, vol. 41, pp 783-788, 2012.

[12]Russell KA, Waldman SD, Tompson B, Lee JM. “Nasal morphology andshape parameters as predictors of nasal esthetics in individuals with completeunilateral cleft lip and palate,” Cleft Palate Craniofac J, vol. 38, pp. 376-485, 2001.

[13]Bilwatsch S, Kramer M, Haeusler G, Schuster M, Wurm J, et al. “Nasolabial symmetry following Tennison-Randall lip repair: A three-dimensionalapproach in 10-year-old patients with unilateral clefts of lip, alveolus and palate,” J Craniomaxillofac Surg, vol. 34, pp.253–262, 2006.

[14]Stauber I, Vairaktaris E, Holst A, Schuster M, Hirschfelder U, et al. “Three-dimensional analysis of facial symmetry in cleft lip and palate patientsusing optical surface data,” J Orofac Orthop, vol.69, pp. 268-282, 2008.

[15]Trotman CA, Faraway JJ, Phillips C, Van Aalst J. “Effects of lip revisionsurgery in cleft lip/palate patients,” J Dent Res, vol. 89, pp. 728-732, 2010.

[16]Lee, Heow Pueh; Garg, Saurabh; Lee, Shu Jin; “A Computer Based Objective Grading System for Facial Paralysis,” 2014.

[17]Jorge Jr, Jose Jarjura; Pialarissi, Paulo Roberto; Borges, Godofredo Campos; Squella, Sara Agueda Fuenzalida; de Gouveia, Maria de Fatiima; et al, “Objective computorized evaluation of normal patterns of facialmuscles contraction,” Braz J Otorhinolaryngol, vol. 78, no.2, pp. 41-51, 2012.

[18]Minamitan, Haruyuk; Hoshino, Yoshihiko; Hashimoto, Hisashi; Iijima, Atsuhiko; Tanaka, Ichiroet al, “Computerized Diagnosis of Facial Nerve Palsy Based onOptical Flow Analysis of Facial Expressions,” Proceedings of the 25’ Annual lntemational Conference of the IEEE EMBS, pp. 663-666, 2003.

[19]Maceno Salvador, Claudia Hosana da; Tessitore, Adriana; Pfeilsticker, Leopoldo Nisan; Paschoal, Jorge Rizzato; Nemr, Kátia; “Measurement Of Evolution TherapyUsing A Digital Caliper In Bell’s Palsy,” CEFAC, vol. 15, no. 3, pp. 592-598, 2013.

[20]Wang S., Li H., Qi F., Zhao Y., “Objective facial paralysis gradingbased on P_{face} and eigenflow,” Med. Biol. Eng. Comput, vol. 42, pp. 598-603, 2004.

[21]van Loon B, Maal TJ, Plooij JM, Ingels KJ, Borstlap WA, Kuijpers-Jagtman AM, et al.“3D stereophotogrammetric assessment of pre- and postoperative volumetric changes in the cleft lip and palate nose,” Int J Oral Maxillofac Surg., vol. 39, no. 6, pp. 534-540, 2010.

[22]Weinberg SM, Naidoo SD, Bardi KM, Brandon CA, Neiswanger K,Resick JM, et al. “Face shape of unaffected parents with cleft affectedoffspring: combining three-dimensional surface imaging and geometric morphometrics,” Orthod Craniofac Res., vol. 12, no. 4, pp. 271-281, 2009.

[23]Tzou, C.-H. J., Pona, I., Placheta , E., Hold, A., Michaelidou, M., Artner, N., et al. “Evolution of the 3-Dimensional Video System for Facial Motion Analysis,” Annals of Plastic Surgery, Vol. 69, no. 2, pp. 173-185, 2012.

[24]K. Anguraj, R. K., “Facial Paralysis Diseases Level Detection using CEM Algorithm for Clinical Applications”., European Journal of Scientific Research, vol.77, no.4 (1450-216X), pp. 543-548, 2012.

[25]K. Anguraj, S. Padma, “Analysis of Facial Paralysis Disease using Image Processing Technique”, International Journal of Computer Applications, vol.54, no.11 (0975 – 8887), 2012.

[26]Delannoy, Jane Reilly; Ward, Tomás E.; "A Preliminary Investigation into the use of Machine Vision Techniques for Automating Facial Paralysis Rehabilitation Therapy," ISSC, 2010.

[27]Soraghan, J.J. and O'Reilly, Brian and He, Shu and McGrenary, Stewart, In: "Automatic facial analysis for objective assessment of facial paralysis,"1st International Conference on Computer Science from Algorithms to Applications (CSAA-2009), 2009.

[28]Shu He, John J. Soraghan, Brian F. O'Reilly, Dongshan Xing, "Quantitative Analysis of Facial Paralysis Using Local Binary Patterns in Biomedical Videos," IEEE Transactions On Biomedical Engineering, vol. 56, no. 7, pp. 1864-1870, 2009.

[29]Dong, Junyu; Ma, Lijing; Li, Qingqiang; Wang, Shengke; Liu, Li-an; Lin, Yang; Jian, Muwei;, "An Approach for Quantitative Evaluation of the Degree of Facial Paralysis Basedon Salient Point Detection," Intelligent Information Technology Application Workshops, pp. 483-486, 2008.

[30]Sucar, L. Enrique; Vargas, Alejandro; Hidalgo, Juan Luis; Martínez, Arnulfo; Leder, Ron S.: et al. "A prototype for automatic image analysis toquantify rehabilitation of chronic facial paralysis," Revista Mexicana de Ingeniería Biomédica, vol. 25, no.2, pp. 109-113, 2004.

[31]Gunaratne, Pujitha; Sato, Yukio; "Estimation of Asymmetry in Facial Actions for the Analysis of Motion DysfunctionDue to Paralysis," International Journal of Image and Graphics, vol. 3, no. 4, pp. 639-652, 2003.

[32]P., Lazarini; E., Mitre; E., Takatu; R., Tidei; "Graphic-visual adaptation of House–Brackmann facial nervegrading for peripheral facial palsy," Clinical Otolaryngology J., vol. 31, pp. 192-197, 2006.

[33]Sforza, Chiarella; Tarabbia, Filippo; Mapelli, Andrea; Colombo, Valeria; Sidequersky, Fernanda V. et al. "Facial reanimation with masseteric to facialnerve transfer: A three-dimensionallongitudinal quantitative evaluation," Journal of Plastic, Reconstructive & Aesthetic Surgery (JPRAS), vol. 67, pp 1378-1386, 2014.

[34]Kim, Minji; Lee, Dong-Yul; Lim, Yong-Kyu; Baek, Seung-Hak; "Three-dimensional evaluation of soft tissue changes after mandibular setback surgery in class III malocclusionpatients according to extent of mandibular setback, vertical skeletal pattern, and genioplasty," OOOOE, vol. 109, no. 5, pp. 20-32, 2010.

[35]Hennessy, Robin J.; Baldwin, Patrizia A.; Browne, David J.; Kinsella, Anthony; Waddington, John L.; "Three-Dimensional Laser Surface Imaging and Geometric Morphometrics Resolve FrontonasalDysmorphology in Schizophrenia," Biol Psychiatry, vol. 62, pp. 1187-1194, 2007.

[36]Ross, B. G., Fradet, G., & Nedzelski, J. M.; "Development of a sensitive clinical facial grading system,"Otolaryngology-Head and Neck Surgery, vol. 114, pp. 380-386, 1996.

[37]Rocchini C., Cignoni P., MOntan C., Pingi P., Scopigno R.; "A low cost 3D scanner based on structured light," vol. 20, no. 3, 2001.

[38]Battle J., Mouaddib E., Salvi J.; "Recent progress in coded structured light as a technique to solve the correspondence problem: A survey," Pattern Recognition, vol. 31, no. 7, pp. 963-982, 1998.

[39]Mitra, Sinjini; Lazar, Nicole A; Liu, Yanxi; "Understanding the role of facial asymmetry in human faceidentification," Stat Comput, vol.17, pp. 57-70, 2007.

[40]Farkas, Leslie G.; Cheung, Gwynne; "Facial asymmetry in healthy North American Caucasians: An anthropometrical study," The Angle Orthodontist, vol. 51, no. 1, 1981.