Computer-aided facial recognition of individuals with X-linked hypohidrotic ectodermal dysplasia

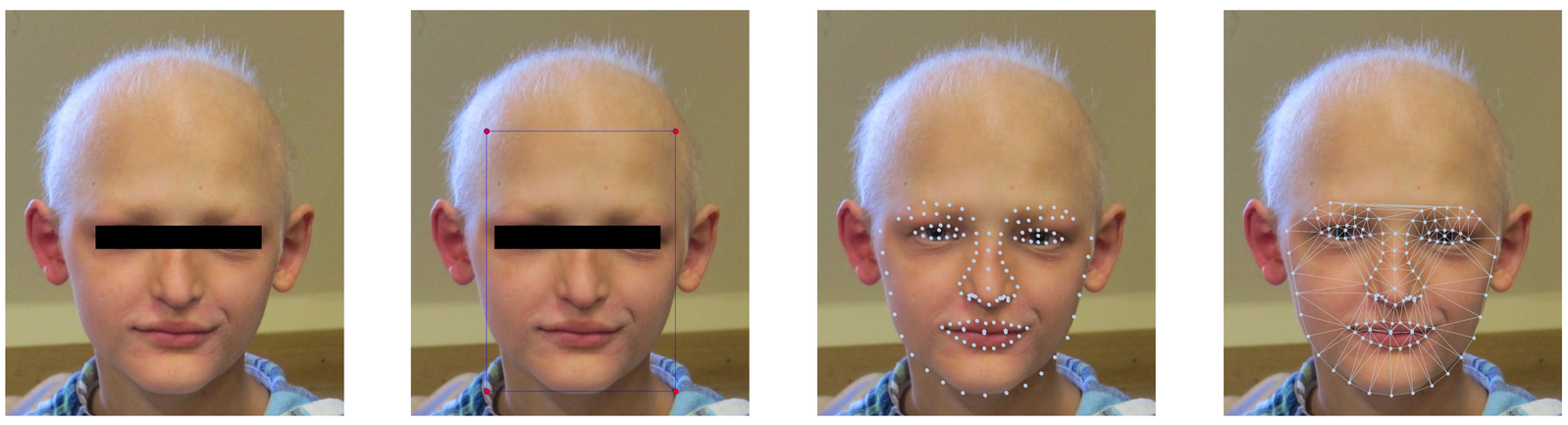
K. M. Huttner[1], L. Karlinsky[2], S. Hadj-Rabia[3], L. Wolf[2,4], M. Shohat[2,4,5], D. K. Grange[6], O. D. Klein[7], H. Schneider[8], E. Guillén-Navarro [9], V. López-González[9], C. Bodemer[3], L. Basel- Vanagaite[2,4,5]

[1]Edimer Pharmaceuticals, Inc., Cambridge, MA, United States, [2]FDNA Ltd., Herzlyia, Israel, [3]Department of Dermatology, French reference centre for genetic skin disorders (MAGEC) Necker Enfants Malades Hospital, APHP, Paris Descartes University, INSERM U 781, Paris, France, [4]Tel Aviv University, Tel Aviv, Israel, [5]Schneider Children's Medical Center of Israel, Raphael Recanati Genetics Institute, Rabin Medical Ctr and and Felsenstein Medical Research Center, Petah Tikva, Israel, [6]Washington Univeristy in St. Louis, St. Louis, MO, United States, [7]University of California San Francisco, San Francisco, CA, United States, [8]University of Erlangen-Nürnberg, Erlangen, Germany, [9]Hospital Clínico Universitario Virgen de la Arrixaca, Murcia, Spain. . KMH is an Edimer employee. LK, LW, MS and LBV are consultants and employees of FDNA.

X-linked hypohidrotic ectodermal dysplasia (XLHED) is a genetic disorder characterized by hypohidrosis, hypotrichosis and hypodontia. Early diagnosis of XLHED is a key factor in reducing the risk for serious and life-threatening hyperthermia. Affected males display a distinct craniofacial phenotype characterized by frontal bossing with depressed nasal bridge, retruded appearance of the midface with maxillary hypoplasia and mandibular prognathism. In this study, a novel facial dysmorphology analysis system based on 2D photographs (FDNA®) was used to identify XLHED-affected individuals.

Image Analysis Pipeline

FDNA's system combines several face recognition methodologies in order to provide robust performance despite of individual differences in ethnicity, illumination, some degree of expression and age. First, the face in the image is detected and the background is discarded. Then, 130 anatomical points (eye corner and the tip of the nose) are located on the face.



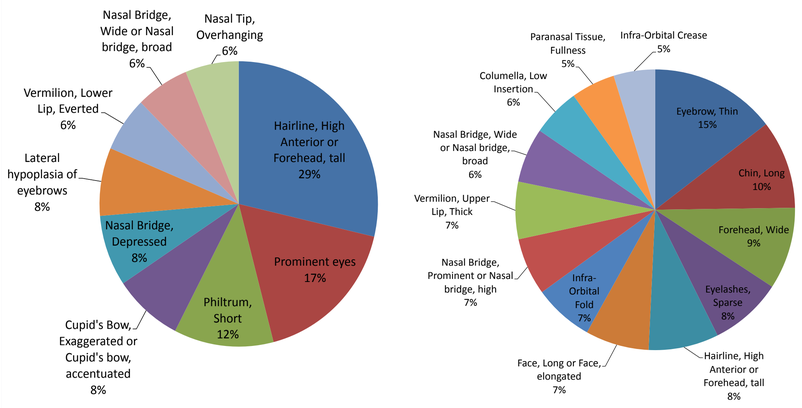
Experimental Procedure

To distinguish between XLHED-affected male patients and controls based on frontal facial photographs, a cross validation scheme was used. In these schemes, the data is split randomly (multiple times) into training sets and test sets.

Each set contained half of the examples (both affected and controls). This random process was repeated 20 times. At each of the 20 rounds, the recognition methods were independently optimized on the training set, and evaluated on the test set. The tests were conducted on 3 different age groups; adults (age 11 yrs and above), children (age 1-10 yrs) and neonates (age up to 1 month).

Features Analysis

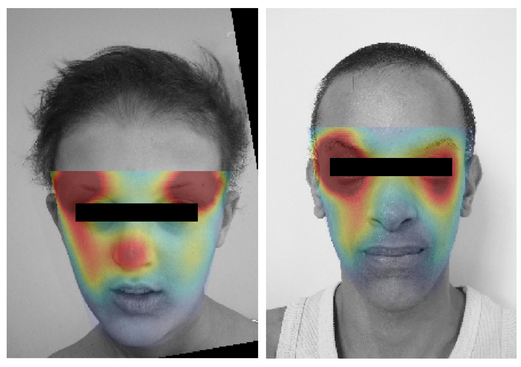
Various lengths, angles and ratios are computed for each face and are used, in combination with statistical mechanisms, to evaluate a list of relevant dysmorphic features from the literature.



(a) children (b) adults

Gestalt Analysis

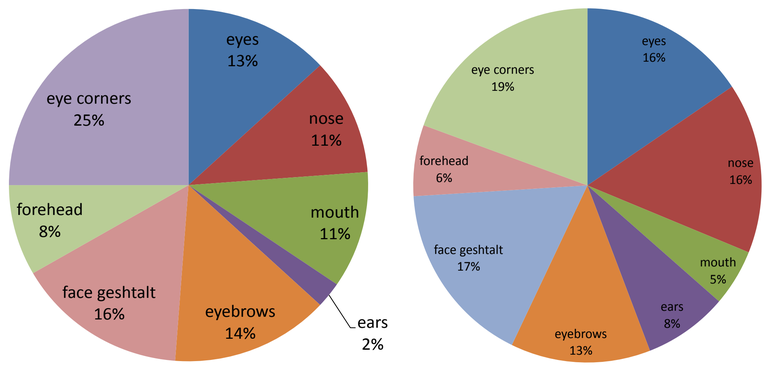
Local image information is integrated in order to provide the appearance or gestalt description of the face. This process enables the direct evaluation of the probability of the syndrome for every part of the face and for the entire face.



Heat maps displaying the most distinguishable regions of XLHED-affected male patients (drawn over examples of child and adult XLHED patients).

Local measurements

The system weights in the relative importance of different face regions in the identification process for each of the datasets.

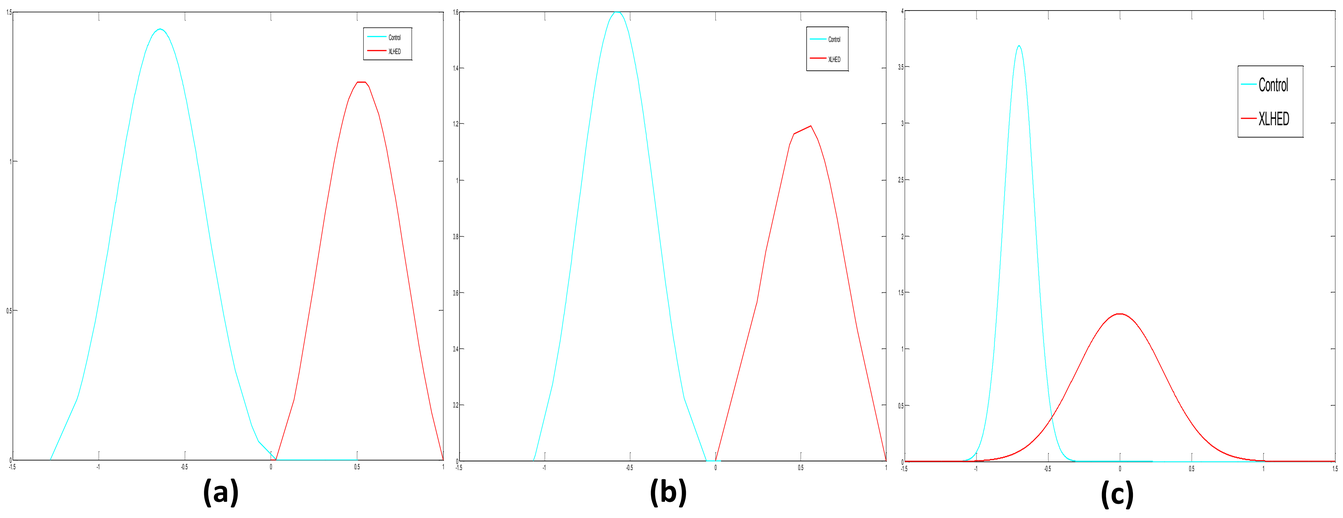


(a) children (b) adults

<u>Results</u>: FDNA's automatic face evaluation system was overall successful in distinguishing between affected individuals and controls, based on frontal face images processed.

Age Group	AUC*	EER**	Specificity at 90% Sensitivity
Adults N=42 affected N=218 controls	0.99	2%	99%
Children N=64 affected N=292 controls	0.99	3%	98%
Neonates N=27 affected N=33 controls	0.98	5%	97%

*An AUC of 1 indicates perfect accuracy, and an AUC of 0.5 is the performance obtained by a "coin-flipping" totally random system.
**EER is the common error rate when one sets the acceptance threshold such that the false acceptance rate and the false rejection rate are equal



(a) (b) (c)

Above are curves that were fitted to the detection scores obtained in this study for: (a) children; (b) adults; and (c) neonates.

<u>Conclusion</u>: Facial Dysmorphology Novel Analysis technology can successfully identify XLHED phenotypes in large and age diversified patient cohorts, and may be applied in the future to newborn screening of XLHED in clinical settings.