The Rainbow Scale for the assessment of the cervicomental angle: a validated scale

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Short running title: Validation of the Rainbow Scale for the CMA.

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INTRODUCTION

A cervicomental angle (CMA) between 90°-100° is considered well defined and a hallmark of a youthful neck.[1-3] Multiple factors play a role in a less defined, increased CMA. Anatomically, the CMA is formed by a breakpoint between the horizontal plane of the submental region and the vertical plane of the neck.[4] When ageing of the neck occurs, the platysma fibers are tended to splay laterally, causing platysmal banding and a subsequent increase in the CMA. Moreover, ageing expands cervical skin laxity as well as preplatysmal and subplatysmal adipose tissue, which contributes to an increased CMA.[3]

Various surgical and non-surgical techniques *e.g.* classical rhytidectomy, short scar face-lifting, traction suture lifting, laser resurfacing and thricholoroacetic acid (TCA) chemical peeling can be used to treat an increased CMA.[5-11] Assessment of these procedures are mostly done based on visual subjective evaluation of the surgeon with or without the use of pre- and post-operative photographs.

To date, only a few descriptive classifications have been developed to evaluate the (ageing) neck.[3,12,13] These systems were, however, not validated. McCollough et al. introduced a condition-specific classification algorithm based on five age groups to match patients' problems with an appropriate treatment plan per class. This subjective system was validated with a moderate agreement.[14] Latter, a validated neck volume scale was proposed based on a printed booklet survey and showed a good agreement.[15] However, both scales were validated with non-weighted analyses.

Thus far, no objective online validated photographic measurement tool exists to assess the outcome of these CMA restoration procedures. In order to measure treatment outcomes, an objective photographic measurement tool seems indispensable.[16]

In literature, a few objective and subjective measurement tools for the assessment of other aesthetic entities are available, such as the FACE-Q for psychometric evaluation and the online Rainbow Scale for the objective assessment of the nasolabial fold and breast ptosis.[17-19] The online Rainbow Scale consists of 5 reference photographs, with each photograph corresponding to a specific grade (Grade I to V). These 5 photographs are arranged in an arc with an empty lower center slot. The photograph to examine can be placed in this lower center slot for objective examination. This tool has been validated and proven to be simple, reproducible and reliable. The online setting allows clinicians to examine photographs with patients during consultation as well as via digital communication or a designated website. Considering the need for an online and easy to use validated photographic measurement tool to assess the severity of the CMA, this study aims to validate the uniform standardized photographic Rainbow Scale for assessing the CMA.

METHODS

The Rainbow Scale for assessing the CMA is based on the 5-point Rainbow Scale format by van Dongen et al. [18] For the design of the current scale, five novel grades were defined: Grade I: a CMA of 90-100°. The cervical skin shows no laxity nor submental fat. Grade II: mild laxity of the cervical skin. The skin does not exceed the notch of the thyroid cartilage. Grade III: moderate laxity of the cervical skin. The skin exceeds the notch of the thyroid cartilage and forms an upward curved line between chin and suprasternal notch. Grade IV: severe laxity of the cervical skin. The skin forms a vertical straight line between chin and suprasternal notch. Grade V: extreme laxity of the cervical skin. The skin forms a downward curved line between the chin and suprasternal notch.

Identification of Reference Photographs

This study was performed in accordance with the Helsinki guidelines and all models gave written informed consent.[20] Reference photographs were taken between March 2013 and August 2017 and were selected from a senior author's (HPS) database. A three-step selection method was used. First, photographs were excluded if not taken in a standardized fashion *i.e.* photographs taken from an incorrect angle, no neutral position of the head or too low quality of the photographs for computer standardization. Second, forty-five photographs were selected as potential reference photographs with each photograph corresponding best to one of the five grades using the aforementioned description per grade. One photograph was selected by the first author (LSvdL) as template to create the Rainbow Scale. The fifteen most representative photographs were selected for validation of the scale (three photographs for each grade) and were included after consensus was reached between all co-authors.

Photographic Editing and Equipment

All photographs were taken in right lateral view with a Nikon mirror reflex D3100 camera (Nikon Corporation, Tokyo, Japan) and a Nikon DX - AF-S Nikkor 18 to 55 mm (1:3.5-5.6G) lens. All photographs were standardized in Adobe Photoshop CS6 Version 13.0 × 64 (Adobe Systems Inc., San Jose, CA) by correcting the background, alignment, skin color, contrast and brightness. The template photograph was used as basis for each grade and changed into the five grades of the Rainbow Scale using Adobe Photoshop to create a homogeneous scale. Small parts from other photographs *e.g.* submental skin or wrinkles were superimposed to create various degrees of severity of the CMA (Figure 1). These other photographs were not included for validation nor used as template photograph.

Online Validation

For the validation of the Rainbow Scale for assessing the CMA, an online survey was created in SurveyMonkey (SurveyMonkey, Palo Alto, CA). The descriptive information on the five grades was included on the front page of the survey. The survey contained fifteen questions; each question was a one-page representation of the Rainbow Scale for assessing the CMA. A reference photograph for assessment was placed in a free spot in the bottom center (Figure 2). All reference photos were anonymized. Each grade was represented in the survey by three questions. A blank copy of the survey is online available as Supplementary Material.

Between January 2018 and March 2018, seven independent panelists (plastic (n=5) and maxillofacial (n=2) surgeons) assessed the photographs in the free spot according to the appropriate corresponding grade on the scale (Table 1). These panelists did not know any of the study subjects used in the survey and have not been involved in

this study. The panelists completed three surveys with a minimal interval of three days to minimize memory bias. Each time, the fifteen questions in the survey were presented in a random order. Computer randomization was performed with Microsoft Excel Version 14.4.9. (Microsoft, Redmond, WA). For each panelist, the intra-observer agreement was calculated based on the comparison of the three completed surveys (first vs. second, first vs. third, and second vs. third). Inter-observer agreement was calculated to determine agreement between pairs of panelists in the three completed surveys.

Statistical analyses

To determine the intra-observer and inter-observer agreement the weighted kappa coefficient was used in SPSS version 21.0.0.1 (IBM, New York, NY).[21] Intra- and interobserver agreements of 0.41-0.60 were regarded as moderate, 0.61-0.80 as substantial and 0.81-0.99 as almost perfect. [22]

RESULTS

Online Validation of the Rainbow Scale for Cervicomental Angle

The study population consisted of only females of 56.5 (range 24 -70.1) years old (Table 2). The seven independent panelists had a mean intra-observer agreement of 0.93 [0.78-1.00] (Table 3). The mean inter-observer agreements within pairs of panelists was 0.796 [0.574-0.961] for survey 1; 0.868 [0.690-0.960] for survey 2; and 0.820 [0.676-0.959] for survey 3 (Table 4).

DISCUSSION

In this study, the Rainbow Scale for the assessment of the CMA has been validated as a result of almost perfect intra-observer and inter-observer agreements. Hence, the Rainbow Scale is a reliable and reproducible and easy-to-use method for the assessment of the CMA in an online fashion.

The use of a grading scale in an online fashion has several advantages. First, assessment can be performed faster and easier than a paper scoring system.[23] Second, results of an online scale can be transferred directly into software of choice *e.g.* SPSS or electronic patient record system, which reduces the risk of loss of data. Third, clinicians or patients can easily be reached by offering the Rainbow Scale by e-mail or via a designated website. In this way, clinicians will be able to communicate easily with patients and fellow clinicians and can have their results assessed in an anonymized and objective manner. Outcomes of the Rainbow Scale can therefore be used to discuss surgical and non-surgical outcomes, especially when comparing different types of treatments. Thus, the use of the Rainbow Scale might improve shared-decision making between patient and clinician. Moreover, the Rainbow Scale imposes no learning curve, because none of the panellists were trained for the assessment and nevertheless almost perfect agreement was reached.

Validation of a measurement tool can be arduous, but the use of these tools is essential for quality outcomes in aesthetic surgery. The quality of such a tool depends on the validity, reliability and feasibility. Validity of an assessment tool is the ability to accurately measure what it is supposed to measure. Reliability refers to the degree of which the measurement tool is free from measurement error.[24] Without reliability, validity cannot be reached.[25] Moreover, the use of the instrument should be feasible. A validation process comes with challenges such as proper head positioning, sufficient

quality of the photographs, experience of the photographer and valid assessment by the panellists. Particularly, variation in head positioning could influence the results significantly. Consistency in photography setting is critical. Hence, we addressed these issues by using a standardized setting and protocol for (neutral) head positioning and professional photo camera. All photographs were taken by the same experienced photographer. In order to accomplish a neutral and standardized head positioning, we would like to propose the following standardized setting. Firstly, the patient should stand straight *i.e.* chest up, shoulders back and arms aligned with the upper body. Secondly, the ears should be aligned directly with shoulders from a lateral view and the eyes should be in line with the ears according to the Frankfurt Horizontal line *i.e.* a line formed by the plane passing through the inferior margin of the orbit and the upper margin of each ear canal or external auditory meatus. This position would ensure no flexion or extension of the neck. Thirdly, the position of the mandible in relation to the upper jaw should be checked for proper occlusion and insured that the mandible is not held in a retruded fashion by the patient, because – if not held in proper occlusion - it could influence the cervicomental angle outcome. A vertical line through the anterior surface of the eye or malar eminence to the menton could be used as guidance to establish similar positions of the mandible.

The Rainbow scale is an online two-dimensional grading system with photographs assessed from the right lateral view only. This design results in an easy and fast assessment of two-dimensional neck rejuvenating surgery *e.g.* surgery that tends to improve skin appearance. Results of the assessment of pre- and postoperative results of two-dimensional neck rejuvenating surgery can easily be understand by patients. However, evaluating the lateral view only makes it impossible to evaluate volume differences of the neck as well as changes in frontal view. In future, a Rainbow Scale could

be developed that supports the frontal view. Moreover, with the increasing applications of 3-dimensional photography and videos a more detailed 3-dimensional scale could be created.

Moreover, the photographs were assessed without the use of a computerized model. In this way, the Rainbow Scale is easy to use, but unable to detect small clinical differences after or between treatments. Two-dimensional photonumeric scales based on computer-simulated photographs have the ability to detect smaller clinical differences. These two dimensional photonumeric scales have already shown to be reliable for the assessment of brow positioning, forehead lines, melomental folds and crow's feet and might be useful to assess CMAs.[26] To increase accuracy, a third dimension could be added analysing three-dimensional soft tissue imaging is more accurate than two-dimensional imaging. [27] However, to use three-dimensional imaging expensive equipment and extensive time-consuming training is needed.

The Rainbow Scale for the assessment of the CMA alters scales that have been proposed in the past, because these scales were non-validated and visualized by simplistic drawings based on anatomical layers [12,13] or suggested a specific CMA restoration procedure per grade *i.e.* laser, liposuction and surgical treatments. [3]

Moreover, the Rainbow Scale for the assessment of the CMA differs from the Rainbow Scale for breast ptosis. The CMA scale was created of a single template photograph edited with Adobe Photoshop instead of using photographs of different patients for each grade.[18] The use of one photograph as template results in a more homogenous scale, potentially leading to less distraction by phenotypical differences, *e.g.* skin type, hair color and wrinkles.

In this validation study, patients with abnormal skeletal development, such as an underdeveloped mandible resulting in retrognathia were excluded. Due to retrognathia,

soft tissue under the lower jaw is thickened and results in a less defined CMA compared to a normally developed mandible.[28] Therefore, photographs of patients with an 'abnormal' facial profile cannot be compared with patients with a 'normal' facial profile. For patients requiring skeletal corrective treatments, it would be useful to create a scale on 'abnormal' facial profiles to assess different types of jaw surgeries and their influence on the CMA. Another limitation of the study is the use of only female subjects. This study only included females due to a low number of male subjects in the senior authors' database. Although there exist differences in bone density, shape, growth and bone loss between genders (women tend to have more bone loss postmenopausal due to hormone changes), gender differences in the process of fat atrophy, which characterizes facial ageing, have not been described. [29] Yet, in the future a male version of the scale could be considered and be useful in the assessment of male neck rejuvenating surgery.

This scale did not evaluate parameters such as digastric muscles (changes) and the submandibular gland nor jawline differences per grade have been addressed. An additional scale could be created focused on the peri-mandibular differences.

With the validated Rainbow Scale for CMA, outcomes of different types of treatment could be evaluated and used to decide the most appropriate technique to rejuvenate the appearance of the neck. To fully assess facial aging, a Rainbow Scale for other facial features could be created, such as a scale to evaluate wrinkle and pigmentation severity.

CONCLUSION

The Rainbow Scale for assessing the cervicomental angle has been validated in an online fashion with high inter- and intra-observer agreements. The scale is reproducible, easy-to-use, reliable, and its use requires no learning curve.

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