Original Article

Smile esthetic: comparison of perception amongst orthodontists, dental students, orthodontic patients and surgical orthodontic patients

Martina Mezio[1]* , Rosanna Guarnieri[2] , Federica Altieri[2] , Gabriella Padalino[1] , Michele Cassetta[3] , Roberto Di Giorgio[4] , Gabriella Galluccio[3] , Ersilia Barbato[5]

[1] Research Assistant, DDS, PhD Student, Department of Oral and Maxillofacial Sciences, School of Dentistry, "Sapienza" University of Rome, Italy.

[2] Research Assistant, DDS, PhD, Department of Oral and Maxillofacial Sciences, School of Dentistry, "Sapienza" University of Rome, Italy.

[3] Associated Professor, DDS, PhD, Department of Oral and Maxillofacial Sciences, School of Dentistry, "Sapienza" University of Rome, Italy.

[4] Associated Professor, MD, DDS, PhD, Department of Sense Organs, "Sapienza" University of Rome, Italy.

[5] Full Professor and Department Chair, DDS, PhD, Department of Oral and Maxillofacial Sciences, School of Dentistry, "Sapienza" University of Rome, Italy.

Corresponding author:
Martina Mezio
Department of Oral and Maxillofacial Sciences "Sapienza" University of Rome Italy,
School of Dentistry Via Caserta, 6-00161- Rome -Italy.
Phone number: 3336204583
e-mail: martina.mezio@uniroma1.it

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Aim: Most patients require orthodontic treatment to improve the esthetics of their smile. Orthodontists must consider how some parameters of mini-esthetics can influence the patient's esthetic perception. **Methods:** A photograph of the smile of a young female was taken and some modifications were made to the buccal corridor, gingival exposure, smile arc and midline position to assess the influence of these variables on smile attractiveness. Two hundred examiners were selected from four groups: orthodontists (O), dental students (DS), orthodontic patients (OP) and surgical-orthodontic patients (SOP). Each examiner was asked to complete the questionnaire with an approval rating from 1 to 10. Significant level was set at $P \leq 0.05$. **Results:** Only orthodontists considered buccal corridors of 4mm and midline deviation of 1mm as non-esthetic; all other examiners considered gingival exposures ≥3 mm and midline angulation as non-esthetic. All examiners assigned higher satisfaction values to the photo with the concordant smile arc and defined as non-esthetic the covered smile and the reverse smile arc. Patients perceived as non-esthetic only midline deviations of 4mm. The surgical orthodontic patients assigned lower values to the photos and showed greater attention to evaluating the esthetics of the smile than the orthodontic patients. **Conclusion:** Smile arc, gingival exposure and midline angulation influence smile esthetics; the role of buccal corridors and midline deviation is dependent on the type of examiner.

Keywords: Esthetics. Smiling. Orthodontics.

Introduction

The esthetics of the smile is becoming increasingly important in modern orthodontic practice. In recent years, orthodontic diagnosis is not only based on the occlusal relationship and cephalometric analysis but also considers soft tissue analysis and patient satisfaction[1,2]. Most patients who require orthodontic treatment want to improve their smile esthetic. An esthetic smile can improve the patient's self-perception and acceptance in modern society by improving first impressions in interpersonal relationships. An esthetic smile can influence judgment on facial attractiveness, just as the presence of a malocclusion can affect a patient's physical, social and psychological conditions and quality of life[3]. Within orthodontics, mini esthetics evaluates the relationship between teeth, lips and face. Knowledge of the influence of some parameters of mini esthetics on smile attractiveness is very important for the correct planning of orthodontic treatment. Some of these, such as gingival exposure, midline position, axial midline angulation, buccal corridors and arc of smile have received more attention[4]. The purpose of this study was to compare the esthetic perception of a young female's smile by orthodontists (O), dental students (DS), orthodontic patients (OP) and surgical-orthodontic patients (SOP) and to evaluate the influence of gender, age and level of education as a secondary outcome. The authors hypothesize that there is no variation in perception of the esthetics of the smile between the different groups and that this perception is not influenced by the variables investigated. The parameters of the mini esthetics evaluated are: smile arc, buccal corridors, midline deviation and angulation, and gingival exposure.

Materials and methods

The study was conducted thanks to the realization of a questionnaire made up of a sequence of photographs, modified with Adobe Photoshop CC version, starting from an original picture characterized by smile arc concordant, buccal corridors of 1 mm, exposure of the interdental papillae and coincident midlines. The photo of the smile of a dental undergraduate student was taken in the Orthognathic Unit of Orthodontics of Sapienza University of Rome with a professional camera (Nikon AF-S 28-300 mm, f/3.5-5.6, VR, EU version). The camera lens was positioned at the same height as the face to avoid distortions.

Sample Size Calculation

The sample size for this study was calculated based on the formula:

$$n = \frac{2(Z_\alpha + Z_{1-\beta})^2\,\sigma^2}{\Delta^2}$$

where α is the significance level and 1-β is the power of the study. We choose an α of 0.05 and a power (1-β) of 80%. σ is the standard deviation of the data and Δ is the difference between means in the two groups of the study. We choose these values from a previous paper. Applying the values explained above, we obtained the following result:

$$n = \frac{2(1.96+0.8416)^2 \, 4{,}33^2}{(18.65-29.96)^2} = 2{,}29 \text{ per arm}$$

So we can say that a choice of 3 examiners for arm could be reasonable and this means a total of 6 examiners for the entire study.

Sample selection

The questionnaire was submitted to 50 orthodontists (O), 50 dental students (DS), 50 orthodontic patients (OP) and 50 surgical-orthodontic patients (SOP) for a total of 200 examiners. Examiners were selected at the Orthognathic Unit of the Policlinico Umberto I and at Sapienza University of Rome. The demographic characteristics of the study sample are described in Table 1.

Table 1. Distribution of examiner categories by gender and age.

Examiner group	Number	Age range	Mean age (years)	Female	Male
Orthodontists	50	29-63	36.16	27	23
Dentistry students	50	23-36	26.32	25	25
Orthodontic patients	50	13-26	17.72	26	24
Surgical orthodontic patients	50	12-53	19.88	29	21

Questionnaire

The participation of all examiners in this study was voluntary, all were required to sign written consent. The examiners were not given any information regarding the parameters to be evaluated and the changes made, all were instructed to fill in the questionnaire by the same person to avoid different information being relayed which could distort the study. Each examiner was given a questionnaire and was asked to assign a grade from 1 (extremely unattractive) to 10 (extremely attractive) for each photo through the Visual Analog Scale (VAS). It was explained to all examiners that satisfaction values from 0 to 5 indicated insufficiency and that values from 6 to 10 indicated satisfaction." All images with a score above 6 were considered satisfactory to the examiner. The questionnaire also collected the following personal data: a) age (>17 years; <17 years); b) gender (M; F); c) level of study (primary school, secondary school, high school, university). Starting from the initial photo, the changes made to the individual parameters of the mini esthetics under assessment are shown in the figures below (Figures 1-4).

Figure 1. a) buccal corridors 1mm [original picture]; b) buccal corridors 4mm; c) absent buccal corridors; d) buccal corridors 3mm.

Figure 2. a) gingival exposure 2mm; b) gingival exposure 5mm; c) exposure of the interdental papillae [original picture]; d) gingival exposure 3mm; e) gingival exposure 1mm; f) gingival exposure 4mm.

Figure 3. a) concordant smile arc [original picture]; b) concordant smile arc with lower lip that touch the incisal edge; c) covered smile; d) straight smile arc; e) reverse smile arc.

Figure 4. a) midline deviation 2mm; b) midline deviation 3mm; c) concordant midline; d) midline angulation 2mm; e) midline deviation 1mm; f) midline deviation 4mm.

Statistical analysis

Descriptive statistics were used and an ordinary least square (OLS) model was applied in order to evaluate the influence of the following categories: a) examiner [orthodontist (O), dental student (DS), orthodontic patient (OP) and surgical-orthodontic patient (SOP)]; b) gender (male: M; female: F). In order to obtain more detailed information on the different esthetic perceptions among patients (OP; SOP) and experts (O; DS), a further statistical analysis was performed. The average values (av) assigned by the patients, OP and SOP, were studied and compared; the influence of gender was also evaluated. The same statistical analysis was performed between the orthodontists (O) and the students (DS). (Table 2). Significant level was set at P ≤ 0.05.

Table 2. Distribution of average values considering the examiner categories (O: DS; OP; SOP); Distribution of average values considering gender (F; M); Distribution of average values considering gender in the patient groups (F*; M*); Distribution of average values considering gender in expert groups (F**; M**).

	O	DS	OP	SOP	F	M	F*	M*	F**	M**
Figure 1a	6.68	7.16	7.44	7.88	7.3	7.32	7.67	7.64	6.9	6.98
Figure 1b	5.48	6.26	6.98	7.44	6.38	6.81	7.13	7.31	5.57	6.28
Figure 1c	6.93	6.82	7.28	7.58	7.21	7.1	7.45	7.4	6.94	6.79
Figure 1d	6.14	6.64	6.96	7.6	6.74	7.0	7.24	7.33	6.2	6.65
Figure 2a	3.75	4.08	5.6	5.2	4.34	5.1	5.13	5.73	3.49	4.44
Figure 2b	1.82	2.2	3.4	2.86	2.49	2.72	3.02	3.27	1.92	2.14
Figure 2c	6.82	6.94	7.04	7.4	7.08	7.02	7.29	7.13	6.86	6.91
Figure 2d	2.66	3.14	4.2	3.5	3.42	3.38	3.87	3.82	2.92	2.91
Figure 2e	4.59	4.66	6.1	6.32	5.34	5.57	6.09	6.36	4.53	4.74
Figure 2f	2.18	2.24	3.78	3.18	2.73	3.3	3.38	3.6	2.02	2.44
Figure 3a	7.25	7.08	7.1	7.42	7.22	7.2	7.2	7.33	7.24	7.07
Figure 3b	5.27	5.54	6.08	6.08	5.89	5.6	6.38	5.71	5.35	5.49
Figure 3c	3.57	4.18	5.18	4.94	4.46	4.53	5.27	4.8	3.59	4.26
Figure 3d	5.39	6.28	6.4	6.32	6.1	6.14	6.31	6.42	5.88	5.84
Figure 3e	3.41	4.58	4.9	4.62	4.02	4.88	4.47	5.11	3.53	4.63
Figure 4a	5.55	6.56	7.18	7.22	6.57	6.77	7.24	7.16	5.84	6.37
Figure 4b	5.09	5.74	6.74	6.6	5.93	6.24	6.71	6.62	5.1	5.84
Figure 4c	6.95	6.44	6.64	6.86	6.77	6.65	6.73	6.78	6.82	6.51
Figure 4d	3.27	3.7	4.78	3.88	3.75	4.14	4.42	4.22	3.04	4.05
Figure 4e	5.93	6.06	6.54	6.82	6.25	6.47	6.64	6.73	5.84	6.19
Figure 4f	4.39	5.34	5.86	5.52	5.08	5.57	5.78	5.58	4.33	5.56

Results

All the examiners completed the questionnaires, which were subsequently statistically analyzed (Table 2).

BUCCAL CORRIDORS. Students and patients (DS; OP; SOP) preferred Figure 1a (av: 7.16 7.44; 7.88.) with buccal corridors of 1 mm while specialists (O) preferred Figure 1c (av: 6.93) with absent buccal corridors. Orthodontists were the only examiners who considered buccal corridors of 4mm as non-esthetic (Figure 1b; av:5.48) compared to other examiners (p=0.000). Students and both groups of patients gave similar values to all 4 photos showing little sensitivity for this parameter (Table 2). Patients (OP; SOP) and students (DS) also appreciated buccal corridors of 3mm and 4mm, with a statistically significant difference compared to orthodontists (p= 0.000; Figure 1b and 1d). No significant differences were found considering age, gender, and level of study.

GINGIVAL EXPOSURE. Concordant data emerged from the evaluation of the average values: all groups preferred Figure 2c with exposure of the interdental papillae only and assigned lower values to Figure 2b with 5mm of gingival exposure. Patients (OP; SOP) preferred gingival exposure of 1mm (Figure 2e, av: 6.1; 6.3) and assigned higher satisfaction values than students and orthodontists who preferred gingival exposure of 2mm with a statistically significant difference (Figure 2e, av: 6.1; 6.3) (p = 0.000). All examiners considered gingival exposures ≥3mm as non-esthetic. For orthodontists and students, a gingival exposure ≥1mm was considered highly unesthetic compared to the values assigned by patients and was statistically significant different (p = 0.000). Females assigned lower values than males in Figure 2a (F: 4.34; M: 5.1) (p=0.006) (Table 2).

SMILE ARC. All examiners assigned higher average satisfaction values to Figure 3a with concordant smile arc without statistically significant differences (p= 0.259) whilst the covered smile and reverse smile arc were defined as non-esthetic (Figure 3c; Figure 3e). Orthodontists assigned lower approval ratings than other examiners with a statistically significant difference (Figure 3c; p=0.000) (Figure 3e; p= 0.001). Patients (OP; SOP) defined a concordant smile arc with lower lip that touched the incisal edge as esthetic (Figure 3b; av: 6.08) as opposed to orthodontists and students (av O: 5.27; DS: 5.54) (p = 0.010). Only orthodontists defined the straight smile arc as non-esthetic (Figure 3d; av:5.39) with a statistically significant difference (p = 0.009). Females assigned lower values than males to the photo with the reverse smile arc (Figure 3e; F: 4.02; M: 4.88); (p=0.000; Table 2).

MIDLINE DEVIATION. All examiners assigned lower ratings to Figure 4d with a midline angulation. Orthodontists considered a coincident midline as esthetic (Figure 4c, av: 6.95), and defined all other photos as non-esthetic, assigning lower satisfaction values than the other examiners with a statistically significant difference (Figure 4a p=0.000; Figure 4b p=0,000; Figure 4d p=0.046; Figure 4e p=0.005; Fig4f p=0.005). Students defined midline deviations ≥3mm as non-esthetic, Figure 4b and Figure 4f (av: 5.74; 5.43). Patients (OP, SOP) considered the midline deviation ≤3mm as esthetic and the midline deviation of 4mm as non-esthetic, Figure 4f (av: 5.86; 5.52). Patients assigned similar satisfaction values to the photos with deviations of 1mm, 2mm and 3mm which may show that they appear not to notice any difference. Females assigned lower ratings to the photo with a midline deviation of 4mm (Figure 4f; av F: 5.08; M: 5.57) (p= 0.036), (Table 2).

Comparison between OP-SOP. Evaluating the average scores assigned by the two types of patient examiner (OP, SOP), surgical-orthodontic patients attributed lower scores than orthodontic patients, with statistically significant differences in gingival exposure of 5mm (Figure 2b; p=0.016), gingival exposure of 4mm (Figure 2f; p=0.007), gingival exposure of 3mm (Figure 2d; p=0.003), reverse smile arc (Figure 3e; p=0.05), midline angulation of 2mm (Figure 4d; p=0.005). Evaluating the influence of gender, female examiners attributed lower scores to a concordant smile arc with a lower lip that touched the incisal edge (Figure 3b; p=0.042) and to a reverse smile arc (Figure 3e p=0.035), (Table 2).

Comparison between O-DS. Evaluating the two expert groups [O; DS], orthodontists (O) assigned lower scores when compared to dental students (DS), with statistically significant differences in the cases of a straight smile arc (Figure 3d; p=0.005), a reverse smile arc (Figure 3e; p=0.001), a midline deviation of 2mm (Figure 4a; p=0.03) and a midline deviation of 4mm (Figure 4f; p=0.05). Female subjects attributed lower scores than males with statistically significant difference in the cases of gingival exposure of 2mm (Figure 2a; p=0.016), a reverse smile arc (Figure 3e; p=0.003), a midline angulation of 2mm (Figure 4d; p=0.009) and a midline deviation of 4mm (Figure 4f; p=0.001) (Table 2).

Discussion

The hypothesis of the study is rejected as there was a diversity of smile esthetic perception between the studied populations for all the parameters evaluated.

BUCCAL CORRIDORS. In 1958, Frush and Fischer[5] defined the buccal corridors as the bilateral space that forms between the buccal surface of the upper posterior teeth and the labial commissures during the smile. Their interest in the buccal corridors was due to the need to create a realistic and esthetic total prosthesis, convinced that the absence of the buccal corridors made the smile unnatural. Today the esthetic perception of the buccal corridors may have changed because fewer patients use removable prostheses as natural teeth. For this reason, a smile with absent buccal corridors may not be considered a "prosthetic smile". In 1970, Hulsey[6] examined the influence of buccal corridors on the attractiveness of the smile, the results showed that the variations of the buccal corridors had no influence. Opposing results emerged from Moore's study[7], whose results showed that lay people appreciated full smiles by defining as unsightly wide buccal corridors. However, Hulsey used only smile images, whilst Moore used full face images. Moore argued that the difference in results was due to the photos used and concluded that the size of the buccal corridors influences the esthetics of the smile when the entire face is considered. In this study, intraoral photos with 4 different sizes of buccal corridors were used. The results showed that specialists preferred absent buccal corridors and defined 4mm buccal corridors as unsightly. On the other hand, the students did not notice any differences in the photos, defining the 3- and 4mm buccal corridors as attractive. Roden-Johnson et al.[8] found no difference in female smiles with and without buccal corridors judged by orthodontists, general dentists, and lay people. These results are contrary to the results of this study, where orthodontists identified some differences which students and patients did not perceive. In the Roden-John-

son study the buccal corridors were classified as present or absent and no millimeter evaluation was performed. This difference may have affected the study results. In another study conducted by Parekh et al.[9] the width of the buccal corridors was evaluated in relation to the variations of the smile arc and the results showed that the smile arc influenced the esthetic perception more than the size of the buccal corridors. This result is in line with the results of this study, where all the photos showed a concordant smile with different buccal corridor widths which were not perceived by students and patients.

GINGIVAL EXPOSURE. According to the literature, gingival exposure during smiling is not a negative characteristic[10]. Recent studies showed that a gingival exposure of no more than 3mm is acceptable, whilst values greater than 3mm were considered non-esthetic. These data agree with the results obtained in our study regarding patient opinion. Orthodontists and students, on the other hand, defined exposures ≥2mm as unsightly. This data shows how the impact of gingival exposure is excessively emphasized among orthodontists. Gingival exposure also depends on the lip line of the smile, and its position varies according to gender and age. Aging determines numerous physiological and pathological changes, one of these is the progressive coronal shift of the lip line of the smile, resulting in less exposure of the gum and upper teeth in favor of the exposure of the lower incisors. Most orthodontic patients are adolescents; therefore, a progressive physiological reduction of gingival exposure must be considered during adulthood. Conflicting data emerged from the study by Kokich et al.[11] where general dentists defined a smile with gingival exposure of 4mm as attractive, while orthodontists and patients defined exposures greater than 3mm as non-esthetic. In Kokich's study, no significant differences were found between ordinary people and specialists. On the other hand, in this study specialists and students showed less tolerance towards gingival exposure than patients. In our study females assigned statistically significant lower satisfaction values than males only to photos with gingival exposure of 2mm. This data is supported by the study by Loi et al.[12] which stated that the gender of the examiners did not have a statistically significant effect on the perception of gingival exposure. A gingival exposure greater than 3mm is defined as a gummy smile, all studies define this condition as extremely unsightly[13-15]. Before starting the orthodontic treatment, it is necessary to make a correct diagnosis of the gummy smile. A very common clinical error is to perform an uncontrolled intrusion of the upper incisors that does not consider the alteration of the smile arc. In these cases, the loss of a concordant smile arc could be more deleterious than gingival tissue exposure[15]. A reverse or straight smile arch can also be obtained by an uncontrolled intrusion of the upper incisors in the treatment of the gummy smile.

Another important aspect to consider in patients with gummy smile is the symmetry of the gingival parabolas, especially in orthodontic patients with impacted canines in which the periodontal aspect may be compromised following orthodontic traction[16].

SMILE ARC. The smile arc is the relationship between the curvature of the incisal edges of the maxillary incisors and canines to the curvature of the lower lip in the social smile. All examiners considered photos with a concordant smile arc and a smile showing the crown of the upper teeth as esthetic.

This condition is typical of young people. A covered smile and reverse smile arc were considered non-esthetic by all examiners as it tends to make patients appear older. With aging, there is a progressive exposure of the lower incisors as a result of the loss of labial muscle tone and the progressive wear of the incisal edges. These results are supported by the literature[17] which showed that the vertical position of the teeth, the visibility of the teeth, the position of the upper lip, the parallelism between the curve described by the incisal edges of the upper teeth and the lower lip are critical factors in the self-perception of smile attractiveness. Today, the arc of the smile is considered the most important factor in the esthetics of the smile[18]. An incorrect orthodontic therapy can negatively modify the smile arc and therefore compromise esthetics.

MIDLINE DEVIATION and ANGULATION. Midline evaluation plays a controversial role in smile esthetics. The symmetry of the midline is regarded by orthodontists as fundamental to obtain correct intercuspidation and a functional occlusion[19]. There is a relationship between the degree of asymmetry and occlusion of the posterior teeth, and the correction of malocclusion is closely related to the re-centering of the midline[20]. This study showed that orthodontists in particular placed great emphasis on midline deviation, even detecting deviations of 1mm. Similar data can be found in a study by Pinho et al.[21] while Johnston et al.[22] stated that specialists noted deviations ≥2mm. In Kokich's study[23], however, orthodontists assigned negative satisfaction values to midline deviations ≥4mm.

With regard to gender, in this study, females assigned statistically significant lower satisfaction values to photos with a midline deviation of 4mm and showed greater sensitivity towards this parameter, defining a deviation of 1mm as unattractive. Males on the other hand, considered deviations of 3mm as esthetic.

Regarding midline angulation, in keeping with other studies this was defined as highly unesthetic by all examiners[11,15]. Given the angle of the midline has a significant impact on the esthetics of the smile, any alteration must necessarily be corrected.

Current studies available in the literature do not analyze the difference in the perception of smile esthetics between different types of patients. This study analyzed the differences in esthetic preferences between orthodontic and surgical-orthodontic patients. While the results between the two groups were the same for buccal corridors, surgical-orthodontic patients assigned lower approval ratings to photos which showed a greater degree of alteration of the mini esthetic parameters of gingival exposure of 3, 4 and 5mm, a reverse smile arc and midline angulation than orthodontic patients. It was noted that pre-surgical orthodontic patients assigned lower values to the photos that most closely reflected their malocclusion, which was often more severe than the malocclusions of orthodontic patients. The results showed surgical orthodontic patients paid greater attention to the evaluation of smile esthetics, including parameters of macro-esthetics, in the evaluation of the profile[1]. This attention could be related to the greater awareness of the severity of the malocclusion in pre-surgical orthodontic patients and to a greater expectation on their part of a positive outcome as a result of treatment. Given the appearance of the smile may influence the patient's expectations, self-perception and psychological attitude, evaluating the psychological profile of the surgical-orthodontic patient

to ascertain the possible existence of issues such as depression and anxiety related to the appearance of the smile[24] is to be recommended.

Regarding specialists, orthodontists and dentistry students showed comparable results, with statistically significant differences in straight and reverse smile arc and midline deviations of 2 and 4mm. These results indicate that postgraduate training in orthodontics may enable examiners to perceive slight changes in the parameters most closely related to orthodontic treatment such as midline deviation and smile arc.

Finally, female subjects expressed more negative judgements than male counterparts, which may be due to factors such as greater social conditioning as far as regards the evaluation of physical esthetics.

Conclusion

- BUCCAL CORRIDORS: Students and patients reported that the width of the buccal corridors does not influence smile esthetics and assigned similar satisfaction values to all photos. Specialists considered buccal corridors of 4mm unattractive.

- GINGIVAL EXPOSURE. Gingival exposure has a very important impact on smile esthetics. An exposure ≥3mm, the so-called gummy smile, negatively influences the esthetics of the smile.

- SMILE ARC. All examiners considered a reverse smile arc and a covered smile to be very unsightly. Patients and students evaluated a straight smile arc more positively compared to specialists.

- MEDIAN LINES. Specialists defined as non-esthetic midline deviation ≥1mm, whereas patients noticed deviations ≥4mm. All examiners defined a midline angulation of 2mm as highly unesthetic.

- The surgical orthodontic patients assigned lower values to the photos and showed greater attention to evaluating the esthetics of the smile than the orthodontic patients.

Smile arc, gingival exposure and midline angulation are the parameters of mini esthetics perceived most clearly by patients. For this reason, these parameters should be evaluated more carefully by the specialists during the treatment plan. In agreement with the literature, the role of buccal corridors and midline deviation on smile esthetics is still controversial.

Acknowledgments

Data availability

Datasets related to this article will be available upon request to the corresponding author.

Conflicts of interest

None.

Author Contribution

M. Mezio, R. Guarnieri, M. Cassetta made the research, collected the data for this study and performed the data extraction, the management and interpretation of the results as well as the draft of this paper. F. Altieri, G. Padalino made substantial contributions to the conception and contributed to writing the manuscript. R. Di Giorgio, G. Galluccio made substantial contributions to interpretation of the results. E. Barbato design of the work and supervised and supported this study. All authors read and approved the final manuscript.

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