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# Reference values of Orthopantomographic indices for early detection of low bone mineral density in Indian population

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ABSTRACT

*Purpose:* Orthopantomographic (OPG) indices are considered tools for early screening for low Bone Mineral Density and Osteoporosis. This tool is being used in the western population, and they have developed their reference values for all the OPG indices. The current study aimed to check the validity of the reference values for OPG indices in the Indian population.

*Material and methods:* A cross-sectional study was conducted on 325 participants, and they were recruited in two sets. Dataset one of 130 aged 20–30 years and dataset two of 195 participants aged 40–60 years. OPG was performed, and indices such as Mental Index (MI), Panoramic Mandibular Index (PMI), Gonial Index (GI) and Antegonial Index (AI) were measured. Values obtained in our study were compared with the established OPG indices for the Indian and Western populations.

*Results:* The mean age of participants in dataset one to develop references was 23.5 ± 2.5 years. Females had a significantly lower MI, PMI, and AI than males ($p < 0.05$). MI was significantly higher in validation dataset one males than females ($p < 0.05$). A good agreement was found in MI and PMI of the two references ($p < 0.05$).

*Conclusions:* The reference values derived from this study for MI, PMI, GI and AI are 3.50,0.27,1.10, 2.50, respectively. Compared with previous studies in Indian and western populations, these references were significantly lower.

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**Author statement**

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## 1. Introduction

Bone Mineral Density (BMD) measurements are crucial in screening patients at risk for osteoporosis and are commonly used in fracture treatment. The routine method of testing is to use Dual-energy X-ray absorptiometry scans of the skeleton system to record BMD of the lumbar spine and hip.[1]

Early detection focuses on detecting symptomatic patients as early as possible, while screening consists of testing healthy individuals to identify before any symptoms appear.[2] In 1994, a World Health Organization (WHO) study group recommended a definition of osteoporosis based on a BMD measurement of the spine, hip, or forearm.[2,3] The WHO report also proposed creating an intermediary category recognized by low bone mass between the normal and osteoporotic states and termed it as ''Osteopenia.''[4]

Furthermore, dental radiographs can also assess bone density, such as periapical and panoramic radiographs.[4] Radiographic assessment of bone density has applications in implantology and research evaluating the correlation between oral bone loss and osteoporosis.[5] Orthopantomograph can be helpful in intercepting patients at risk of reduced BMD.[6] A large number of measurements of the mandibular bone were drawn up

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from radiographs, have been for this purpose, including densitometry and morphometry.[6,7]

These Radiomorphometric indices include qualitative and quantitative indices. Many Orthopantomogram (OPG) indices, including the mental index (MI), panoramic mandibular index (PMI), gonial index (GI) and antegonial index (AI), have been developed to assess and quantify the quality of mandibular bone mass and to observe signs of resorption on panoramic radiographs.[8] Qualitative indices include the Mandibular Cortical Index (MCI). Quantitative indices include MI, PMI, GI and AI. Clinicians have now started to consider some mandibular panoramic indices to identify elderly individuals who should undergo BMD assessment.[9]

The prevalence of osteoporosis and the incidence of fracture show variability by demographic characteristics.[10] Knowledge of mandibular Radiomorphometric indices is essential to recognize individuals whose mandibular Radiomorphometric indices are abnormally low. Previously several studies were conducted in western countries with the use of dental radiographs for osteoporosis screening,[11,12] data from developing and underdeveloped countries is negligible.[13]

In a previous study conducted by Pal et al. MCI, MI and AI but not GI on the Indian population was considered. Also, their study was conducted only in 80 participants aged 30–70 years, and their osteoporosis status was not considered. Participants with diagnosed Osteoporosis and Osteopenia should be further evaluated using the reference value (cut-off value) for OPG. Hence, further studies need to establish and validate new reference values.[14]

The objective for the current study was to establish the reference values for OPG indices, including MI, PMI, GI and AI, to identify low BMD.

## 2. Subjects and methods

A cross-sectional study was conducted to establish the reference values for OPG indices to identify lower OPG indices indicative of low BMD. Two sets of participants were recruited for the study. The sample size was derived for data set one based on previous studies conducted by (Pal and Amrutesh in 2013),[14] (Bajoria AA and others)[9] 2015. As per earlier studies, 20% of the Indian population have osteoporosis.[9] Thus, the sample size was calculated expecting 80% of Indians having normal BMD to achieve a confidence level of 80%, a confidence limit of 5%, and a design effect of 1. The sample size was calculated to be 105. Two data set of participants were recruited for the study.

### 2.1. Study participants

#### 2.1.1. Data set one

One hundred and forty healthy adults aged 20–30 years were recruited. Out of 140 participants, 130 met the inclusion criteria and were included in the data set one to develop the reference values. Considering that 20% of participants may have osteoporosis, 21 extra participants were recruited. Thus sample size was calculated to be 126. Thus 20% of $105 = 21$

$$105 + 21 = 126$$

**Inclusion Criteria:** Dentulous subjects with a minimum of 20 teeth present, normal bone density on a Dual-energy X-ray absorptiometry scan (Lumbar spine and Femoral BMD Z score $> -1$); aged 20–30 years. Exclusion criteria: patients with root piece, impacted teeth, H/O orthodontic treatment, severe systemic debilitating conditions such as malignancy, mental disorder, or any pathological disorder of mandible.

### 2.2. Data set two (validation dataset)

Two hundred and ten participants aged 40–60 years were also recruited. Out of 210, 195 participants met the inclusion criteria and were included in the data set to validate the references developed in the current study. Written informed consent was obtained from all participants. Ethical clearance was obtained from Institutional Ethics Committee of Sinhgad Dental College and Hospital, approval number was SDCH/IEC/2017-18/OUT/61. Anthropometric parameters and Digital panoramic radiographs were performed on all participants in both data sets. A physician examined all participants to confirm that they were healthy.

### 2.3. Anthropometric parameters

Body Mass Index (BMI) was calculated by dividing weight in kg by height in meter square. Weight was measured on an electronic weight scale to the accuracy of 100 g (Salter). Standing height was measured to the nearest 1 mm, using a stadiometer (Leicester Height Meter, UK, range 60–207 cm).

### 2.4. Digital panoramic radiographs

Then Orthopantamograph (OPG) was performed for all participants in the Department of Oral Medicine, Diagnosis, and Radiology; the scan was obtained using a Planmeca Promax 3D Mid Proface CBCT unit manufactured in Finland. The exposure settings were set at 90 kV and 11.2 mA. The examiner was calibrated by an experienced faculty from the Department of Oral Medicine, Diagnosis and Radiology to ensure standardized examinations. For further analysis, images were saved as DICOM (Digital Imaging and Communications in Medicine) files, and these data sets were accessed in the software viewer Romexis version 4.2.0 R 10/13/15. Radiographic indices. Mental Index (MI), Panoramic Mandibular Index (PMI), Gonial Index (GI) and Antegonial Index (AI) were measured as given below (Fig. 1).

Mental Index (MI): Mandibular cortical thickness was measured at the line running at the middle of the mental foramen, perpendicular to the base of the mandible.

Panoramic Mandibular Index (PMI): The PMI is the ratio of mandibular cortex thickness and the distance between the inferior mandibular cortex and mental foramen.

Gonial Index (GI): Mandibular cortical thickness was measured on the bisection between the tangent lines and the bottom of the mandible.

Antegonial Index (AI): AI is a measurement of the width of the cortex in the region which is frontal to the gonial, at a point which is in line with the 'best fit' on the anterior border of the ramus, running down the inferior border of the mandible. The anterior border of the ramus was markedly curved, and the line was drawn to fit as closely as possible, inferior to the bone margin, which was above the third molar region.

### 2.5. Statistical methods

Data were analyzed using SPSS version 25 for Windows (version 25, 2017, IBM Corporation, Armonk, New York, United States). Data are

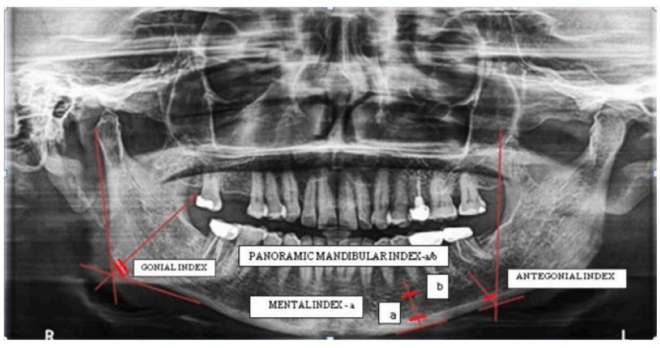


**Fig. 1.** Radiomorphometric indices – Gonial index, Antegonial index, Mental index. (a) Panoramic mandibular index (a/b) [31].

presented as Mean ± SD or Median (Inter Quartile Range (IQR)). Normality of data was tested using the Shapiro Wilk test after classifying the data by gender. Normally distributed data were compared between the two genders using the Independent Sample T-test, whereas the Mann Whitney *U* test was used to compare non-normally distributed data.

Z scores were calculated for MI, PMI, GI and AI for the validation subset (data set 2) using the references developed in the current study. Z scores were also calculated for MI, PMI and AI using the reference data published by Pal and Amrutesh (2013)[15] and Gaur B et al.[16] The formula used for calculating the Z score was:

Z score = Value of participant-Mean SD

The references developed in the current study were validated by comparing the Z score references of 2 classifications (current study vs Pal and Amrutesh and Gaur B et al.)[15,16] using Cohen's Kappa test. Participants were classified into two groups for all the OPG indices based on Z scores: i) participants with Z score $> -2.5$ ii) Z score $< -2.5$. Cohen's Kappa value $< 0.20$ indicates poor agreement, 0.21–0.40 indicates fair agreement, 0.41–0.6 indicates moderate agreement, 0.61–0.80 indicates good agreement, and 0.81–1.00 indicates excellent agreement.[15] $P < 0.05$ was considered to be statistically significant.

## 3. Results

Results of the current study were conducted in 2 phases to generate references for OPG indices are presented in the current study.

### 3.1. Phase 1: development of references for OPG indices

In the present study the anthropometric indices of study participants were recorded. Males were significantly taller and weighed more than females ($p < 0.05$). No significant difference was observed in BMI between the two groups ($p > 0.05$). The mean age of participants in dataset one to develop references was 23.5 ± 2.5 years (Table 1).

Digital panoramic radiographs were conducted in all 130 participants enrolled in dataset one, and MI, PMI, GI and AI were calculated. The means of all four indices were computed to derive the references. Females had a significantly lower MI, PMI, and AI than males ($p < 0.05$). No significant differences were observed in GI between the two genders ($p > 0.05$) (Table 1).

### 3.2. Phase 2: validation of reference values

Dataset two of 195 participants were recruited to validate the reference values of OPG indices developed in the current study. Anthropometry and OPG indices of the validation dataset were recorded (Table 2). MI was significantly higher in validation dataset one, amongst males than females ($p < 0.05$). No other significant differences were observed ($p > 0.05$). Z scores were calculated for OPG indices compared to reference values. Z scores were also calculated for OPG indices compared to Pal and Amrutesh (2013) (Table 3). A significant gender-based difference in the MI and PMI, Z score was calculated using the references from the current study ($p < 0.05$). There was also a gender-based significant difference in PMI and AI, Z score calculated using Pal and Amrutesh[15] and Gaur et al.[16] Z score ($p < 0.05$). There was also a gender-based significant difference in PMI and AI, Z score calculated using Pal and Amrutesh Z score ($p < 0.05$).

When the Z scores obtained by two references were compared, the Z scores calculated using Pal and Amrutesh references were significantly lower than those calculated using references from the current study ($p < 0.05$). Data presented as median (IQR) ($p < 0.05$) for comparison between males and females.

Participants in dataset one used for validation were classified into two groups: Z scored less than −2.5, and Z scored more than −2.5 (Fig. 2). Using the current study references, a similar number of participants had low Z scores for all four parameters. On the other hand, when using Pal and Amrutesh references, a very high number of participants had low AI Z scores compared to the number of participants having low MI and PMI Z scores. It indicates an internal discrepancy using the different indices for measuring OPG using Pal and Amrutesh data.

To further validate the references developed in the current study Cohen's Kappa was calculated between the prevalence of low Z score using current study data and Pal and Amrutesh references (Table 4). A good agreement was found in MI and PMI of the two references ($p < 0.05$). A fair significant agreement was found between AI of the references ($p < 0.05$).

When mean values are compared for OPG indices such as MI, PMI, GI and AI, the mean values were more significant amongst the western population than the Indian population. Hence the references for the current sample derived from the Indian population cannot be validated using previous studies conducted on the Caucasian population.

**Table 1**
Anthropometric indices and Reference values of the participants enrolled to develop normative data.

| | Males (n = 67) μ±SD | Females (n = 63) μ±SD | Total (n = 130) μ±SD | p value |
|---|---|---|---|---|
| **Age, years** | 23.3 ± 2.9 | 23.7 ± 2.0 | 23.5 ± 2.5 | 0.425 |
| **Height, cm** | 170.1 ± 7.1 | 157.7 ± 6.2 | 164.1 ± 9.1 | 0.001 |
| **Weight, kg** | 71 ± 15.5 | 59.3 ± 9.8 | 65.3 ± 14.3 | 0.001 |
| **BMI, kg/m$^2$** | 24.4 ± 4.2 | 23.9 ± 4.1 | 24.2 ± 4.1 | 0.476 |
| **MI (mm)** | 3.7 ± 0.6 | 3.2 ± 0.4 | 3.4 ± 0.6 | 0.001 |
| **PMI** | 0.3 ± 0.04 | 0.3 ± 0.04 | 0.3 ± 0.04 | 0.010 |
| **GI (mm)** | 1.2 ± 0.4 | 1.2 ± 0.43 | 1.2 ± 0.04 | 0.813 |
| **AI (mm)** | 2.9 ± 0.5 | 2.5 ± 0.5 | 2.7 ± 0.5 | 0.001 |

Mean and SD of anthropometric indices and reference value in order to derive the normative data.

**Table 2**
Anthropometry and Orthopantomogram indices in validation subset.

| | Males (n = 105) Median (IQR) | Females (n = 90) Median (IQR) | Total (n = 195) Median (IQR) | p value |
|---|---|---|---|---|
| **Age, years** | 41.3 (19.6) | 41.6 (21.4) | 41.4 (20) | 0.414 |
| **Height (cm)** | 168 (7.4) | 154 (9.4) | 161.5 (14.3) | 0.001 |
| **Weight (kg)** | 73 (18) | 63 (13.4) | 66.8 (18.6) | 0.001 |
| **BMI (kg/m$^2$)** | 25.5 (5.2) | 26.8 (7.2) | 26 (5.8) | 0.093 |
| **MI (mm)** | 3.60 (0.70) | 3.40 (0.50) | 3.50 (0.60) | 0.001 |
| **PMI** | 0.27 (0.05) | 0.26 (0.05) | 0.27 (0.05) | 0.566 |
| **GI (mm)** | 1.10 (0.50) | 1.10 (0.55) | 1.10 (0.58) | 0.582 |
| **AI (mm)** | 2.50 (0.90) | 2.50 (1.10) | 2.50 (1.00) | 0.801 |

Median (IQR) of anthropometry and Orthopantomogram indices in the validation subset.

## 4. Discussion

Osteoporosis mostly affects older people, and is usually detected at an advanced stage when the patient may present bone fractures. Fractures are clinically relevant implications of the disease due to their association with morbidity and mortality. The risk for osteoporosis is also higher among post-menopausal females, as age and oestrogen deficiency are both recognized as factors associated with a reduction in bone mass.[18]

Studies have shown that the alveolus is similar to the vertebrae as neither bone type has muscle insertions. Hence, dental radiographs might prove a reliable indicator of systemic osteoporosis. In the present study, Radiomorphometric indices of the mandible were recorded and

**Table 3**
References for Orthopantomogram Z scores in validation subset of the current study as compared to previous study.

| | Males (n = 105) | | | Females (n = 90) | | | Total (n = 195) | | |
|---|---|---|---|---|---|---|---|---|---|
| | A[a] | B[b] | p value | A[a] | B[b] | p value | A[a] | B[b] | p value |
| **MI Z score** | −0.06 (1.21) | −0.53 (1.07) * | 0.001 | 0.53 (1.22) | 0.38 (0.82) | 0.001 | 0.30 (1.29) | 0.38 (0.88) | 0.001 |
| **PMI Z score** | 0.25 (1.25) | −0.85 (0.85) * | 0.001 | 0.25 (1.31) | −0.87 (0.76) * | 0.001 | 0.25 (1.5) | −0.87 (0.90) | 0.001 |
| **GI Z score** | −0.33 (1.16) | NA | NA | −0.28 (1.29) | NA | NA | −0.31 (1.35) | NA | NA |
| **AIZ score** | 0.20 (1.94) | −1.48 (1.7) | 0.001 | 0.08 (2.24) | −0.9 (1.78) * | 0.001 | −0.12 (2.04) | −1.13 (1.64) | 0.001 |

[a] Current study references.
[b] Pal and Amrutesh references14.

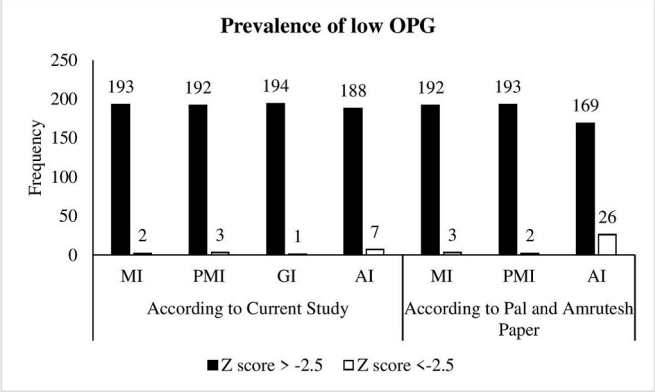


**Fig. 2.** Frequency of z score > −2.5 as compared to z score < −2.5 for MI, PMI, GI, and AI for the current study and study conducted by Pal et al.14.

**Table 4**
Validity of References obtained for Orthopantomogram indices using Cohen's Kappa.

| Classification based on current study references | Classification Based on Pal and Amrutesh References | | | Cohen's Kappa | p value |
|---|---|---|---|---|---|
| | Z score > -2.5 | Z score < -2.5 | Total | | |
| Mental Index | | | | | |
| Z score > -2.5 | 192 | 1 | 193 | 0.798 | 0.001 |
| Z score < -2.5 | 0 | 2 | 2 | | |
| Total | 192 | 3 | 195 | | |
| **Panoramic Mandibular Index** | | | | | |
| Z score > -2.5 | 192 | 0 | 192 | 0.798 | 0.001 |
| Z score < -2.5 | 1 | 2 | 3 | | |
| Total | 193 | 2 | 195 | | |
| **Antegonial Index** | | | | | |
| Z score > -2.5 | 169 | 19 | 188 | 0.390 | 0.001 |
| Z score < -2.5 | 0 | 7 | 7 | | |
| Total | 169 | 26 | 195 | | |

Validity of the reference values derived from the current study for Orthopantomogram indices using Cohen's Kappa.

evaluated in the form of panoramic radiographs.[19] Since dental panoramic radiography is used as a routine screening tool in general dental practice, assessing Radiomorphometric indices in it may be helpful to identify low BMD.

The current study's mean values for MI, PMI, GI and AI were 3.4, 0.3, 1.2 and 2.7, respectively. In a similar study conducted by Bajoria AA et al. (n = 23) in the Indian population, the mean values for MI, GI and AI were 0.98, 2.98 and 3.37, respectively.[9] When; the western population was considered in a study conducted by Dagistan et al. the mean values for MI, PMI, GI and AI were 5.71, 0.35, 1.10 and 3.41.[15,20] Whereas Devin et al. showed a mean value of 4.73, 1.24 and 3.41 for MI, GI and AI respectively.[17] The results show that the mean value of OPG indices is more significant in the western population when compared to the Indian population and hence cannot be used to validate references of OPG indices for the Indian population.

In another study conducted by White AC et al. for the western population, the mean values for MI, GI and AI were 1.35, 3.29 and 4.46.[20] They also stated that OPG indices have an overall downward trend with increasing age until 60 years of age, after which values fall drastically compared to the normal values.[20] The variation in mean values of the indices compared to those in the previous studies could be due to differences in ethnicity and small sample size.[6,20] The value for GI in the present study was 1.2 ± 0.4 and 1.2 ± 0.43 in males and female participants, respectively. According to Bras et al., GI showed a very gradual thinning with age, and the values were lower in females than males.[21]

The relationship between osteoporosis and oral health remains controversial. It is crucial to evaluate the relationship between osteoporosis and bone loss in the oral cavity. The dentist can screen patients for osteoporosis. Such screening aims to identify individuals at risk for osteoporosis and refer them immediately.[22] Panoramic radiography could be a reliable tool in screening for osteoporosis.[23,24]

The mean age of participants in dataset one to develop references was 23.5 ± 2.5 years. In the previous study conducted by Pal et al.,[14] was performed on a small sample size aged 30–70 years were included; hence there was a need to conduct a study in young adults aged 20–30 yrs. The current study was done on a larger sample size to increase the study's power and overcome the limitations similar to previous studies. In the present study, males were significantly taller and weighed more than females. No significant difference was observed in Body Mass Index between the two groups ($p > 0.05$); these findings are similar to the study published by Martin et al.[25]

In the present study, females had a significantly lower MI, PMI, and AI than males ($p < 0.05$). No significant differences were observed in GI between the two genders ($p > 0.05$). These findings confirm those of previous studies conducted among British females.[12] A negative correlation was found for GI, MI and AI with age.[12] Another study demonstrated a decrease in AI, MI, PMI in females at the age of 60 ($p < 0.05$). Our study showed a significant difference in the values of MI and AI between males and females ($p < 0.05$). Lower values in females could be attributed to the anatomical and physiological differences between the sexes. Similar findings in a previous study found that MI and AI decreased with age in females but increased in males.[26] Another study, there was decrease in values of MI and AI in both genders up to 75 years, and then both indices decreased sharply for females in contrast to males.[11]

MI was significantly higher in the validation dataset amongst males than females ($p < 0.05$). There was a significant gender-based difference in MI and PMI, Z score calculated using the references from the current study. Previous study demonstrated a decrease in AI, MI, PMI in Females at 60 years.[15] Lower values amongst females is due to anatomical and physiological differences between the genders. A previous study recorded that MI and AI decreased with age in females but increased in the

male.[27] Patients with the thinnest mandibular cortices (≤3 mm) should be referred for further investigation as this group has the highest likelihood of osteoporosis.[12] Major advantage of PMI over MI is that since it is a ratio, its method of calculation will show the difference in magnification associated with different panoramic equipments.[21]AI is considered to be a poor index for osteoporosis.[12]

Several limitations the participants in the present study were not osteoporotic as suggested by a Dual-energy X-ray absorptiometry scan. Hence, the reference values were only derived for low BMD and not for Osteopenia or Osteoporosis. There is a need for further research amongst Osteoporotic adults to get accurate references of OPG indices in osteoporosis screening.[28] A further study with a larger group of dentate and edentulous patients of both genders, including a more significant proportion of osteoporotic individuals, should be conducted. Previous studies have included severity of chronic periodontitis and 10-year significant osteoporotic fracture probability (MOFP) and hip osteoporotic fracture probability (HOFP) in female patients. Severe periodontitis show higher osteoporotic fracture probability.[29] We can also include periodontitis as a parameter in future studies. Values of BMD for men cannot be extrapolated from that of Women; the mean value of MI, PMI and AI showed lower references in females compared to males. Gender-specific reference databases must be constructed.[30]

The reference values derived from this study for MI, PMI, GI and AI are 3.50, 0.27,1.10, 2.50, respectively. Compared with previous studies in Indian and western populations, these references were significantly lower.

## 5. Conclusions

The mean value for OPG indices showed good agreement with MI and PMI references derived from earlier studies done in Indian population. The thickness and shape of the mandibular cortex reflected the systemic condition of BMD, and OPG could be used to identify patients at risk for low BMD. Using the OPG, patients with normal bone mass could be differentiated from those with reduced bone mass (osteopenia/osteoporosis). The dentist can screen patients with unrecognized osteoporosis. Such screening aims to identify individuals at risk for osteoporosis and refer them appropriately.

## Declaration of competing interest

Nil.

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