Diagonal Earlobe Crease and Long-Term Survival After Myocardial Infarction

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Abstract

**Background:** The association between the presence of a diagonal earlobe crease (DEC) and coronary artery disease (CAD) has been prescribed earlier. However, it is unclear whether patients with acute myocardial infarction (AMI) and DEC have a higher risk of dying.

**Methods:** Study participants were persons with AMI who were included in the KORA Myocardial Infarction Registry Augsburg from August 2015 to December 2016. After taking pictures of both earlobes, two employees independently assessed the severity of DEC in 4 degrees. For analysis, the expression of the DEC was dichotomized. Information on risk factors, severity and therapy of the AMI was collected by interview and from the medical record. Vital status post AMI was obtained by population registries in 2019. The relationship between DEC and survival time was determined using Cox proportional hazards models.

**Results:** Out of 655 participants, 442 (67.5%) showed DEC grade 2/3 and 213 (32.5%) DEC grade 0/1. Median observation period was 3.06 years (5-1577 days). During this period, 26 patients (12.2%) with DEC grade 0/1 and 92 patients (20.8%) with grade 2/3 died (hazard ratio 1.91, 95% confidence interval (CI) 1.23 - 2.96, p = 0.0037). In the fully adjusted model, patients with DEC grade 2/3 had a 1.48-fold increased risk of death compared to the DEC grade 0/1 patient group (CI 0.94 - 2.34, p = 0.0897). The fully adjusted model applied for 1-year survival revealed a significant, 2.57-fold hazard ratio of death (CI 1.07 - 6.17, p = 0.0347) for the patients with DEC grade 2/3.

**Conclusions:** Our results indicate that DEC is independently associated with 1-year AMI survival.

Background

Coronary artery disease (CAD) is the most common disease in Europe and in the US. In the US, CAD accounts for 1 in 7 deaths, killing over 366,800 people a year [1, 2]. For decades, factors that promote CAD have been investigated. In addition to classic risk factors, the diagonal earlobe crease (DEC) has been described as an independent indicator for CAD and other vascular diseases [3]. DEC was first introduced in 1973 by S.T. Frank and is subsequently also described as “Frank's sign” [4]. It can be easily seen as a diagonal wrinkle in various depths extending from the tragus through the lobule.

The pathogenesis of Frank's sign is based on several theories. One concept considers primarily a microvascular disorder in the earlobe with elastic fiber tears and thickening of the arteries [5]. Others reported shortened telomeres in patients with metabolic syndrome that may indicate atherosclerosis driven accelerated aging [6, 7]. Recently, a context of (bilateral) Frank's sign with vascular dysfunction has been identified [8]. Another hypothesis discusses collagen degeneration as a cause of atherosclerosis formation also occurring in the skin [9]. In autopsy, risk of death from acute myocardial infarction (AMI) was doubled with at least moderate two-sided DEC [9].
Although previous studies have shown that DEC is an independent indicator of CAD, its association with the prognosis after AMI is not investigated so far. Thus, the objective of the present study was to prospectively examine the association of Frank's sign on long-term survival in patients with AMI.

**Methods**

The study was conducted in accordance to the Declaration of Helsinki and approved by the ethics commission of the Bavarian Medical Association (Approval No. 15016, 28/04/2015). From all participants written informed consent was obtained.

The study population consisted of patients with AMI who were admitted to a hospital in the study region of the KORA Myocardial Infarction Registry. Figure 1 shows flow diagram of eligibility. The population-based AMI registry was implemented in 1984 as part of the WHO-MONICA (Monitoring Trends and Determinants in Cardiovascular Disease) project. After the termination of MONICA in 1995, the registry became part of the framework of KORA (Cooperative Health Research in the Region of Augsburg). Since 1984, all cases of coronary deaths and non-fatal AMI of the 25–74 year old study population in the city of Augsburg and the two adjacent counties (about 600,000 inhabitants) have been continuously registered [10, 11]. In 2009, the age range of participants was extended to 84 years.

In the present study, patients who were registered at the KORA Myocardial Infarction Registry between 1 August 2015 and 31 December 2016 were contacted by a study nurse during their hospital stay after transfer from the intensive care unit. They received information about the study and were asked to participate.

Photos of both ear lobes were taken in sitting position by a study nurse. All photos were rated for the presence of a DEC by two trained study nurses independently. The raters were blind towards the rated patients and their clinical characteristics. The results of the two raters were compared and in case of disagreement an third person discussed the findings with the raters and a common decision was made. The assessment was based on the classification published by Patel et al. [9]: grade 0 is no crease, grade 1 is any degree of crease less than 2, grade 2a is a deep diagonal crease greater than 50% but less than 100% across the lobe, grade 2b is a complete crease across the lobe that is superficial but not deep, grade 3 is a deep crease across the whole lobe (see Fig. 2).

From the KORA Myocardial Infarction Registry, socio-demographic and clinical data collected by patient interview and chart review was used. Clinical information which was not routinely collected for the KORA Myocardial Infarction Registry, was extracted from the medical charts. Information on current vital status and date of death was obtained from the population registries in 2019.

Continuous data were expressed as median values with interquartile ranges (IQR) or means with standard deviation and categorical variables as percentages. The Chi²-test was used to test the differences in frequencies, t-Test or Wilcoxon test for differences in continuous variables, respectively.
Agreement between the raters was determined by weighted Kappa coefficients and related 95% confidence intervals.

To investigate the association between DEC and mortality, relative risks were computed by Cox proportional hazards models. The proportional hazards assumption was valid for all factors used in the Cox models shown by parallel lines of log(-log(event)) versus log of event times. An unadjusted model, a model adjusted for age and sex as well as a model adjusted for all meaningful potential confounding variables was calculated. Potential confounding factors were sex (male/female), age (continuous), history of reinfarction (yes/no), history of diabetes mellitus (yes/no), history of stroke (yes/no), chronic kidney disease (yes/no), peripheral arterial occlusive disease (yes/no), any recanalization therapy (yes/no), number of affected vessels (1/2/3/others), c-reactive protein level (≤ 3 vs. > 3 mg/dl), left ventricular ejection fraction < 50% vs. ≥ 50%. Variables with a p-value < 0.05 were taken to be statistically significant.

For the main analysis, the DEC variable was dichotomized by collapsing grades 0 and 1, and grades 2a, 2b and 3. The ear with the highest grade was considered. Sensitivity analyses were performed with different combinations of gradings: grades 0, 1, 2 (2a and 2b) and 3, sum of grades of both ears, grad 3 vs. grades 2 – 0.

**Results**

We included 655 patients with AMI in our study (mean age 68.0 ± 10.8 years) (see Fig. 1). The weighted kappa coefficient of agreement for DEC classification was 0.68 (95% confidence interval (CI) 0.64–0.71). Median observation period was 1117 days (5-1577 days). Further characteristics are detailed in Table 1. Angiographic findings are presented in Supplementary Table S1.
Table 1
Demographic and clinical characteristics of the study population with and without diagonal earlobe crease (n = 655)

|                                | Total   | DEC grade 0/1 | DEC grade 2/3 | p-value |
|--------------------------------|---------|---------------|---------------|---------|
|                                | Mean    | SD            | Mean          | SD      | Mean  | SD  |        |
| Age                            | 67.95   | 10.78         | 62.43         | 11.60   | 70.60 | 9.26| < .0001|
| C-reactive protein             | 1.85    | 8.88          | 1.81          | 4.46    | 1.87  | 5.27| 0.0287 |
| Gender                         |         |               |               |         |       |     |       |
| male                           | 490     | 74.81         | 180           | 84.51   | 310   | 70.14| < .0001|
| female                         | 165     | 25.19         | 33            | 15.49   | 132   | 29.86|         |
| Risk factors                   |         |               |               |         |       |     |       |
| Smoking                        |         |               |               |         |       |     |       |
| Current smoker                 | 181     | 27.72         | 80            | 37.74   | 101   | 22.90| 0.0003 |
| Ex smoker                      | 241     | 36.91         | 65            | 30.66   | 176   | 39.91|         |
| Never smoker                   | 231     | 35.38         | 67            | 31.60   | 164   | 37.19|         |
| Hypertension                   | 529     | 80.76         | 159           | 74.65   | 370   | 83.71| 0.0058 |
| Diabetes                       | 233     | 35.57         | 75            | 35.21   | 158   | 35.75| 0.8934 |
| Hyperlipidemia                 | 428     | 65.34         | 127           | 59.62   | 301   | 68.10| 0.0327 |
| Coronary heart disease         | 194     | 29.62         | 50            | 23.47   | 144   | 32.58| 0.0168 |
| Heart failure                  | 73      | 11.15         | 16            | 7.51    | 57    | 12.90| 0.0402 |
| Renal failure                  | 90      | 13.74         | 14            | 6.57    | 76    | 17.19| 0.0002 |
| COPD                           | 47      | 7.18          | 14            | 6.57    | 33    | 7.47 | 0.6782 |
| Angina pectoris                | 90      | 13.74         | 22            | 10.33   | 68    | 15.38| 0.7830 |
| PAOD                           | 85      | 13.00         | 21            | 9.91    | 64    | 14.48| 0.1035 |
| Stroke                         | 67      | 10.23         | 12            | 8.92    | 48    | 10.86| 0.4429 |
| Obesity (BMI > 30)             | 183     | 27.94         | 57            | 26.76   | 126   | 28.51| 0.6408 |
| Xantelasmata                  |         |               |               |         |       |     |       |
| yes                            | 18      | 2.75          | 4             | 1.89    | 14    | 3.17 | 0.3762 |
| no                             | 625     | 95.57         | 206           | 97.17   | 419   | 94.80|         |
|                                | Total | DEC grade 0/1 | DEC grade 2/3 |
|--------------------------------|-------|---------------|---------------|
| unclear                        | 11    | 1.68          | 2             |
|                                |       |               | 0.94          |
|                                |       |               | 9             |
|                                |       |               | 2.04          |
| **AMI characteristics**        |       |               |               |
| Reinfarction                   | 148   | 22.60         | 41            |
|                                |       | 19.25         | 107           |
|                                |       |               | 24.21         |
|                                |       |               | 0.1551        |
| STEMI                          | 229   | 34.96         | 84            |
|                                |       | 39.44         | 145           |
|                                |       |               | 32.81         |
|                                |       |               | 0.0049        |
| NSTEMI                         | 331   | 50.53         | 113           |
|                                |       | 53.05         | 218           |
|                                |       |               | 49.32         |
| Bundle branch block            | 69    | 10.53         | 12            |
|                                |       | 5.63          | 57            |
|                                |       |               | 12.90         |
| Not determined                 | 26    | 3.97          | 4             |
|                                |       | 1.88          | 22            |
|                                |       |               | 4.98          |
| 1-vessel disease               | 167   | 26.13         | 59            |
|                                |       | 27.96         | 108           |
|                                |       |               | 25.23         |
|                                |       |               | 0.1543        |
| 2-vessel disease               | 190   | 29.73         | 71            |
|                                |       | 33.65         | 119           |
|                                |       |               | 27.80         |
| 3-vessel disease               | 265   | 41.47         | 76            |
|                                |       | 36.02         | 189           |
|                                |       |               | 44.16         |
| Main artery disease            | 14    | 2.19          | 3             |
|                                |       | 1.42          | 11            |
|                                |       |               | 2.57          |
| Diffuse stenosis or absence of | 3     | 0.47          | 2             |
| coronary artery disease        |       | 0.95          | 1             |
|                                |       |               | 0.23          |
| **AMI treatment and outcome**  |       |               |               |
| Any recanalization therapy     | 592   | 90.38         | 193           |
|                                |       | 90.61         | 399           |
|                                |       |               | 90.27         |
|                                |       |               | 0.8904        |
| PTCA                          | 524   | 80.00         | 174           |
|                                |       | 81.89         | 350           |
|                                |       |               | 79.19         |
|                                |       |               | 0.4528        |
| CABG                          | 74    | 11.3          | 22            |
|                                |       | 10.33         | 52            |
|                                |       |               | 11.76         |
|                                |       |               | 0.5865        |
| LVEF                          |       |               |               |
|                                |       |               |               |
| > 50%                          | 357   | 54.75         | 133           |
|                                |       | 62.44         | 224           |
|                                |       |               | 51.03         |
| 41–50%                        | 122   | 18.71         | 40            |
|                                |       | 18.78         | 82            |
|                                |       |               | 18.68         |
| 31–40%                        | 95    | 14.57         | 22            |
|                                |       | 10.33         | 73            |
|                                |       |               | 16.63         |
| <=30%                         | 45    | 6.90          | 12            |
|                                |       | 5.63          | 33            |
|                                |       |               | 7.52          |
| undetermined                  | 33    | 5.06          | 6             |
|                                |       | 2.82          | 27            |
|                                |       |               | 6.15          |
| Stenting                      | 367   | 78.92         | 129           |
|                                |       | 81.13         | 238           |
|                                |       |               | 77.78         |
|                                |       |               | 0.4002        |
| Number of stents              |       |               |               |
| 1                              | 184   | 50.27         | 57            |
|                                |       | 44.19         | 127           |
|                                |       |               | 53.59         |
|                                |       |               | 0.3322        |
| 2                              | 114   | 31.15         | 44            |
|                                |       | 34.11         | 70            |
|                                |       |               | 29.54         |
| 3                              | 41    | 11.20         | 18            |
|                                |       | 13.95         | 23            |
|                                |       |               | 9.70          |
|                  | Total | DEC grade 0/1 | DEC grade 2/3 |
|------------------|-------|---------------|---------------|
| >3               | 27    | 7.38          | 10            |
| Any in-hospital complication* | 98    | 14.96         | 26            |
|                  |       | 7.75          | 17            |
|                  |       | 7.17          | 72            |
|                  |       | 16.29         | 0.1700        |

DEC: diagonal ear lobe crease; HISIHD: history of ischemic heart disease; COPD: chronic obstructive pulmonary disease; PAOD: peripheral arterial occlusive disease; STEMI: ST-elevation myocardial infarction; NSTEMI: non ST-elevation myocardial infarction; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft; LVEF: left ventricular ejection fraction;

*shock, stroke, bleeding, brady/tachycardia, atrial fibrillation, lung edema

DEC 2/3 was significantly more often detected in men (p<0.0001). Also, higher age, hypertension, smoking, hyperlipidemia, history of ischemic heart disease, heart and renal failure, and higher levels of c-reactive protein were significantly associated the presence of DEC. Patients with DEC 2/3 had more often a reduced LV ejection fraction after PCI (p=0.0243) and had a higher 1 year mortality (p<0.0031). STEMI was more often seen with DEC 2/3, whereas NSTEMI with DEC 1/2 (p=0.0049).

No frequency differences were seen between right and left ear (see Table 2). A total of 442 (67.5%) patients showed DEC grade 2/3 and 150 (22.9%) patients DEC grade 3, whereas 213 (32.5%) presented with DEC grade 0/1.
Table 2
Frequency of different diagonal ear lobe crease severity grades (n = 655)

| Severity grade | Right ear (n = 642) | n   | %    |
|----------------|---------------------|-----|------|
|                |                     | 0   | 15.89|
|                |                     | 1   | 26.79|
|                |                     | 2   | 39.56|
|                |                     | 3   | 17.76|
| Left ear (n = 640) |                   | 0   | 15.78|
|                |                     | 1   | 26.41|
|                |                     | 2   | 40.78|
|                |                     | 3   | 17.03|
| Ear with strongest severity |                | 0   | 10.38|
|                |                     | 1   | 22.14|
|                |                     | 2   | 44.58|
|                |                     | 3   | 22.90|
| Aggregate of both ears (n = 627) |            | 0   | 9.89 |
|                |                     | 1   | 7.81 |
|                |                     | 2   | 16.75|
|                |                     | 3   | 16.75|
|                |                     | 4   | 27.11|
|                |                     | 5   | 10.05|
|                |                     | 6   | 11.64|
| Grade 2 or 3 on ≥ 1 ear |               | no  | 32.52|
|                |                     | yes | 67.48|
| Grade 3 on ≥ 1 ear |               | no  | 22.90|
|                |                     | yes | 77.10|
During the observation period of 3 years in average, 26 patients (12.2%) with DEC grade 0/1 and 92 patients (20.8%) with grade 2/3 died. Figure 3 shows the Kaplan-Meier survival function. Log-rank test indicated a significantly \((p = 0.0031)\) higher risk of death for patients with DEC grade 2/3 compared with patients with DEC 0/1.

In the unadjusted Cox regression model patients with DEC grade 2/3 had a 1.91-fold higher risk of death (95% confidence interval (CI) 1.23–2.96, \(p = 0.0037\)) within a median follow-up time of 3 years compared to patients with DEC grade 0/1. After adjusting for age and sex, the hazard ratio decreased to 1.30 (95% CI 0.82–2.04, \(p = 0.2613\)) (see Supplementary Table S2).

In the fully adjusted Cox regression model, patients with DEC grade 2/3 had a 1.48-fold increased risk of death compared to the DEC Grade 0/1 patient group (CI 0.94 - 2.34, \(p = 0.0897\)) (see Table 3). Furthermore, patients with higher age, with left ventricular ejection fraction < 50, history of peripheral arterial occlusive disease and higher levels of c-reactive protein had a significantly higher hazard of death compared with those without these conditions.
Table 3
Cox proportional hazards models: Associations with all cause 1-year and 3-year mortality in patients with acute myocardial infarction (n = 651)

| Variable                                | Reference | 1-year mortality | 3-year mortality |
|-----------------------------------------|-----------|------------------|------------------|
|                                          | Reference | Hazard ratio     | 95% CI           | p-value | Hazard ratio | 95% CI | p-value |
| DEC (grade 2/3)                         | Grade 0/1 | 2.57             | 1.07–6.17       | 0.0347  | 1.48        | 0.94–2.34 | 0.0897  |
| Gender (female)                         | male      | 0.60             | 0.31–1.16       | 0.1301  | 0.71        | 0.47–1.08 | 0.1046  |
| Age [years]                             |           | 1.05             | 1.01–1.09       | 0.0242  | 1.03        | 1.01–1.06 | 0.0057  |
| Diabetes mellitus (yes)                 | no        | 1.02             | 0.54–1.91       | 0.9632  | 1.05        | 0.70–1.56 | 0.8177  |
| PAOD (yes)                              | no        | 1.90             | 0.98–3.67       | 0.0566  | 2.11        | 1.37–3.25 | 0.0007  |
| History of stroke (yes)                 | no        | 1.56             | 0.75–3.23       | 0.2334  | 1.55        | 0.96–2.49 | 0.0717  |
| Chronic kidney disease (yes)            | no        | 1.19             | 0.57–2.46       | 0.6423  | 1.39        | 0.88–2.22 | 0.1628  |
| Reinfarction (yes)                      | no        | 1.39             | 0.69–2.83       | 0.3595  | 0.83        | 0.55–1.25 | 0.3784  |
| Any recanalization therapy (yes)        | no        | 0.34             | 0.15–0.76       | 0.0088  | 0.63        | 0.37–1.10 | 0.1046  |
| LVEF < 50                               | ≥ 50      | 2.27             | 1.16–4.42       | 0.0161  | 2.21        | 1.47–3.32 | 0.0002  |
| 1-VD                                    | 3-VD      | 0.64             | 0.25–1.65       | 0.3531  | 0.74        | 0.42–1.31 | 0.2965  |
| 2-VD                                    | 3-VD      | 1.28             | 0.64–2.58       | 0.4839  | 1.21        | 0.77–1.91 | 0.4107  |
| VD: Others, missing                     | 3-VD      | 1.12             | 0.38–3.23       | 0.8415  | 1.39        | 0.67–2.87 | 0.3735  |
| CRP > 3 mg/dl                           | ≤ 3 mg/l  | 4.02             | 2.18–7.41       | <.0001  | 3.13        | 2.09–4.68 | <.0001  |
| CRP data missing                        | ≤ 3 mg/l  | 1.29             | 0.38–4.40       | 0.6861  | 0.94        | 0.42–2.08 | 0.8768  |

CI: confidence interval, DEC: diagonal ear lobe crease, PAOD: peripheral arterial occlusive disease, LVEF: left ventricular ejection fraction, VD: vessel disease, CRP: c-reactive protein
In addition, an analysis restricted to the first year after AMI was performed. During the first year, 6 patients (2.8%) with DEC grade 0/1 and 42 patients (9.5%) with grade 2/3 died. In the unadjusted Cox regression model patients with DEC grade 2/3 had a 3.52-fold higher risk of death (95% CI 1.50 – 8.28, p = 0.0039) compared to patients with DEC grade 0/1. After adjusting for age and sex, the hazard ratio decreased to 2.14 (95% CI 0.89 – 5.14, p=0.0879). In the fully adjusted Cox regression model, patients with DEC grade 2/3 had a 2.57-fold increased risk of death compared to the patients with DEC grade 0/1 (CI 1.07 - 6.17, p = 0.0347) (see Table 3).

Sensitivity analyses using other categorizations of DEC (grade 3 of at least one ear, highest grade of both ears, sum of grades of both ears) overall confirmed these results (see Supplementary Table S2). Unadjusted hazard ratios ranged between 1.13 (95% CI 1.02–1.26, p = 0.0201) for the sum of grades of both ears and 1.97 (95% CI 0.98–3.97, p = 0.0585) for the highest grade of both ears (3 vs. 0). After adjusting for other covariables, the hazard ratios decreased and were not statistically significant.

Discussion

The analysis of 655 patients with AMI showed that presence and extent of DEC were positively associated with mortality three years after AMI. After adjusting for further potential confounding variables, patients with DEC 2/3 had a 1.48-fold increased risk of death compared with patients with DEC 0/1, but this finding failed statistical significance. However, in the first year after AMI the association between DEC and mortality was considerably stronger and also statistically significant.

An association between DEC and CAD was already assumed in 1973 by the first describer S.T. Frank [4]. Frank himself proposed in 1977 that this sign should be considered in addition to classic risk factors [12]. Hereafter, numerous studies have confirmed a higher risk of CAD in persons with DEC, while others failed to find an association [13, 14]. Of importance due to its impressive number of 10.885 individuals is the Copenhagen City Heart Study. During the 35 years of follow-up DEC was associated with increased risk of ischemic heart disease and myocardial infarction independent of age and other cardiovascular risk factors [15]. A meta-analysis by Lucenteforte from 2014 summarized the available data and strongly supported the hypothesis that DEC could be a marker for CAD. Based on 37 studies in 31.188 participants, an overall pooled sensitivity of 0.62 (95% CI: 0.56–0.67), a specificity of 0.67 (95% CI: 0.61–0.73) and an OR of 3.27 (95% CI: 2.47–4.32) was found [14].

Beyond the investigations on the association between DEC and risk of CAD, only a few studies have addressed the prognostic value of DEC. On autopsy of 520 forensic cases DEC was observed in 55% and strongly correlated with CAD in both genders. The sensitivity of DEC was 75% and the positive predictive value was 68%. Interestingly, individuals under the age of 40 years had the highest positive predictive value of 80%. The authors also reported a correlation of DEC with sudden cardiac death in men [16].

Within patients referred for coronary angiogram, a Chinese study revealed that at presence of more than four risk factors and of bilateral DEC a higher chance of major adverse cardiac events (MACE) after successful percutaneous coronary intervention (PCI) [17]. Elliott et al. [18] also followed patients referred
for coronary angiography. After adjustment for ten established cardiac risk factors, the relative risk for future cardiac events was significantly elevated with DEC (1.33 for unilateral, and 1.77 for bilateral DEC compared to no DEC) [18].

In the present study, 89.6% of the AMI patients had any manifestation of DEC. This finding is consistent with studies that demonstrated a higher risk of CAD in persons with DEC. Moreover, the present study confirmed that DEC is strongly related with age, but the higher mortality risk associated with DEC remains irrespective of the chronological age. Consistent with previous studies, it can be hypothesized that DEC is a simple indicator for accelerated biological ageing. Since DEC can be easily detected by physical examination, the role of this indicator in the assessment of post-AMI risk for adverse outcomes should be investigated in further studies. Previous studies already suggest that DEC in combination with other cardiac risk factors may improve CAD risk assessment [17, 19]. The results of the present study showed that the strength of the association between DEC and mortality attenuates with increasing time after the AMI event. This might be explained by effects of variables which could not be considered in this study, though affecting long-term survival, such as medication or newly diagnosed risk factors. Moreover, in the analysis of 1-year mortality there was only a small number of fatal cases (n = 6) in the group with DEC grade 0/1, which may have distorted the results.

A limitation of our study is the inclusion of patients with residency in Germany and at the age of 25 to 84 years which reduces transferability of results to other countries and age groups. In addition, residual confounding cannot be completely ruled out. Strengths are its consecutive enrollment, standardized data acquisition of the registry, double judgement of DEC classification, consideration of relevant covariables, and sensitivity analyses with different classifications of DEC.

**Conclusions**

To our knowledge, there are no studies which have investigated the association between DEC and survival in a consecutive AMI population. Although a only slightly increased mortality risk of AMI patients with DEC was observed in the present study, clinical implications may include prolonged rhythm monitoring, more aggressive risk factor reduction, extended dual platelet inhibition, intensive heart failure management (e.g. early initiation of angiotensin/neprilysin inhibition), and in-patient rehabilitation of AMI patients with DEC. Despite all sophisticated diagnostic techniques to determine the prognosis of CAD, the simple determination of a DEC seems to facilitate the identification of patients at higher mortality risk after AMI.

**Declarations**

**Ethics approval and consent to participate**

The study was approved by the ethics commission of the Bavarian Medical Association (Approval No. 15016, 28/04/2015). From all participants written informed consent was obtained.
Consent for publication

Not applicable.

Availability of data and materials

Data cannot be made available for the public, because the patient consent did not include such an agreement. However, data may be made available for selected research questions and researchers on request to the authors. Please contact Dr. Inge Kirchberger by email: Inge.Kirchberger@med.uni-augsburg.de, or Prof. Christine Meisinger Christine.Meisinger@med.uni-augsburg.de. The Homepage of the Chair of Epidemiology is http://www.uni-augsburg.de/med/epidemiologie.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

Christian Thilo: Conceptualization, Methodology, Investigation, Writing - Original Draft.

Christine Meisinger: Conceptualization, Investigation, Resources, Supervision, Writing - Review & Editing.

Margit Heier: Conceptualization, Investigation, Writing - Review & Editing.

Wolfgang von Scheidt: Conceptualization, Resources, Supervision, Writing - Review & Editing.

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**Figures**
Figure 1

Flow diagram
Figure 2

Examples of ear lobe crease classification
Figure 3

Three-year survival of 655 patients with myocardial infarction according to diagonal ear lobe crease grading

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