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Ten-year probability of osteoporotic fracture in 2012 Polish women assessed by FRAX and nomogram by Nguyen et al.—Conformity between methods and their clinical utility

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ABSTRACT

Purpose: The aim of the cross-sectional study was to establish the degree of conformity between 10-year probability of osteoporotic fracture, assessed by FRAX, and using the nomograms, as proposed by Nguyen at al.

Methods: Postmenopausal Polish women (2012) were examined in their mean age of 68.5 ± 7.9 years (age range 55–90 years). Fracture probability by FRAX was based on age, BMI, prior fracture, hip fracture in parents, steroid use, rheumatoid arthritis, alcohol use, secondary osteoporosis and *T*-score for femoral neck BMD. Fracture probability by Nguyen's nomograms was based on age, the number of prior fractures, the number of falls and *T*-score for femoral neck BMD.

Results: The mean conformity rate was 79.1% for any fracture risk (for threshold 20%) and 79.5% for hip fracture (threshold 3%). Any and hip fracture risks were significantly higher for both methods in women with fracture history in comparison to those without fracture and increased with ageing. The influence of prior fracture and ageing was more evident in Nguyen's nomograms. ROC analyses of any fracture risk in FRAX and Nguyen's methods demonstrated the area under curve (AUC) at 0.833 and 0.879, respectively. Similar analyses for hip fracture demonstrated AUCs for FRAX and Nguyen's technique at 0.726 and 0.850, respectively. The AUCs for Nguyen's nomograms were significantly larger than the AUCs for FRAX ($p<0.0001$).

Conclusion: The mean conformity for any fracture risk is 79.1% and 79.5% for hip fracture. Nguyen's nomograms seem to be more efficient in fracture risk assessment, especially for hip fractures, due to a higher accuracy of the method. The information on the number of falls during the last year and multiple fractures ought to be incorporated into the method of fracture risk prediction.

Mini-Abstract: The degree of conformity was assessed in a group of 2012 women between 10-year FRAX prognosis of fracture and Nguyen et al.'s nomograms. The mean conformity for any fracture risk is 79.1% and 79.5% for hip fracture. Nguyen's nomograms seem to be more efficient in fracture risk assessment due to higher accuracy.

Introduction

Nowadays, osteoporosis is one of the most serious health problems, being of great consequence for public health policies and expenditures. Osteoporosis is usually a clinically silent disease and, fairly often, an osteoporotic fracture comes up as its first manifestation. As already known, fracture history is one of the strongest risk factors for subsequent fractures [1]. Therefore, the main goal of osteoporosis management is primary prevention from osteoporotic fractures. In order to properly set up prophylactic therapy, an accurate assessment of fracture risk is imperative. Recently, a few prognostic models have been developed [2–4]. They are based on bone density measurements, which are commonly applied, and they take into

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consideration several defined clinical risk factors. In 2008, the WHO introduced a new fracture prediction tool (FRAX) to determine patient's absolute fracture risk over a 10-year span [5]. Other authors have proposed algorithms for individualized 5- and 10-year fractures risk prognoses, targeting subjects above 55 years [6,7]. Fracture risk assessment cannot entirely replace objective examination, and absolute fracture risk should be accounted for in appropriate management approach. Another problem concerns the threshold for management application. For example, some analyses suggest that osteoporosis treatment would generally be a cost-effective enterprise in patients with a 10-year hip fracture risk at about 3% [8,9]. In Poland, a group of experts have proposed to introduce the treatment in patients with any fracture risk higher than 20% [10].

Irrespective of the accepted threshold for the management of osteoporotic patients, there is an obvious necessity to verify the conformity of different methods and techniques, regarding their accuracy of fracture risk assessment. The purpose of the reported cross-sectional study was to establish the conformity level between 10-year fracture risk assessment by FRAX [5] and the nomograms proposed by Nguyen at al. [6,7].

Material

A group of 2012 postmenopausal women (55 years and older) were evaluated. Data from bone densitometry centers in four Polish towns (Zabrze, Lodz, Warsaw and Poznan) were acquired for the period from March 2008 till April 2009. Three of those bone densitometry units were located at university hospitals (Zabrze, Lodz, Poznan). All subjects were subjected to bone mineral density (BMD [g/cm^2]) measurements at the hip. Three GE Lunar devices and one Norland facility were used.

The mean age of examined women was 68.5 ± 7.9 years (the range from 55 to 90), the mean weight: 68.9 ± 12.4 kg, the mean height: 156.9 ± 6.5 cm and the mean body mass index (BMI) 28.0 ± 4.8 kg/m^2. A group of 473 (23.5%) subjects presented with *T*-score for femoral neck BMD below −2.5. Table 1 presents the number and percentage of clinical risk factors for the examined women.

A group of 728 women (36%) had at least one low-trauma fracture at the age above 45 (identified as a risk factor in FRAX assessment). Among them, 692 women revealed fracture history (one or more cases) at the age of 50 or later (which is taken into consideration during assessment according to Nguyen's method). Two hundred fifty-one women presented with a history of multiple fractures (maximum 9), which amounts to a total of 1080 fractures in that subgroup.

Fractures were recorded in the following skeletal sites: distal forearm ($n=496$), vertebrae ($n=300$), proximal femur ($n=40$), humerus ($n=55$), ribs ($n=75$), and tibia and fibula ($n=114$). Spine radiographs were not widely available so only clinical (symptomatic) spine fractures were accounted for.

Methods

Fracture probability was assessed both by FRAX [5] and by the use of the nomogram system, as proposed by Nguyen et al. [6,7]. Fracture risk by FRAX was based on age, BMI, prior fracture, hip fracture in parents, steroid use, rheumatoid arthritis, alcohol use, secondary osteoporosis and *T*-score for femoral neck BMD. In order to calculate fracture probability by FRAX, US Caucasian population was referred to; first, because Polish data are not available and second, because hip fracture probability in remaining lifetime probability of hip fracture at the age of 50 and 10-year probability of hip fracture for age (ages of 60 and 70 years) [11] were close between US Caucasian population and the population of German women. One may expect that Polish fracture risk ought to be comparable with that in Germany. Data acquisition comprised the period from March 2008 till April 2009, and FRAX assessment data, regarding the German female population, have been available since January 2009, when the majority of data were collected. In order to calculate fracture risk online, FRAX calculator was used. The 10-year fracture probability for each person is expressed in percent [%].

Fracture probability, estimated by Nguyen's nomograms, was based on age, the number of prior fractures, the number of falls during previous 12 months and *T*-score for femoral neck BMD. The overall fracture probability was a sum of four digits, expressing the level for four risk factors, taken into consideration for each woman. All the calculations of fracture probability, according to Nguyen's nomograms, were performed by the first author of this report. The 10-year fracture probability for each person has been expressed in percent as well [%].

The data, used in the calculation of fracture probability, were collected in interviews, performed by members of the study team.

In order to apply an analysis of assessment conformity by both methods, the studied group was divided into:

- two fracture risk thresholds in case of any fracture ($\leq$20% and >20%)
- two fracture risk thresholds in case of hip fracture ($\leq$3% and >3%).

Conformity was defined as the same fracture risk threshold in either method.

For further analysis, we assumed that FRAX would be regarded as the reference method of fracture risk assessment and the index of conformity was calculated as the percentage of women classified at given risk level established by FRAX, who achieved the same risk threshold by Nguyen.

Study received an approval of local ethics committee.

Statistics

Statistical analysis was performed with the use of Microsoft Office Excel application, the Statistica 8 program (StatSoft, Inc., USA) and MedCalc 11.1.1.0 (MedCalc, Belgium), run on a PC computer. Fracture risk was calculated for each studied subject, according to the

Table 1
Clinical risk factors, taken into consideration during fracture risk assessment by FRAX and by Nguyen's method in the studied women—presented in the whole group and stratified by fracture status.

Clinical risk factor	The number and percentage of women with given risk factor		
	Whole group ($n=2012$)	Non-fractured women ($n=1284$)	Fractured women ($n=728$)
Fractures[a,b]	728 (36.2%)	0 (0.0%)	728 (100.0%)
Multiple fractures[b]	251 (12.5%)	0 (0.0%)	251 (34.5%)
Hip fracture in parents[a]	144 (7.2%)	92 (7.2%)	52 (7.1%)
Steroid use[a]	201 (10.0%)	136 (10.6%)	65 (8.9%)
Rheumatoid arthritis[a]	167 (8.3%)	128 (10.0%)	39 (5.4%)
Secondary osteoporosis[a]	207 (10.3%)	120 (9.3%)	87 (12.0%)
Alcohol use[a]	11 (0.5%)	8 (0.6%)	3 (0,4%)
Smoking[a]	189 (9.4%)	124 (9.7%)	65 (8.9%)
Falls[b]	565 (28.1%)	297 (23.1%)	268 (36.8%)

[a]Risk factors influencing the fracture risk assessment by FRAX.
[b]Risk factors influencing the fracture risk assessment by Nguyen's method.

algorithm of FRAX [5] and given by Nguyen et al. [6,7]. Descriptive statistics are presented as mean values and standard deviations (SDs). The comparison of subpopulations, classified at consecutive fracture risk thresholds by two methods, was done using the chi-square test. The comparison of fracture risk between the age subgroups was performed with the Mann–Whitney *U*-test and between the two methods of fracture risk assessment with Wilcoxon's matched pairs test. The comparison of subgroups with prior fracture classified at low fracture risk by both methods was done using the test of difference between two structure rates. The receiver-operating characteristics (ROC) curve analysis was used to compare the accuracy of both methods in the assessment of any and hip fracture risks.

All the results of statistical tests were regarded as statistically significant when $p<0.05$.

Results

Ten-year fracture probability for any fracture and hip fracture

The fracture risk was assessed by both methods in each studied case for hip and any fracture. The mean risk values for hip and for major osteoporotic fracture at any other location (hip, spine, forearm or humerus) within 10 years are presented in Table 2. All the values of fracture risk, as obtained in the study, were higher for Nguyen nomograms in comparison to the FRAX method, thus the Australian method seems to be predictive for a broader scope of fractures.

Conformity between the methods for 10-year any fracture risk

The mean conformity for any fracture risk was 79.1% and conformity for consecutive thresholds of any fracture risk is shown in Table 3.

The mean conformity at the level of 79.1% means that 20.9% of women achieved different fracture risk threshold during assessment by the two methods. There could be the following possible reasons for achieving high scores for any fracture risk (>20%) by FRAX and low scores for any fracture risk (≤20%) by Nguyen (the subgroup $n=142$): the presence of hip fracture in parents (34% of that subgroup), steroid use (37%), rheumatoid arthritis (32%), secondary osteoporosis (14%) and smoking (10%). In turn, possible reasons for a reversed situation (i.e., high any fracture risk score by Nguyen with low any fracture risk score by FRAX (subgroup $n=166$) could be as follows: multiple fractures (23%) and falls (57%).

In case of any fracture, 52% women ($n=1043$) would be left without treatment and 48% ($n=969$) would be treated according to FRAX. The assessment by Nguyen would give 51% untreated women ($n=1019$) and 49% ($n=993$) women classified as needing treatment. Comparison of those subgroups by chi-square test denotes that the difference between subgroups' headcount is not statistically significant ($\chi^2=0.57$; $p>0.05$).

Fig. 1 presents subgroups of women without indications for treatment in either scale (fracture risk ≤20%), with indications for treatment in both scales (fracture risk >20%), and with indications for treatment according to one method established in any fracture risk analysis.

Conformity between the methods for 10-year hip fracture risk

A separate analysis was done for hip fracture risk assessment. The mean conformity for hip fracture risk was 79.5% and the conformity values for thresholds of hip fracture risk are shown in Table 4. Similarly as in case of any fracture risk conformity, 20.5% of women achieved different fracture risk thresholds during assessment by the two methods. Possible reasons for achieving high hip fracture risk score (>3%) by FRAX and low hip fracture risk score (≤3%) by Nguyen (subgroup $n=42$) could include steroid use (40% of that subgroup), rheumatoid arthritis (33%), the presence of hip fracture in parents (17%), smoking (17%) and secondary osteoporosis (14%). For reversed situation (subgroup $n=371$): multiple fractures (15%) and falls (47%).

In case of hip fracture risk, 49% women ($n=991$) should be left without treatment and 51% ($n=1021$) should be treated according to FRAX. The assessment by Nguyen would give only 33% untreated women ($n=662$) and up to 67% women ($n=1350$) classified as treatment requiring (>3%). A comparison of those subgroups by the chi-square test shows that the difference is statistically significant ($\chi^2=111.1$; $p<0.0001$), while suggesting a possibility of 'overestimation' of the fracture risk by Nguyen in case of hip fracture risk assessment in comparison to FRAX. On the other hand, it cannot be excluded that FRAX 'underestimates' hip fracture risk.

In Fig. 2, subgroups of women are presented as without indications for treatment in both scales (fracture risk ≤3%), with indications for treatment in both scales (fracture risk >3%), and with indications for treatment according to one method established in hip fracture risk analysis.

Fracture risk and age

With advancing age, fracture risk increased for both methods. Table 5 presents fracture risk in the age subgroups for either method and both fracture localizations (any fracture and hip fracture). Fig. 3 shows changes in fracture risk over the age range of the studied subjects. The plotted curves denote not only fracture risk, increasing with advancing age, but they also show a tendency towards a slightly higher fracture risk index in Nguyen's method than in that by FRAX in both fracture localizations. Moreover, the older age range is analyzed, the bigger difference is observed between Nguyen and FRAX assessment.

Fracture risk in women below and over the age of 65 years

Fracture probability was also calculated separately for women below and over the age of 65 years.

In case of any fracture, the mean value of fracture risk in women at the age of 65 or younger was 15.9% by FRAX and 17.6% by Nguyen. In women at the age over 65 mean fracture risk was 26.6% by FRAX and 32.9% by Nguyen's prognostic nomograms. A comparison of fracture risk results, achieved by the two analyzed methods, made by Wilcoxon's matched pairs test, showed that in both younger and older women fracture risk assessed by Nguyen's nomograms was significantly higher than that assessed by FRAX ($p<0.00001$). A comparison of fracture risk results between younger and older subgroup, made by Mann–Whitney *U*-test, showed that in both methods, fracture risk was significantly higher in older women than in younger ones ($p<0.00001$).

In case of hip fracture, the mean values of fracture risk were as follows: 2.9% by FRAX and 5.2% by Nguyen's nomograms in women at the age of 65 or younger, 6.9% by FRAX and 15.7% by Nguyen's nomograms in women at the age above 65. The results of comparisons were similar to those in case of the any fracture risk analysis—fracture risk was significantly higher in older women than in younger ones for

Table 2
Ten-year fracture probability [%].

Any fracture risk by FRAX	22.5 ± 12.1%
Any fracture risk by Nguyen's method	26.9 ± 18.6%
Hip fracture risk by FRAX	5.3 ± 6.7%
Hip fracture risk by Nguyen's method	11.6 ± 16.8%

Table 3
Conformity for 10-year any fracture risk thresholds: ≤20% and >20%.

Any fracture risk threshold	No. of subjects classified by FRAX	No. of subjects classified by Nguyen's method at the same threshold of fracture risk	Conformity [%]
≤20%	1043 (52%)	877	84.1
>20%	969 (48%)	827	85.3

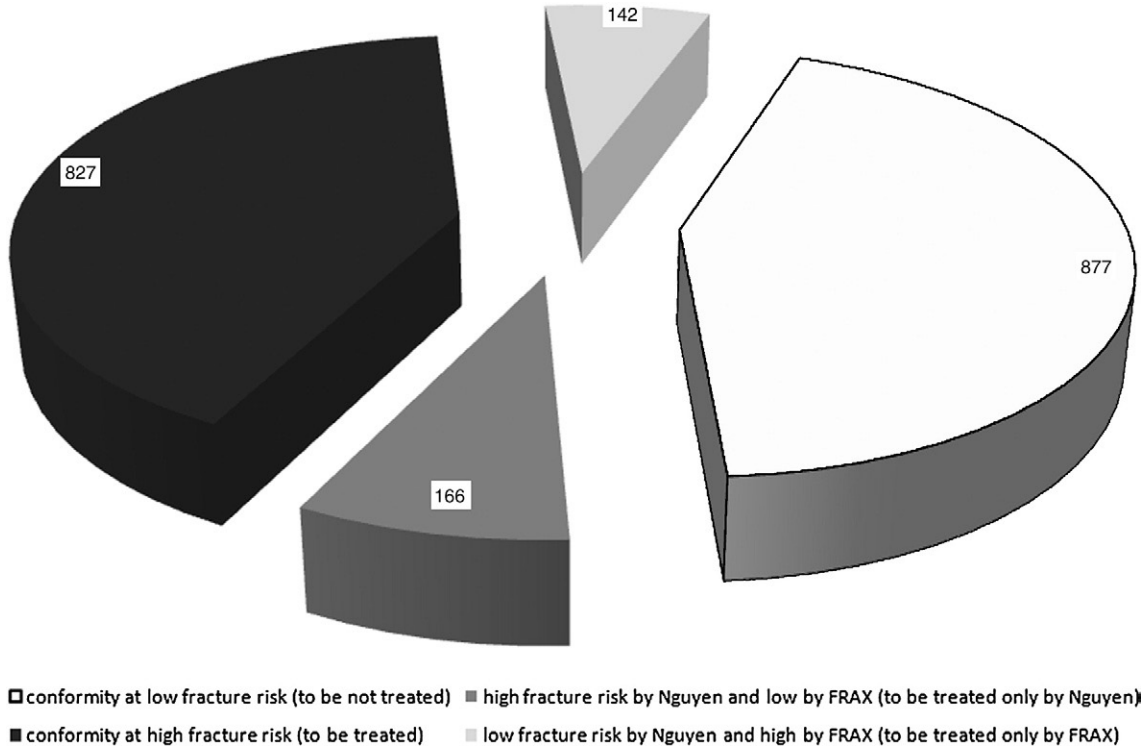

Fig. 1. Subgroups of women with or without indications for treatment according to FRAX and Nguyen's method for any fracture risk.

both methods (Mann–Whitney *U*-test; $p<0.00001$) and fracture risk assessed by Nguyen's nomograms was significantly higher than that assessed by FRAX in both age subgroups (Wilcoxon's matched pairs test; $p<0.00001$).

Fracture risk stratified by fracture status

Prior osteoporotic fracture is known as a strong predictor of subsequent fracture. Table 6 presents fracture risk according to fracture status, e.g., the presence or absence of prior fracture. As many as 64% of the studied subjects ($n=1284$) had no fracture, while 36% ($n=728$) revealed osteoporotic fracture. For both methods, the fracture risk was significantly higher in women with fracture history, in comparison to those without any fractures in the past. However, the risks, estimated by FRAX, in the presence of prior fracture increased by 1.76 and 2.11-fold for any and hip fracture, respectively, and according to Nguyen et al.' nomograms, the risk for any fracture and hip fracture increased much more: namely by 2.3 and 4.56-fold, respectively.

Prior fracture and fracture risk

Prior fracture is one of the most important indications for initiation of therapy for osteoporosis, and commonly such patients begin therapy irrespective of other data, e.g. BMD or fracture risk. Some patients from our group could be not classified as requiring treatment due to low 10-year fracture risk, although they had fractures. We performed additional analysis in a subgroup of patients with prior fracture ($n=728$). In that subgroup 148 (20.3%) patients would not be classified as requiring treatment by FRAX and 112 (15.4%) by Nguyen due to fracture risk lower than 20% in case of any fracture risk analysis. In case of hip fracture risk analysis 202 (27.7%) women with prior fracture has fracture risk lower than 3% according to FRAX and 50 (6.9%) women has low fracture risk according to Nguyen and those subgroups would not have established indications for treatment regardless of their prior fractures. In both any and hip fracture risk analysis the percentage of women with prior fracture not classified for treatment is significantly higher for FRAX method ($p<0.05$ for any fracture; $p<0.0001$ for hip fracture).

Table 4
Conformity for 10-year hip fracture risk thresholds: ≤3% and >3%.

Hip fracture risk threshold	No. of subjects classified by FRAX	No. of subjects classified by Nguyen at the same threshold of fracture risk	Conformity [%]
≤3%	991 (49%)	620	62.6
>3%	1021 (51%)	979	95.9

Estimation of the accuracy of FRAX and Nguyen's nomograms in the assessment of the fracture risk

In order to establish the accuracy of both methods, ROC analyses were performed for any and hip fractures. Both for any and hip fractures, the area under the ROC curve (AUC) was significantly higher for Nguyen's algorithm (Fig. 4).

AUCs from ROC curve analysis were 0.833 (95%CI 0.816–0.849) and 0.879 (0.864–0.893) for any fracture risk by FRAX and Nguyen's nomograms, respectively which gives a difference of 0.0458 ± 0.00736 ($p<0.0001$).

The higher difference was revealed when to compare AUCs for risk of hip fracture: 0.726 (0.706–0.746) and 0.850 (0.834–0.865) by FRAX and Nguyen's nomograms, respectively which gives a difference of 0.124 ± 0.00836 ($p<0.0001$). Those findings support the statement that Australian nomograms are better fracture risk predictors.

Discussion

To our knowledge, the current study has been the first one to compare a 10-year fracture risk, assessed by FRAX [5] and by the nomogram method proposed by Nguyen et al. [6,7]. The general conformity between these methods, being close to 80%, seems to be satisfactory for practitioners involved in the management of osteoporotic patients. In a broad age range, fracture risk changes are usually

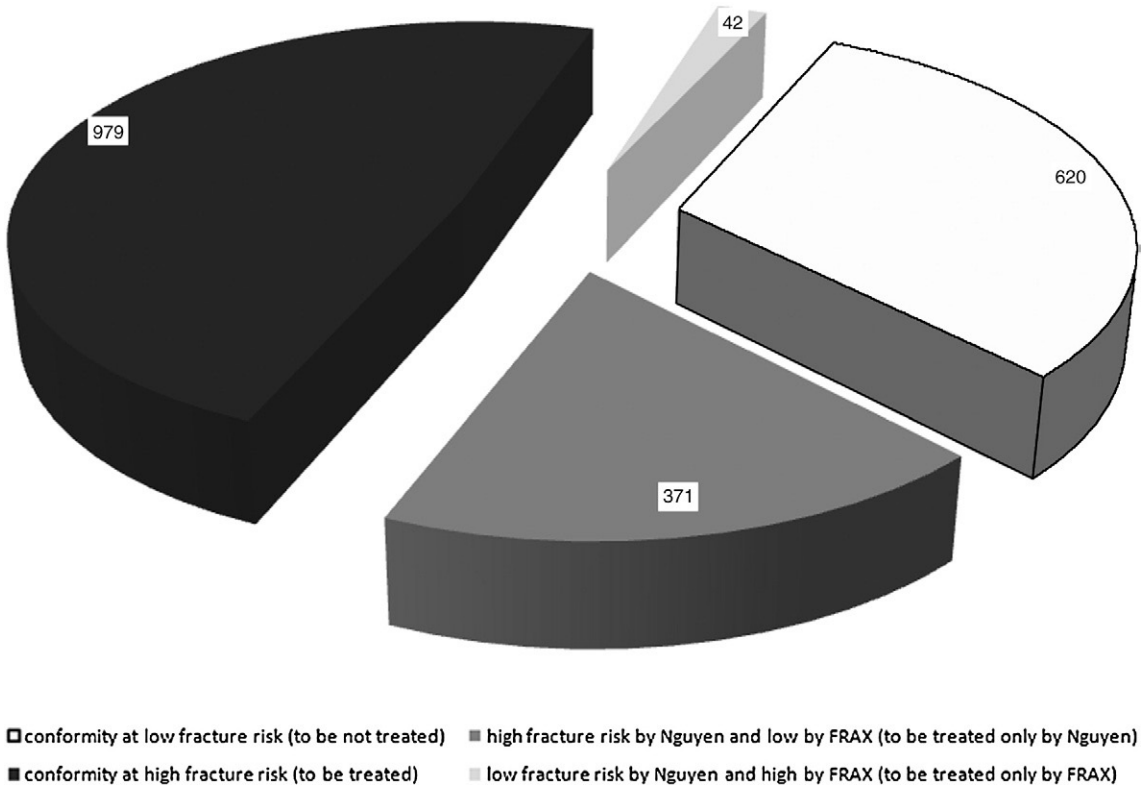

Fig. 2. Subgroups of women with or without indications for treatment according to FRAX and Nguyen's method for hip fracture risk.

low in younger postmenopausal women while demonstrating higher values in more elderly subjects. The study was performed in a sufficiently large group of patients with broad age range to follow how ageing influenced fracture risk. The results from ROC analysis indicate that Nguyen's nomograms are better fracture risk predictors and the information on the number of falls during the last year and multiple fractures ought to be incorporated into the method of fracture risk prediction.

Our results (Fig. 3) show that, for women younger than 65 years, the curves depicting fracture risk, established by both methods, are almost parallel with a constantly higher level of risk obtained by Nguyen's method in comparison to FRAX. After the age of 65 we observed a trend towards increasing fracture risk for both methods; an increase for any fracture risk increased clearly slower than that for hip fracture risk. The difference in fracture risk between the youngest subgroup, aged 55–60 years, and the oldest subgroup, aged 81–90 years, for Nguyen's nomograms for any and hip fracture increased twice and 7.5 times, respectively. The same values for FRAX increased twice and three times. Especially in older women, the curve for hip fracture risk was steep. Therefore, it may be stated that the increasing risk for any fracture and, even in a greater extent, for hip fracture in elderly women was modified by the number of falls. One might expect that also multiple fractures may contribute to a rapid increase in fracture risk in elderly women but multiple fractures were much less present (12.5%) in comparison to recorded falls (28.1%). Also prior fractures significantly increased fracture risk, in comparison to those without fracture and the factor more strongly influenced the results according to Nguyen's nomograms.

In the current study, we used thresholds of risk for any fracture—20% and for hip fracture risk—3%. The conformity concerns the classification of women studied within the same range. For example, if any fracture risk for a given patient was 6% by FRAX and 9% by Nguyen's nomograms, an expected conformity was obtained. However, a more important issue

Table 5
Fracture risk [%] in age subgroups.

Method	55–60 years	61–70 years	71–80 years	81–90 years
	$n=392$	$n=799$	$n=682$	$n=139$
Any fracture risk by FRAX	14.86 ± 9.9	18.78 ± 9.5	29.18 ± 11.6	31.94 ± 10.7
Any fracture risk by Nguyen	15.83 ± 10.9	22.00 ± 14.2	34.57 ± 18.8	49.45 ± 22.7
Hip fracture risk by FRAX	3.03 ± 6.0	3.26 ± 4.3	8.17 ± 7.9	9.69 ± 7.1
Hip fracture risk by Nguyen	4.21 ± 6.3	7.67 ± 10.8	16.44 ± 19.3	31.85 ± 26.6

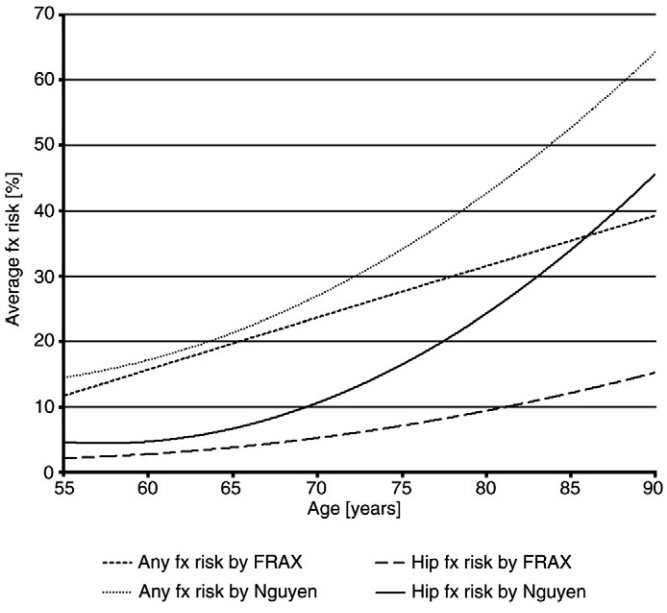

Fig. 3. Changes in fracture (fx) risk over age range.

Table 6
Fracture risk [%] stratified by fracture status.

Applied model	Non-fractured women ($n=1284$)	Fractured women ($n=728$)	p
Any fracture risk by FRAX	17.58 ± 9.05	31.04 ± 11.97	<0.000001
Hip fracture risk by FRAX	3.79 ± 5.06	8.03 ± 8.3	<0.000001
Any fracture risk by Nguyen	18.27 ± 9.47	42.28 ± 2.87	<0.000001
Hip fracture risk by Nguyen	5.17 ± 6.04	23.04 ± 22.61	<0.000001

concerns the conformity in respect to treatment decisions. The following questions are most important for any physician: Who should be treated? And when to start treatment? Therefore, establishing the threshold for therapy onset is of great importance. According to the suggestions, given by Tosteson at al. [8] and Dawson-Hughes et al. [9], we assumed that the threshold for hip fracture risk was 3%, and the threshold for treatment with regard to any fracture risk at the level of 20% was based on position of a group of Polish experts [10].

The results of ROC analyses for both methods indicate superiority of Nguyen's nomograms due to a higher accuracy. It means that, despite the generally acceptable conformity between both methods, one method cannot be easily replaced by the other especially in regard to hip fracture risk. We may assume that the probability of hip fracture risk is 'overestimated' by Nguyen's nomograms or 'underestimated' by FRAX. We consider that, in respect to hip fracture risk, probably more appropriate is the algorithm proposed by Nguyen because hip fractures are typical for the elderly and falls play an essential role as a risk factor. Falls occurred in 28.5% of the studied women; Australian nomograms took this factor into account, while FRAX did not. The number of falls increases in the elderly, and especially in the eighth and the ninth decades of life Nguyen's algorithm should be recommended.

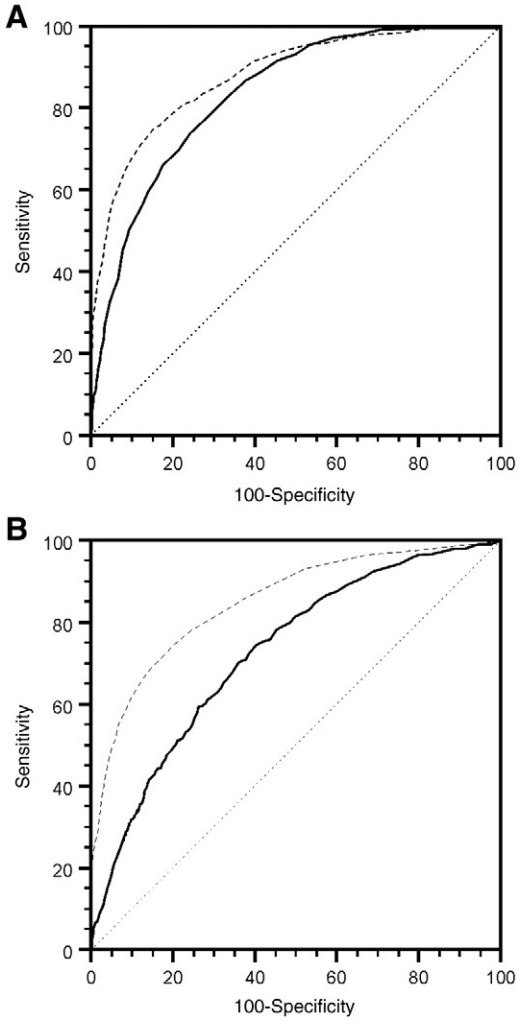

Fig. 4. Receiver operating characteristic (ROC) curves for FRAX [—] and Nguyen's algorithm [- - -] in the assessment of the any fracture (A) and hip fracture (B) risk. In both cases areas under ROC for Nguyen are higher than for FRAX, $p<0.0001$.

In several studies, clinical risk factors for fractures were identified and falls were found to be one of them [3,11–17]. In some other studies, the authors showed that some factors, e.g., glaucoma [18], reduced visual acuity [19], reduced walking speed [20] and self-reported health status and self-reported physical activity [21] contributed significantly to fracture risk. All the later observations suggest that a risk for fall and, in consequence, the risk for hip fracture might be increased.

From the opposite side, in Nguyen's nomograms some other important risk factors were not used. Therefore, the probability for fracture might be diminished. However, the prevalence of hip fracture in parents, steroid use, rheumatoid arthritis, alcohol use, smoking and secondary osteoporosis was low and did not exceed 10%. We may hypothesize that the cumulative role of falls (present in 28.5% of the subjects) and multiple fractures (12.5%) was stronger than other clinical risk factors and the risk for fracture, according to Nguyen's method, was constantly higher.

However, it must be emphasized that the start of pharmacological treatment cannot be linked only to the assessment of fracture probability. Each patient should be individually diagnosed, and the final decision must be based on a broad clinical aspects. The obvious necessity of personalized treatment recommendations is not in conflict with a broader use of fracture risk assessment. We urgently need to implement the available data for calculation of absolute, 10-year fracture risk into clinical practice. Practitioners expect more precise recommendations for treatment and we consider that enough valuable data were thus gathered.

The current study has several limitations. For the calculation of fracture risk by FRAX we used US Caucasian population because the data for Polish population are not available. US FRAX estimates have changed over 15 months since the first posting of data onto the web. The risks by Nguyen et al. were calculated, the using Australian female population, and fracture risk in Australia may be different in comparison to Polish women. The authors of FRAX propose to use this algorithm only in treatment-naive subjects. The substantial parts of our population were women on the antiresorptive therapy. We decided to include them because we were not interested to follow-up patients and long-term modification of fracture risk, due to the therapy, does not interfere with single comparison of both methods.

One ought also to take into consideration that in order to calculate fracture risk by FRAX we need online connection with the internet and by Nguyen's method such requirement is not present. Due to the higher accuracy showed by ROC analysis Nguyen's method seems to be more reliable probably because of stronger influence of multiple fractures and falls not taken into consideration in FRAX.

Our study has also some strength; we enrolled a large group of patients, the women were recruited from four centers and the age range was fairly broad. Also the number of risk factors, present in the studied women, allowed to obtain reliable fracture risk assessment. The prevalence of fractures, obtained in the current study (36%), is close to the data from literature [1].

Concluding, the mean conformity for any fracture risk is 79.1% and 79.5% for hip fracture. Nguyen's nomograms seem to be more efficient in fracture risk assessment, especially for hip fractures, due to a higher accuracy of the method, and the information on the number of falls during the last year and multiple fractures ought to be incorporated into the method of fracture risk prediction. In case of patients with different fracture risk level, achieved in both methods, an individualized approach is strongly recommended.

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