ELEKTRONIKAS UN DATORZINĀTŅU INSTITŪTS
INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

Osteoporozes riska noteikšana ar mākslīgo intelektu

SADARBĪBA – CEĻŠ UZ VEIKSMĪGU FUNKCIONĒŠANU, VESELĪBU UN LABKLĀJĪBU

LATVIJAS NACIONĀLAJĀ BIBLIOTĒKĀ

Ivars Namatēvs

EDI

08.10.2024.

Dziļās mašīnmācīšanās pieeja osteoporozes atpazīšanai ar konusa staru datortomogrāfiju, lzp 2021/1-0021

FLPP
FUNDAMENTĀLO UN LIETIŠĶO PĒTĪJUMU PROJEKTI

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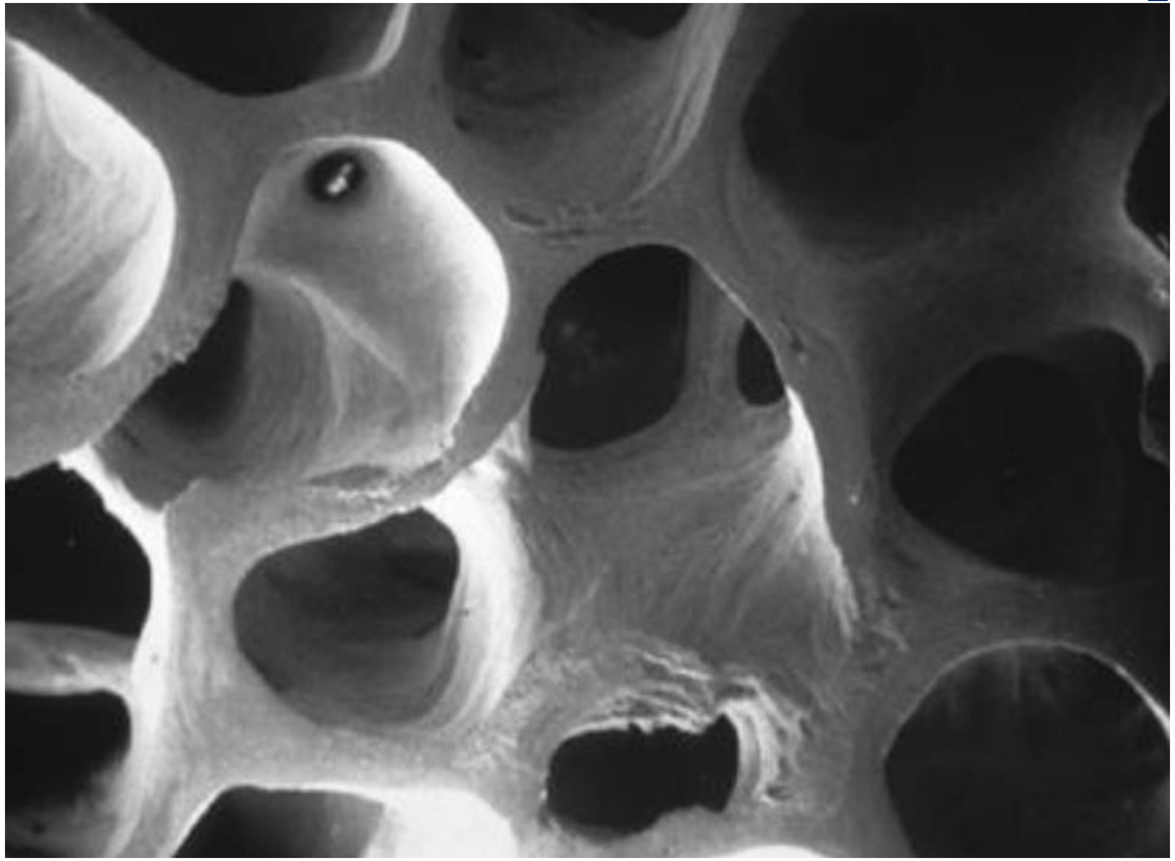
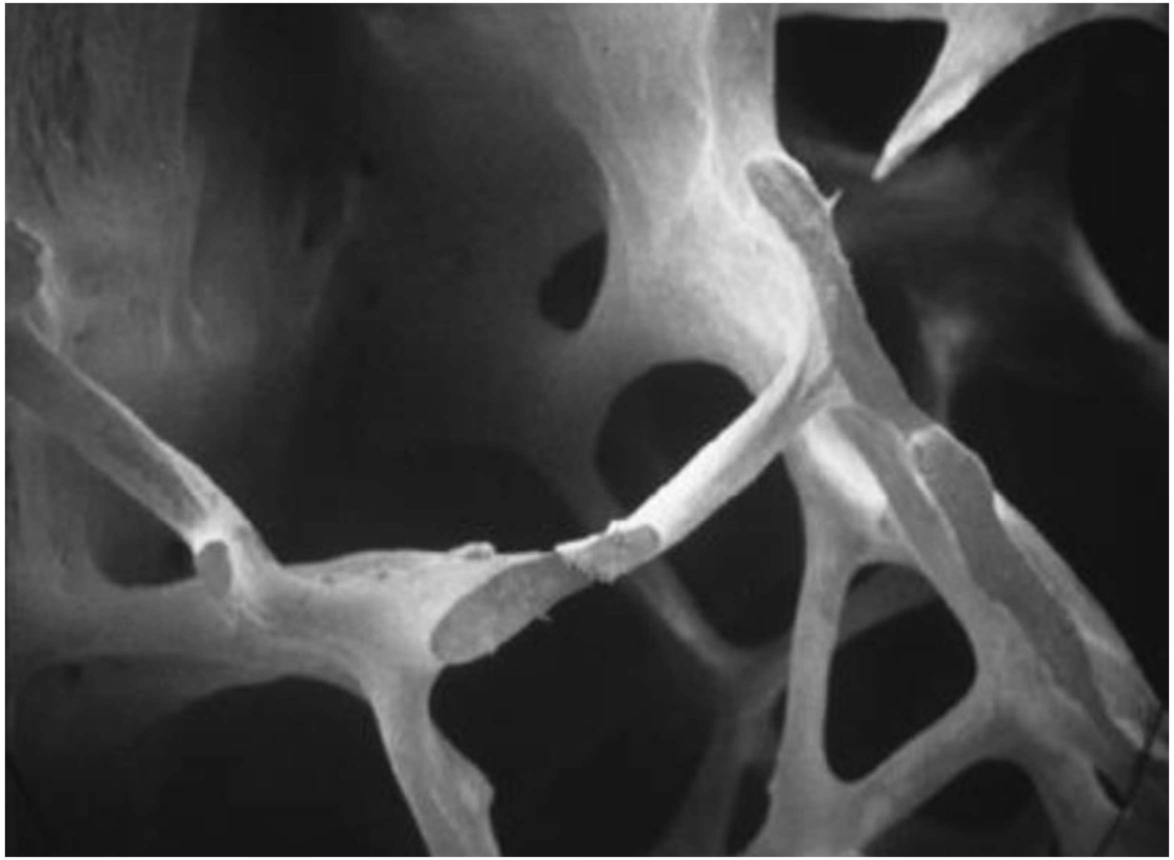
Osteoporoze



Normāls kauls

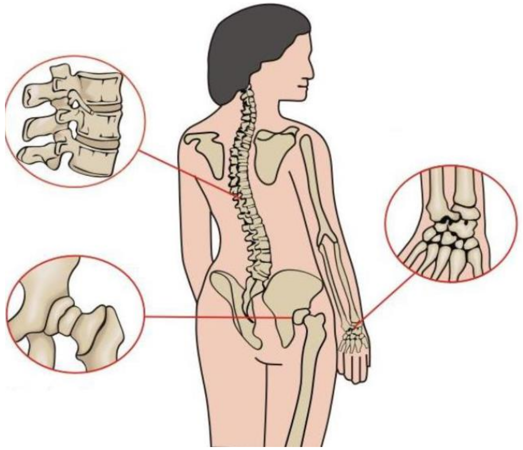


Osteoporotisks kauls

Reproduced from J Bone Miner Res. 1986;1:15-21 with permission of the American Society for Bone and Mineral Research.

Osteoporozes diagnostika

	T-skala
Norma	+2.5 līdz -1
Osteopēnija	T-score <-1.0 to -2.5
Osteoporoze	≤ -2.5
Smaga osteoporoze	≤ -2.5 + lūzums



Osteoporotiskie lūzumi:

- Aukšdelma kauli, 80%
- Augšstilba kaula kakliņš, 70%
- Skriemeļi. 58%

Johnell and Kanis ,2006

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Osteoporoze diagnostika

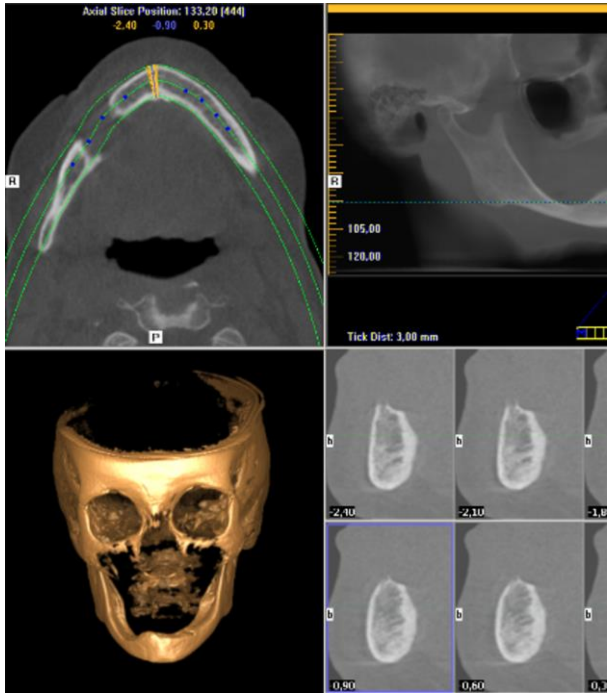
Pētījuma mērķis

Izstrādāt inovatīvu metodi osteoporozes riska noteikšanai sejas un žokļu rajona KSDT izmeklējumos un novērtēt tās efektivitāti, izmantojot dziļās mašīnmācīšanās pieeju

Osteoporozes pamata riska faktori

- Vecums
- Dzimums – sieviete
- Piederība rasei
- Ģenētiskā predispozīcija
- Lūzumi anamnēzē
- Zems ķermeņa svars (ĶMI)
- Medikamenti: glikokortikosteorīdu lietošana, etc.

- Reimatoīdais artrīts
- Smēķēšana
- Nepietiekamas fiziskās aktivitātes
- Pastiprinātā alkohola lietošana
- Nepietiekams Ca un D vitamīnu daudzums
- etc.



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Pocock et al, 1987; Seeman et al, 1989; Thijssen, 2006; Kanis et al, 2004; De Laet , 2005; Albrand,2003; Cummings, 1995; Albrand,2003; Cummings, 1995; Albrand,2003; Cummings, 1995; Ward et al, 2001; Kanis et al, 2005; Law et al, 1997; Kanis J et al, 2005; Felson et al, 1988; Reid, 1997; Adachi, 1997; Kanis et al, 2008; Reid, 1997; Adachi, 1997; Kanis et al, 2008

Koniskā staru datortomogrāfija (KSDT)

i-CAT Next generation, KaVo Dental GmbH, Germany:

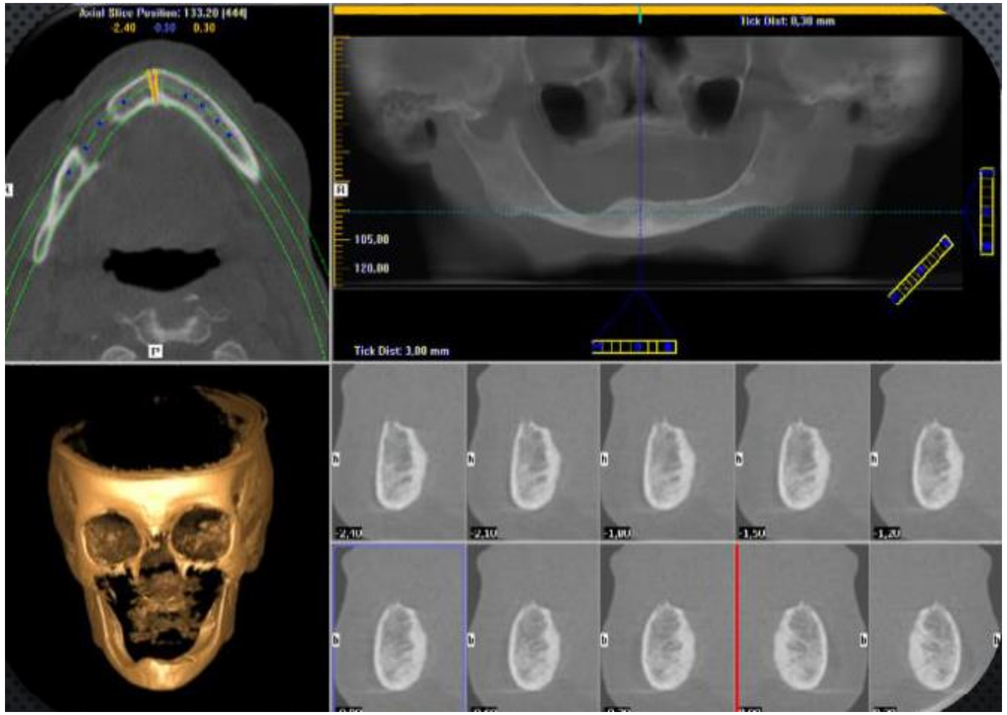
120 kVp

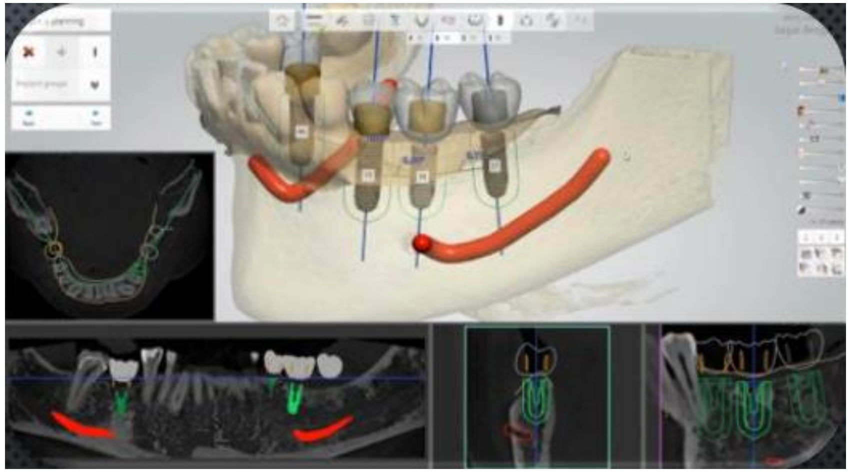
5 mA

4 sekundes

vokseļu izmērs 0.3 mm

FOV 230x115 mm





Vai KSDT var izmantot osteoporozes riska noteikšanā?

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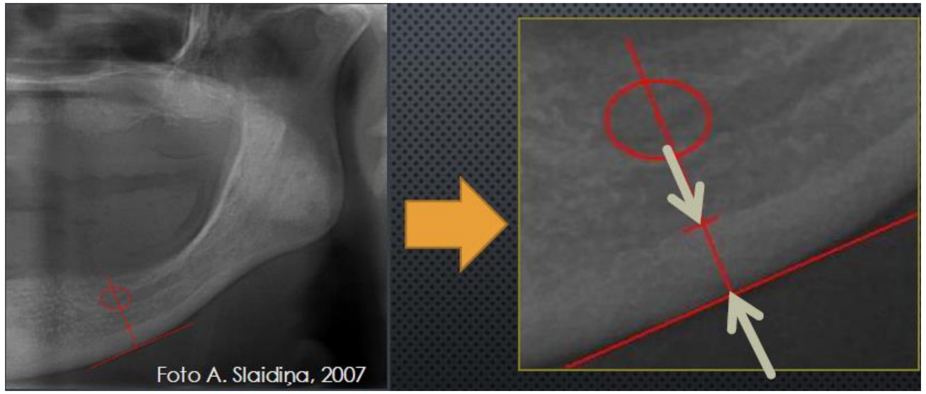
Pacientiem ar osteoporozi

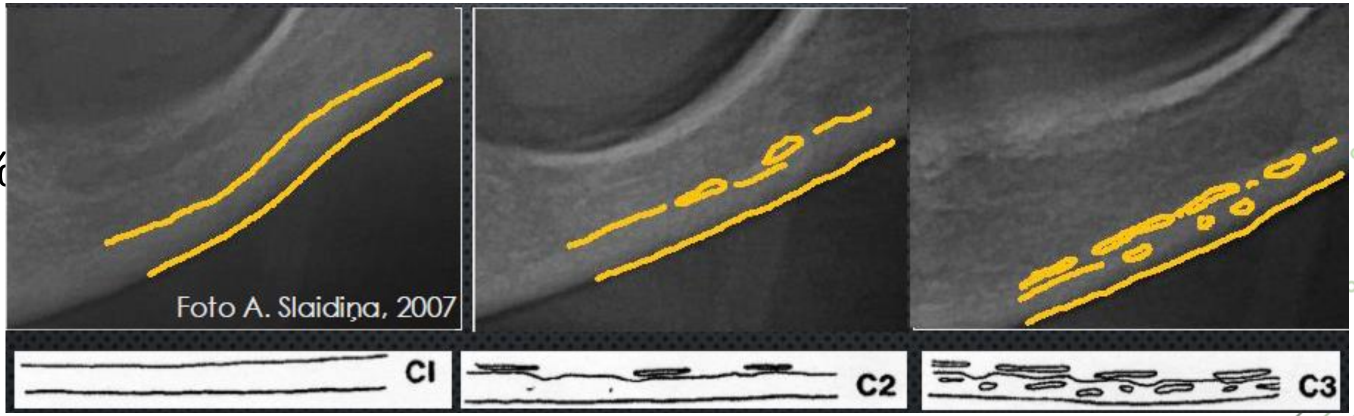
- **Ir samazināts kortikālā kaula biezums apakšžoklī:**



✓ **Kortikālā kaula biezums** – mazāks par 3 mm norāda uz augstu osteoporozes risku (met. jutība – 78.3% & specifiskums- 47.8%)

- **Ir izmainīta žokļa kaula struktūra:**

✓ **Kortikālais indekss C2 & C3** – liecina par **samazinātu KMB** (met. jutība-94.1% & specifiskums 38,8%)



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Izlase

- **188 pacientes**: 54 – 87 g.v.

(vid. 69,1 +/- 8.1)

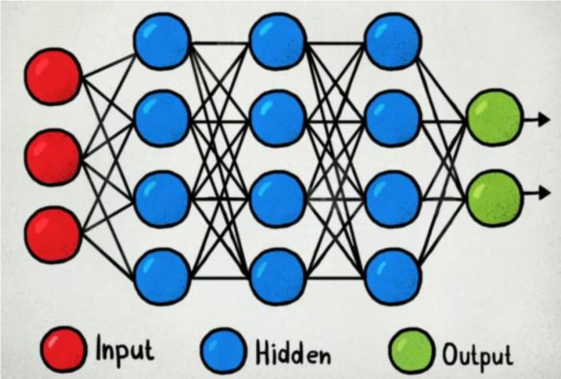
- 3D KSDT
- Ētikas komisijas atļauja

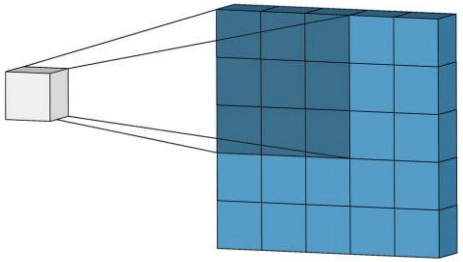
- **Bezzobu pacientes:** neslimo un nelieto medikamentus, kas ietekmē KMB
- **Pacientes ar daļēju zobu zaudējumu:** neslimo un nelieto medikamentus, kas ietekmē KMB

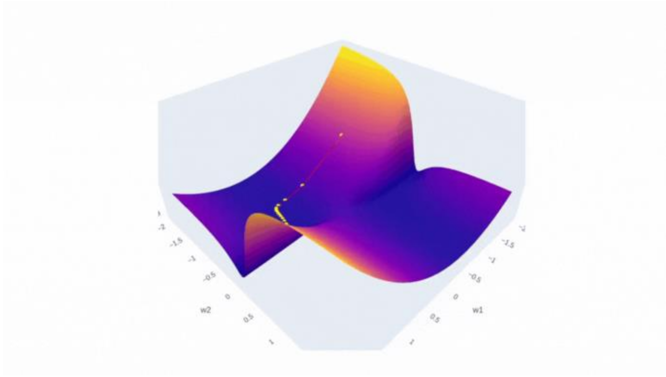
Mašīnmācīšanās: modulārs neironu tīkls

Dziļās mašīnmācīšanās konvolūciju neironu tīkli: ResNet-101

- 1 tīkls: Apakšžokļa kaula griezuma atrašana
- 2 tīkls: Apakšžokļa kaula šķērsgriezuma vietu atrašana
- 3 tīkls: Apakšžokļa biezuma kaulu mērījumi







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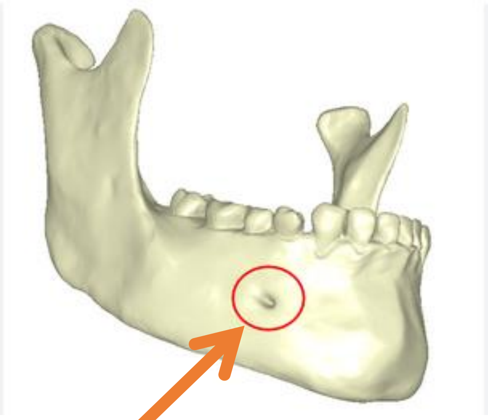
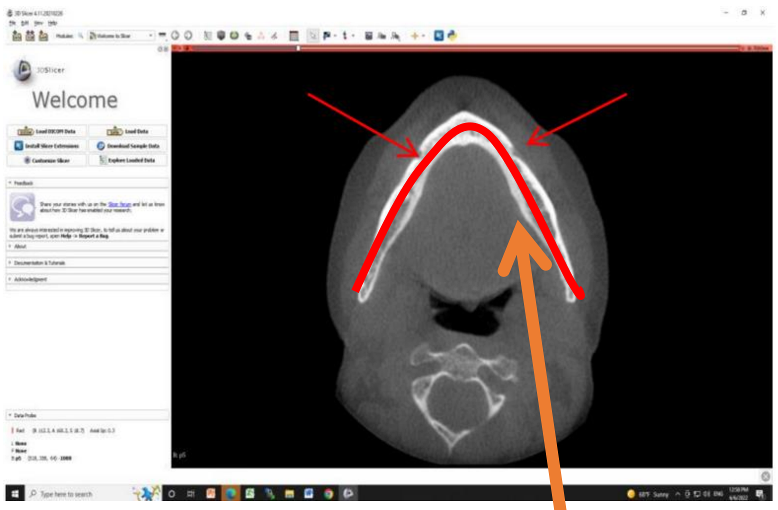
Marķēšana

- **Datu failu formāts:** .nrrd (multidimensionāli CT dati)
- **Marķēšana:** pareizais griezums a nervu kanāliem, septiņi punkti
- **Rīks:** 3D Slicer
- **Datu priekšapstrāde:** normalizācija: min -0.5 & max +0.5
- **Datu konversija:** .nrrd uz numpy.
- **Marķēšanas programmatūra:** Python
- **Marķētie dati tiek saglabāti** kā divi faili ar *.json* paplašinājumu marķēts apakšžoklis un marķēts ***foramen mentale,*** kā arī .png aksiālā griezuma marķēto attēlu fails.





- Aksiālā griezumā izvēlas apakšžokļa griezumu, kurā labi redzamas abas *foramen mentale*
- Manuāli pa apakšžokļa vidu atliek apakšžokļa loku

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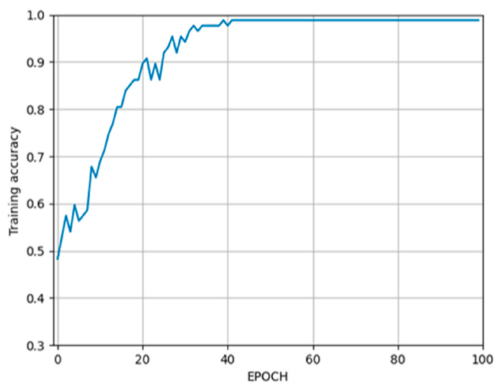
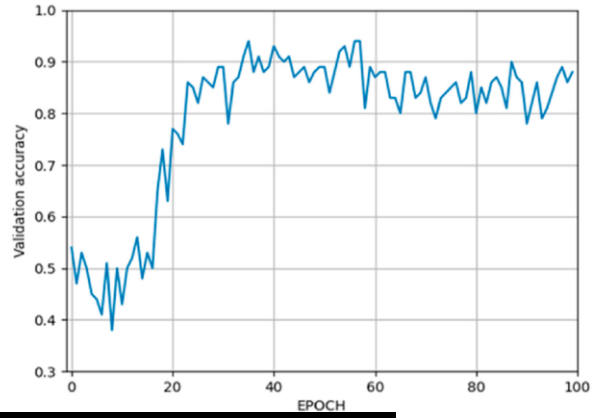
1 solis: Apakšžokļa kaula griezuma atrašana

- **Klasifikācijas uzd./tīkls**
- **Inicializācija**: ResNet-101, nejauši svari
- **Ieeja**: 3D attēli, vertikāls skenējums
- **Klasifikācija: jā**, - ir atrasts griezums, **nē**, - nav (+ varbūtība)
- **Izeja**: optimālais apakšžokļa ortogonālais griezums
- **Svari:** saglabāti atsevišķā failā
- **Apmācība/validācija:** 70/30%
- **Precizitāte:** apmācības 98,9%, validācijas 93.4% (40 p.)





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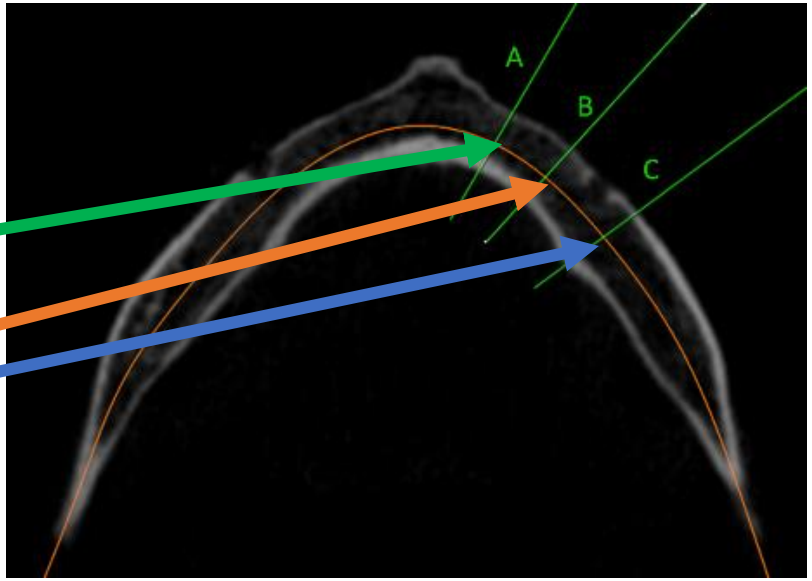
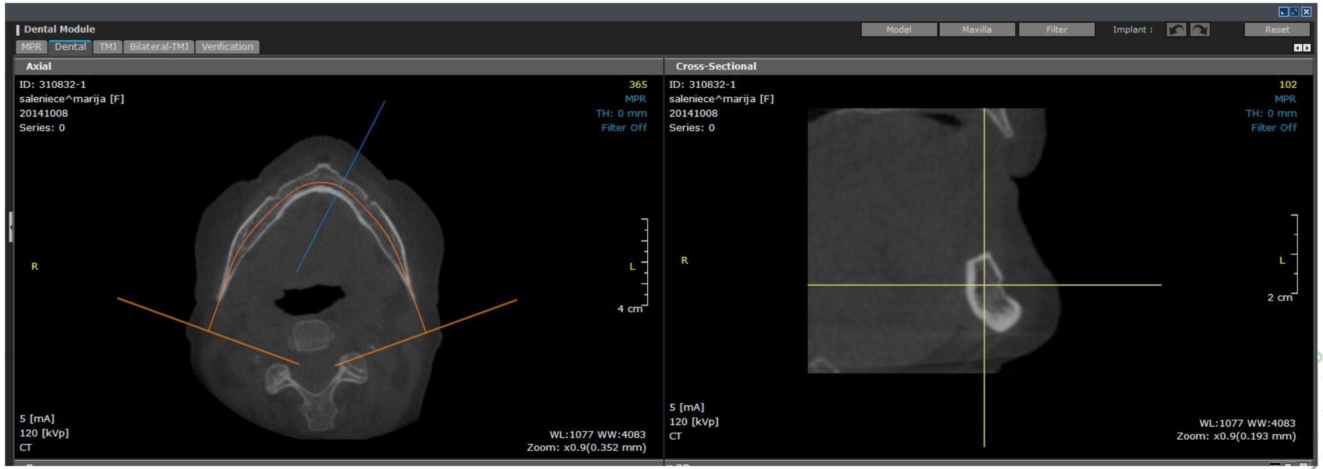
2 solis: Apakšžokļa kaula šķērsgriezuma vietu atrašana

- **Regresijas uzd./tīkls**
- **Ieeja:** optimālais apakšžokļa ortogonālais griezums, septiņi punkti
- **Izeja**: 14 klases (septiņu punktu x, y koordinātes) šķērsgriezuma attēli
- No šiem raj. iegūst apakšžokļa laukuma griezuma attēlus

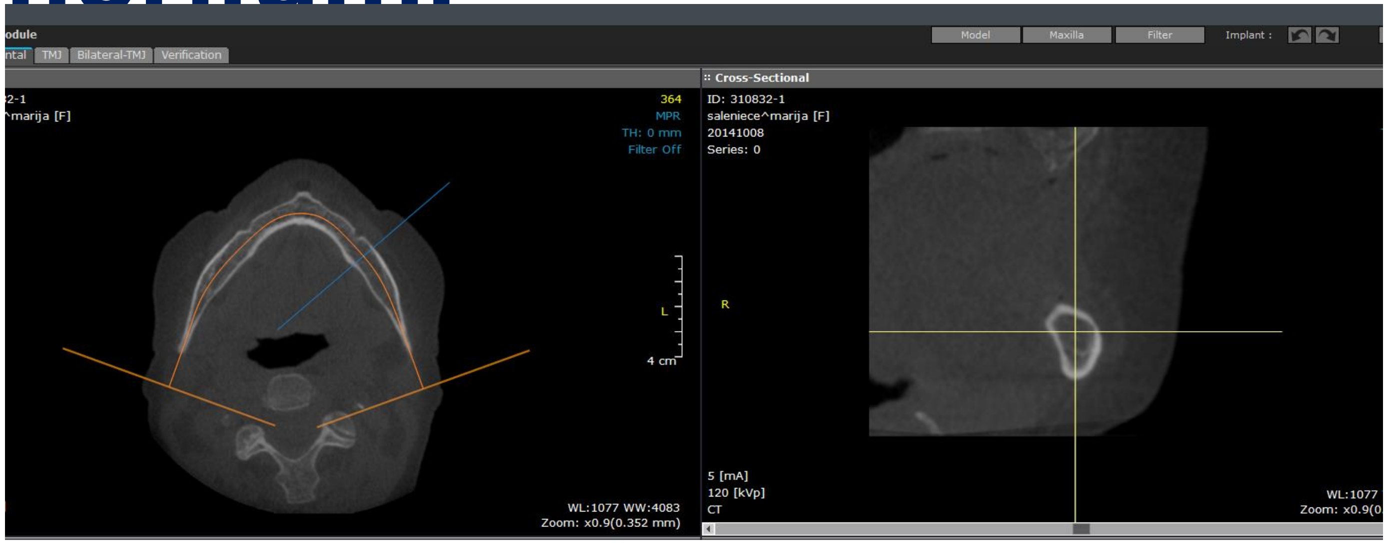
A: laterālo incisīvu raj
B: pirmo premolāru raj.
C: pirmo molāru raj.

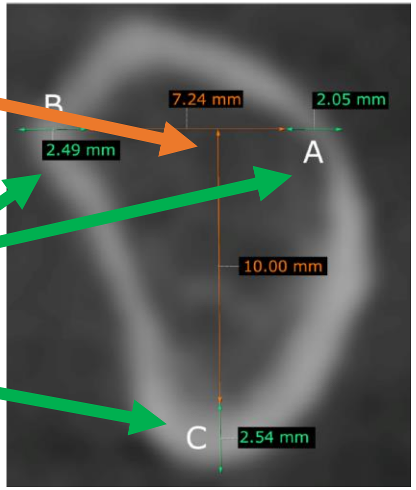


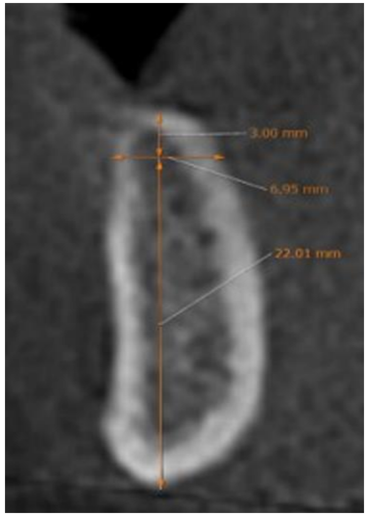


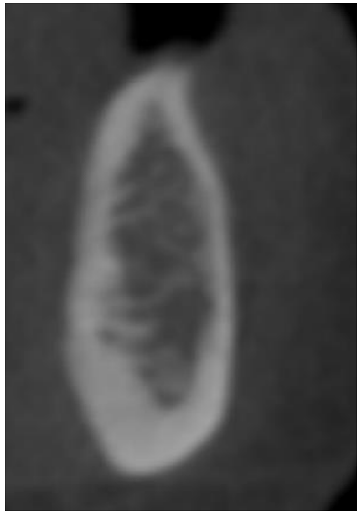
3 solis: Apakšžokļa kaulu biezuma mērījumi

- **Algoritms:**
- **Ieeja**: trīs apakšžokļa (A, B, C) raj.
- **Mērījumi**: tiek veikti visos trīs apakšžokļa raj.
- **Izmērīts:** trabekulārā, kortikālā kaula biezums

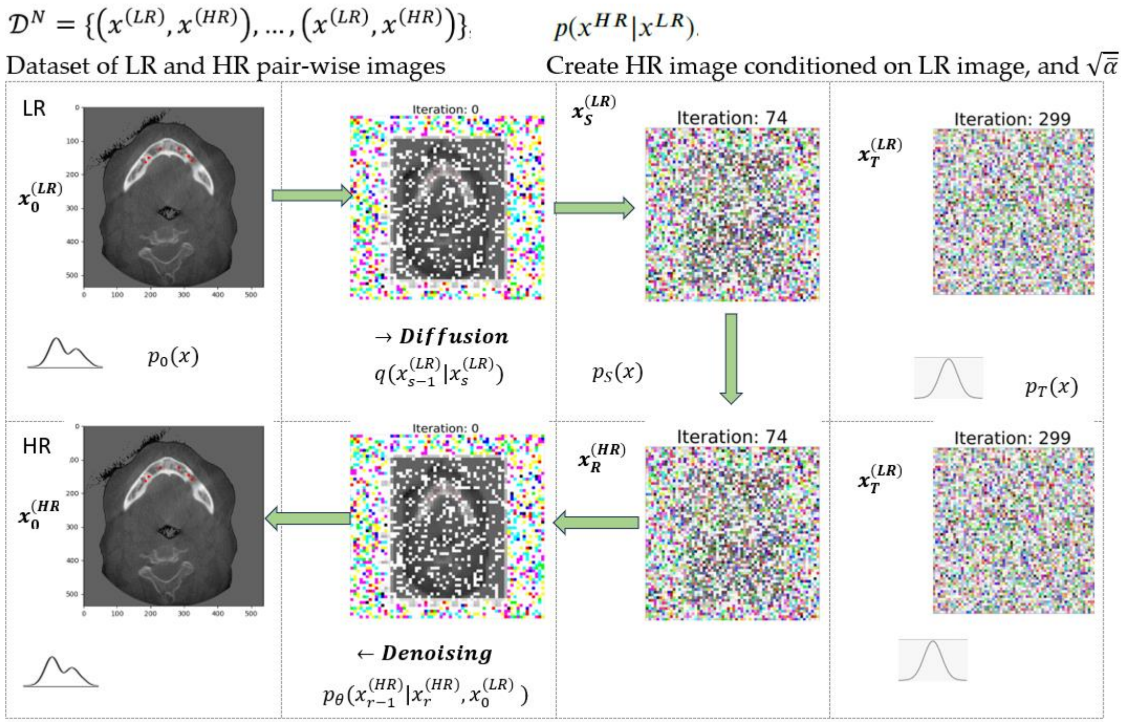








Pētījuma rezultāti I



tomography

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Modular Neural Networks for Osteoporosis Detection in Mandibular Cone-Beam Computed Tomography Scans

Ivars Namatevs; Arturs Nikulins; Edgars Edelmers; Laura Neimane; Anda Slaidina; Oskars Radzins; Kaspars Sudars

Tomography **2023**, Volume 9, Issue 5, 1772-1786

Denoising Diffusion Algorithm for Single Image In-plaine Super-resolution in CBCT Scans of the Mandible

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2023 64th International Scientific Conference on Information Technology and Management Science of Riga Technical University (ITMS)

RĪGAS STRADIŅA UNIVERSITĀTE

Pētījuma rezultāti II

Towards Explainability of the Latent Space by Disentangled Representation Learning

Ivars Namatēvs[1*], Kaspars Sudars[2], Artūrs Ņikuļins[3], Anda Slaidiņa[4], Laura Neimane[5], Oskars Radziņš[6]
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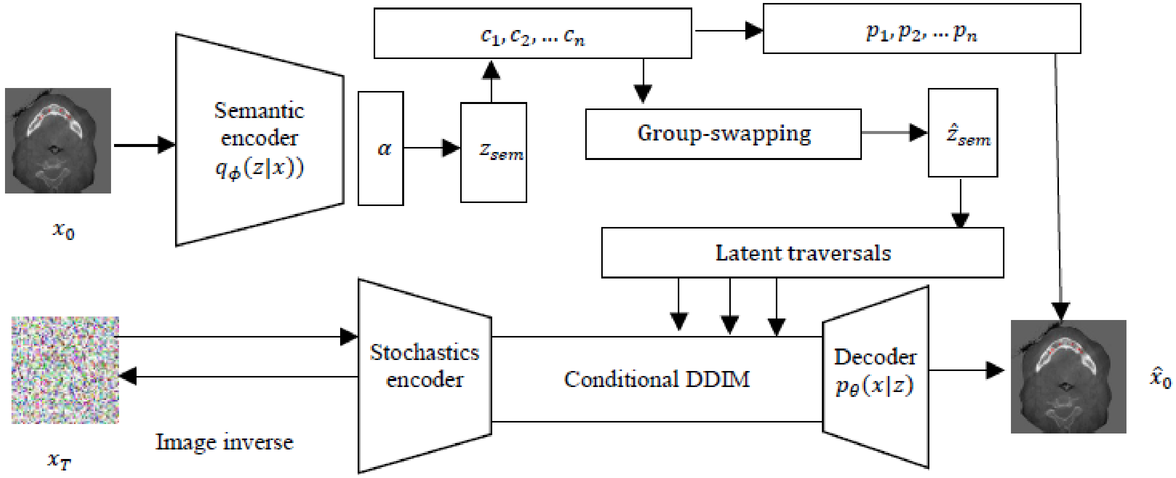

Fig. 1. The proposed latent space representative disentanglement explainability pipeline.

Dentomaxillofacial Radiology | Oxford Academic

Dentomaxillofacial Radiology

academic.oup.com

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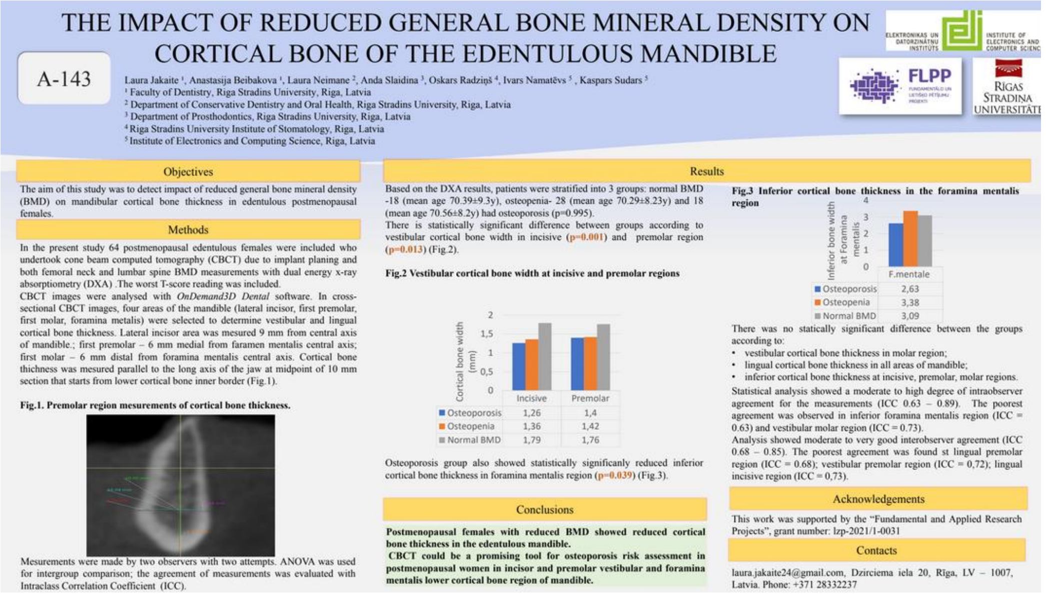
Pētījuma rezultāti III



A-143

THE IMPACT OF REDUCED GENERAL BONE MINERAL DENSITY ON CORTICAL BONE OF THE EDENTULOUS MANDIBLE

Laura Jakaite [1], Anastasija Beibakova [1], Laura Neimane [2], Anda Slaidina [3], Oskars Radziņš [4], Ivars Namatēvs [5], Kaspars Sudars [5]
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Objectives

The aim of this study was to detect impact of reduced general bone mineral density (BMD) on mandibular cortical bone thickness in edentulous postmenopausal females.

Methods

In the present study 64 postmenopausal edentulous females were included who undertook cone beam computed tomography (CBCT) due to implant planing and both femoral neck and lumbar spine BMD measurements with dual energy x-ray absorptiometry (DXA). The worst T-score reading was included.

CBCT images were analysed with *OnDemand3D Dental* software. In cross-sectional CBCT images, four areas of the mandible (lateral incisor, first premolar, first molar, foramina metalis) were selected to determine vestibular and lingual cortical bone thickness. Lateral incisor area was mesured 9 mm from central axis of mandible.; first premolar – 6 mm medial from faramen metales central axis; first molar – 6 mm distal from foramina mentalis central axis. Cortical bone thickness was mesured parallel to the long axis of the jaw at midpoint of 10 mm section that starts from lower cortical bone inner border (Fig.1).

Fig.1. Premolar region mesurements of cortical bone thickness.

Mesurements were made by two observers with two attempts. ANOVA was used for intergroup comparison; the agreement of measurements was evaluated with Intraclass Correlation Coefficient (ICC).

Results

Based on the DXA results, patients were stratified into 3 groups: normal BMD -18 (mean age 70.39±9.3y), osteopenia- 28 (mean age 70.29±8.23y) and 18 (mean age 70.56±8.2y) had osteoporosis (p=0.995).

There is statistically significant difference between groups according to vestibular cortical bone width in incisive (p=0.001) and premolar region (p=0.013) (Fig.2).

Fig.2 Vestibular cortical bone width at incisive and premolar regions

	Incisive	Premolar
Osteoporosis	1,26	1,4
Osteopenia	1,36	1,42
Normal BMD	1,79	1,76

Osteoporosis group also showed statistically significanly reduced inferior cortical bone thickness in foramina mentalis region (p=0.039) (Fig.3).

Fig.3 Inferior cortical bone thickness in the foramina mentalis region

	F.mentale
Osteoporosis	2,63
Osteopenia	3,38
Normal BMD	3,09

There was no statically significant difference between the groups according to:
- vestibular cortical bone thickness in molar region;
- lingual cortical bone thickness in all areas of mandible;
- inferior cortical bone thickness at incisive, premolar, molar regions.

Statistical analysis showed a moderate to high degree of intraobserver agreement for the measurements (ICC 0.63 – 0.89). The poorest agreement was observed in inferior foramina mentalis region (ICC = 0.63) and vestibular molar region (ICC = 0.73).

Analysis showed moderate to very good interobserver agreement (ICC 0.68 – 0.85). The poorest agreement was found st lingual premolar region (ICC = 0.68); vestibular premolar region (ICC = 0,72); lingual incisive region (ICC = 0,73).

Conclusions

Postmenopausal females with reduced BMD showed reduced cortical bone thickness in the edentulous mandible.

CBCT could be a promising tool for osteoporosis risk assessment in postmenopausal women in incisor and premolar vestibular and foramina mentalis lower cortical bone region of mandible.

Acknowledgements

This work was supported by the "Fundamental and Applied Research Projects", grant number: lzp-2021/1-0031

Contacts

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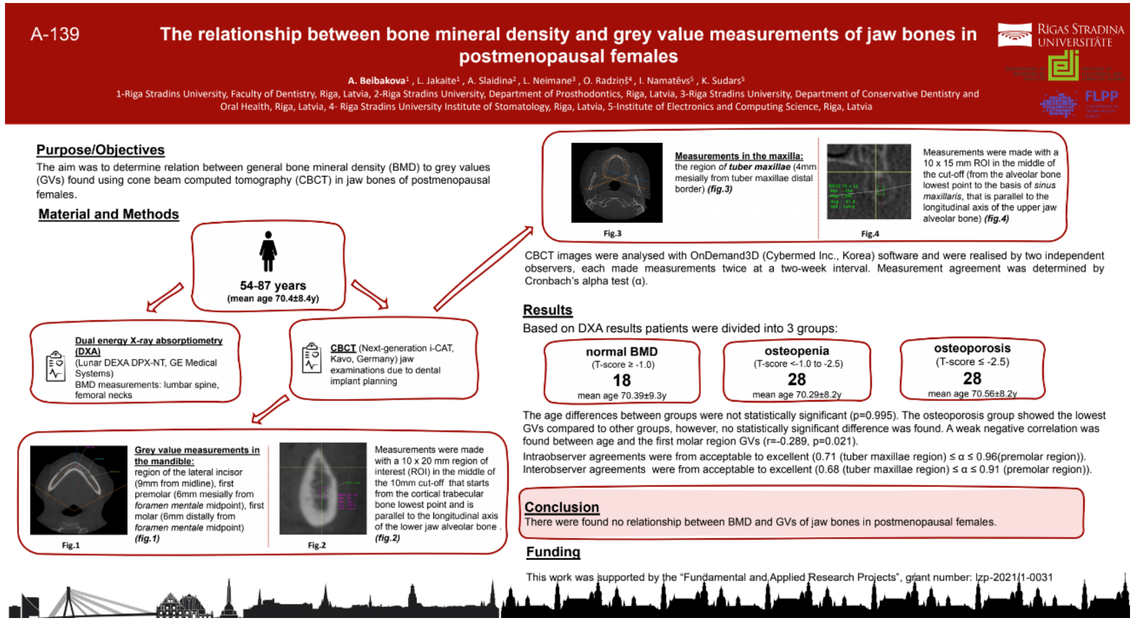

A-139

The relationship between bone mineral density and grey value measurements of jaw bones in postmenopausal females

A. Beibakova[1], L. Jakaite[1], A. Slaidina[2], L. Neimane[3], O. Radziņš[4], I. Namatēvs[5], K. Sudars[5]
1-Riga Stradins University, Faculty of Dentistry, Riga, Latvia, 2-Riga Stradins University, Department of Prosthodontics, Riga, Latvia, 3-Riga Stradins University, Department of Conservative Dentistry and Oral Health, Riga, Latvia, 4- Riga Stradins University Institute of Stomatology, Riga, Latvia, 5-Institute of Electronics and Computing Science, Riga, Latvia

Purpose/Objectives

The aim was to determine relation between general bone mineral density (BMD) to grey values (GVs) found using cone beam computed tomography (CBCT) in jaw bones of postmenopausal females.

Material and Methods

54-87 years (mean age 70.4±8.4y)

Dual energy X-ray absorptiometry (DXA) (Lunar DEXA DPX-NT, GE Medical Systems) BMD measurements: lumbar spine, femoral necks

CBCT (Next-generation i-CAT, Kavo, Germany) jaw examinations due to dental implant planning

Grey value measurements in the mandible: region of the lateral incisor (9mm from midline), first premolar (6mm mesially from *foramen mentale* midpoint), first molar (6mm distally from *foramen mentale* midpoint) *(fig.1)*

Measurements were made with a 10 x 20 mm region of interest (ROI) in the middle of the 10mm cut-off that starts from the cortical trabecular bone lowest point and is parallel to the longitudinal axis of the lower jaw alveolar bone *(fig.2)*

Fig.1 Fig.2

Measurements in the maxilla: the region of *tuber maxillae* (4mm mesially from tuber maxillae distal border) *(fig.3)*

Measurements were made with a 10 x 15 mm ROI in the middle of the cut-off (from the alveolar bone lowest point to the basis of *sinus maxillaris*, that is parallel to the longitudinal axis of the upper jaw alveolar bone) *(fig.4)*

Fig.3 Fig.4

CBCT images were analysed with OnDemand3D (Cybermed Inc., Korea) software and were realised by two independent observers, each made measurements twice at a two-week interval. Measurement agreement was determined by Cronbach's alpha test (α).

Results

Based on DXA results patients were divided into 3 groups:

normal BMD (T-score ≥ -1.0)	osteopenia (T-score <-1.0 to -2.5)	osteoporosis (T-score ≤ -2.5)
18	28	28
mean age 70.39±9.3y	mean age 70.29±8.2y	mean age 70.56±8.2y

The age differences between groups were not statistically significant (p=0.995). The osteoporosis group showed the lowest GVs compared to other groups, however, no statistically significant difference was found. A weak negative correlation was found between age and the first molar region GVs (r=-0.289, p=0.021).

Intraobserver agreement were from acceptable to excellent (0.71 (tuber maxillae region) ≤ α ≤ 0.96(premolar region)).

Interobserver agreements were from acceptable to excellent (0.68 (tuber maxillae region) ≤ α ≤ 0.91 (premolar region)).

Conclusion

There were found no relationship between BMD and GVs of jaw bones in postmenopausal females.

Funding

This work was supported by the "Fundamental and Applied Research Projects", grant number: lzp-2021/1-0031

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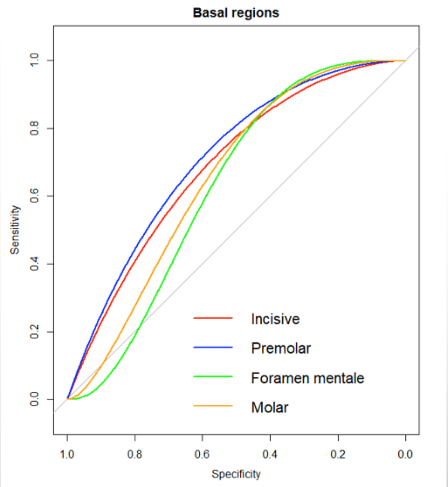
Pētījuma rezultāti IV

Slaidina Anda; Krumpane Laura; Beibakova Anastasija; Neimane Laura; Radzins Oskars; Namatevs Ivars; Sudars Kaspars.   *Cone Beam Computed Tomography for the Identification Risk of Osteoporosis*. 2023 Continental European and Scandinavian Divisions Meetings (Rhodes, Greece)

ROC CURVES AND AUC FOR BASAL CORTICAL BONE



	AUC	95% CI
Incisive region	**0.69**	0.58;0.8
Premolar region	**0.74**	0.61;0.81
Foramen mentale region	**0.6**	0.5;0.7
Molar region	**0.64**	0.55;0.74

FLPP FUNDAMENTAL AND APPLIED RESEARCH PROJECTS

IDENTIFICATION OF WOMEN WITH OSTEOPOROSIS BY BASAL CORTICAL BONE

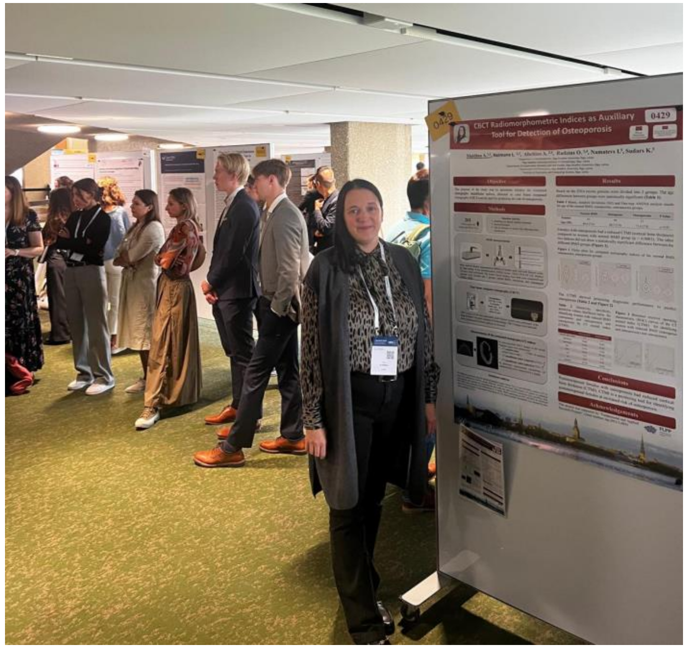
	Incisive basal	Premolar basal	Foramen mentale basal	Molar basal
Cuttoff value	2.4	2.5	2.7	2.2
Sensitivity	50%	73.9%	46.2%	52%
Specificity	82.5%	85%	58.1%	66%
PPV	43.2%	31.9%	22.7%	28.9%
NPV	86.1%	89.3%	80.2%	83.8%
+LF	2.86	4.6	1.1	1.53
-LR	0.61	0.38	0.93	0.73
Acuracy	75.7%	78.1%	55,6%	63.1%

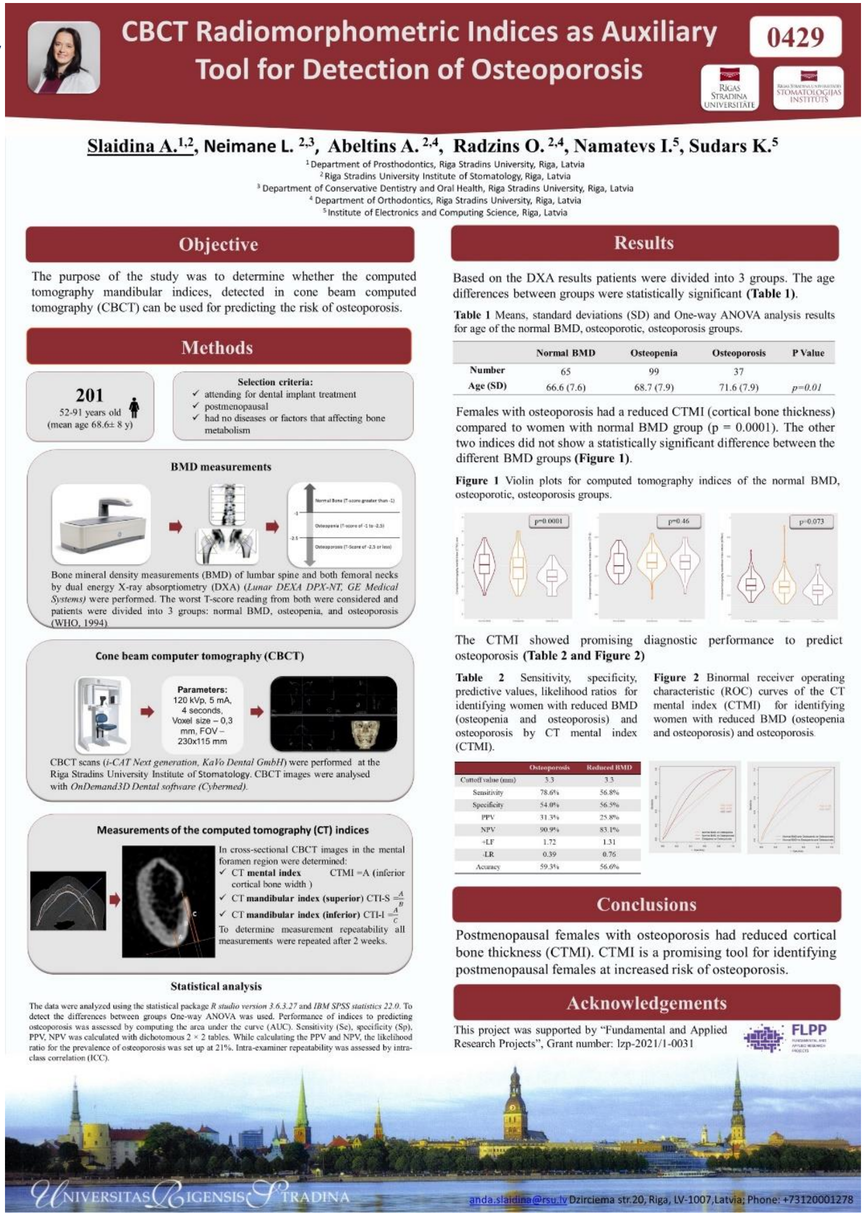
FLPP FUNDAMENTAL AND APPLIED RESEARCH PROJECTS

RĪGAS STRADIŅA UNIVERSITĀTE

Pētījuma rezultāti V

Slaidina Anda; Neimane Laura; Radzins Oskars; Namatevs Ivars; Sudars Kaspars. *CBCT Radiomorphometric Indices as Auxiliary Tool for Detection of Osteoporosis.* 2024 Continental European and Scandinavian Divisions Meetings (Geneva, Switzerland)





ELEKTRONIKAS UN DATORZINĀTŅU INSTITŪTS

INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

Paldies par uzmanību!

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