

# Package ‘MDSS’

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**Type** Package

**Title** Modeling Human Dentin Serial Sectioning

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**Imports** graphics, grDevices, stats

**Description** Modeling microstructures of human tooth dentin and horizontal serial-sectioning of the dentin. Corresponding age range of dentin serial sections, that is used in stable isotope analyses, can be calculated by using this package.

**Repository** CRAN

**License** GPL (>= 3)

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MDSS-package

*Modeling Human Dentin Serial Sectioning*

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**Description**

MDSS is a package to model microstructures of human tooth dentin and horizontal serial-sectioning of the dentin. The corresponding age range of dentin serial sections, that is used in stable isotope analyses, can be calculated by using this package.

**Details**

Package: MDSS  
Type: Package  
Version: 1.0-1  
Date: 2022-08-21  
License: GPL (>= 3)

Function `mds` models tooth dentin microstructures and horizontal sectioning patterns. The changing dentin growth rates, oblique dentin growth layers, and dentin outer shape are modeled with pre-determined parameters and user's manual adjustments in `mds`. Function `cca` calculates corresponding age ranges for each dentin serial sections set with `mds`. This package adopts S3 class. The detail of mathematical models is described in Tsutaya (in prep).

**Author(s)**

Takumi Tsutaya <tsutayatakumi@gmail.com>

**References**

Tsutaya T 2020. Blurred time resolution of tooth dentin serial sections. *American Journal of Physical Anthropology* 173:748–759. DOI: 10.1002/ajpa.24113.

**See Also**

[mds](#), [cca](#), [PlotSections](#)

**Examples**

```
## See ?mds and ?cca for examples.
```

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cca *Calculate corresponding age range for dentin serial sections*

---

### Description

cca calculates corresponding age range for horizontal dentin serial sections under a given class "mds" object and given ages at the start and end of tooth dentin formation.

### Usage

```
## Default S3 method:
cca(x, t.start, t.end)
```

### Arguments

x	An object of class "mds".
t.start	The age at the start of tooth dentin formation.
t.end	The age at the end of tooth dentin formation.

### Details

Function cca calculates corresponding age range for each serial section. Each GL has its formation age, and serial sections consist of several GLs that were formed in different ages. Relative volume assigned to each GL in a section is used to weigh the contribution from the GL. Modeled age ranges for the stable isotopic trajectory of dentin serial sections can be obtained by using this function.

### Value

cca returns an object of class "cca".  
 The function `plot` is used to show figures of the results.  
 An object of class "cca" has following list components in addition to those succeeded from "mds":

t.all	List including 5 elements.
t.g	Numeric vector of assigned age to each growth lines with the equal temporal division.
t.n	Numeric vector of assigned age to each sectioning plane with the equal temporal division.
t.g.mid	Numeric vector of midpoint age of each GL.
t.n.ref	Numeric vector of calculated midpoint of the modeled age range of each section with the consideration of changing.
t.n.obs	Numeric vector of assigned midpoint age to each section with the equal temporal division.
cca	Matrix of assigned ages to each section. The row consists of the assigned midpoint ages to sections with equal-temporal division (equally), the modeled midpoint age calculated from the weighted contribution from GLs (weighted), the duration of modeled age range (duration), and lower and upper ages of the modeled age range (lower and upper). The column corresponds to each section, and the smallest column number represents the crown-most section.

**Author(s)**

Takumi Tsutaya developed this model.

**References**

Tsutaya T 2020. Blurred time resolution of tooth dentin serial sections. *American Journal of Physical Anthropology* 173:748–759. DOI: 10.1002/ajpa.24113.

**See Also**

[MDSS](#), [mds](#), [plot.cca](#)

**Examples**

```
## 18 sections for 18 mm lateral incisor
l18_I2_s18.mds <- mds(
  tooth = "I",
  rt.y = 18,
  section.y = 0:18,
  n.GL = 100)
l18_I2_s18.cca <- cca(
  x = l18_I2_s18.mds,
  t.start = 0.5875,
  t.end = 10.5)

# Plot corresponding age ranges.
plot(l18_I2_s18.cca)

## Example of the first molar of ST61 from the Unseiji temple.
unseiji_ST61_M1.mds <- mds(
  tooth = "M1",
  rt.y = unseiji_ST61_M1$rt.y,
  ecj = unseiji_ST61_M1$ecj,
  section.y = unseiji_ST61_M1$section.y,
  n.GL = 100)
unseiji_ST61_M1.cca <- cca(
  x = unseiji_ST61_M1.mds,
  t.start = unseiji_ST61_M1$t.start,
  t.end = unseiji_ST61_M1$t.end)

# Plot modeled age ranges with stable nitrogen isotope ratios.
plot(unseiji_ST61_M1.cca,
  age = unseiji_ST61_M1$section$age,
  delta = unseiji_ST61_M1$section$d15N,
  type = "o")

# Plot without excluded sections with the porous dentin structure.
plot(unseiji_ST61_M1.cca,
  age = unseiji_ST61_M1$section$age[1:13],
  delta = unseiji_ST61_M1$section$d15N[1:13],
  type = "o")
```

```
## Irregular sectioning for 20 mm canine.
l20_C_irr.mds <- mds(
  tooth = "C",
  rt.y = 20,
  section.y = c(2:14, 15, 17, 19),
  n.GL = 100)
l20_C_irr.cca <- cca(
  x = l20_C_irr.mds,
  t.start = 0.35,
  t.end = 13.5)

# Plot corresponding age ranges.
plot(l20_C_irr.cca, xlim = c(0, 14))
```

mds

*Model dentin serial sections*

## Description

Function `mds` models tooth dentin microstructures and horizontal sectioning patterns. The changing dentin growth rates, oblique dentin growth layers, and dentin outer shape are modeled with pre-determined parameters and user's manual adjustments.

## Usage

```
## Default S3 method:
mds(tooth, rt.y = 1, ecj = NULL, section.y,
     factor.GL = 1, n.GL = 500, thin = FALSE)
```

## Arguments

<code>tooth</code>	Character scalar showing the target tooth type. Only <code>c("I", "C", "M1", "M2", "M3")</code> is supported.
<code>rt.y</code>	A positive y-value of dentin root tip in mm. Dentin horn is set on the geometric origin, and the longitudinal central axis of dentin equals the y-axis.
<code>ecj</code>	<code>c(x, y)</code> coordinates of enamel-cement junction (ECJ) in mm. If <code>NULL</code> (default), the standardized coordinate is used.
<code>section.y</code>	Vector of y-values for serial sections. Please sandwich by the start and end points for each section, so that the length of <code>section.y</code> equals the +1 number of the serial sections.
<code>factor.GL</code>	Numeric vector to adjust slope of dentin growth layers (GLs). A product of <code>factor.GL</code> and pre-determined slope is used to describe the obliqueness of GLs. If <code>factor.GL = 1</code> , obliqueness of GLs is the same with the reference. If <code>&gt;1</code> , steeper GLs. If <code>&lt;1</code> , gentler GLs.
<code>n.GL</code>	Scalar indicating number of GLs. Default is 500.

**thin** If dentin sample was sliced out into a longitudinal thin plate, put TRUE. If TRUE, the two-dimensional area of individual GLs is used to weigh their contribution in a given section. But if cylindrical dentin sample, such like the whole dentin or longitudinal half/quarter of dentin, was cut into serial sections, put FALSE (default). If FALSE, the cylindrical three-dimensional volume of individual GLs, that is calculated by turning it around the longitudinal central axis of the tooth, is used.

## Details

The `mds` is a function to model tooth dentin microstructures and horizontal serial-sectioning patterns for human permanent incisors, canines, and molars. The changing dentin growth rates, oblique dentin growth layers, and curved dentin outer shape are considered in this model. Users can adjust these parameters for individual tooth dentin samples. The details of this model are described in Tsutaya (in prep).

## Value

`mds` returns an object of class `"mds"`.

The function `plot` is used to plot a figure of the results.

An object of class `"mds"` is a list containing at least the following components:

<code>parea</code>	Matrix of weighted proportion (volume contribution) for each GL included in each section. The row and column correspond to GLs and sections, respectively.
<code>included</code>	List containing the growth line numbers that are included in each section. The crown-most section has the smallest number as a list element.
<code>ge.x</code>	Numeric vector of the standardized x-value of cross-section between growth lines and crown dentin outer shape.
<code>ge.y</code>	Numeric vector of the standardized y-value of cross-section between growth lines and crown dentin outer shape.
<code>gd.x</code>	Numeric vector of the standardized x-value of cross-section between growth lines and root dentin outer shape.
<code>gd.y</code>	Numeric vector of the standardized y-value of cross-section between growth lines and root dentin outer shape.
<code>ecj.x</code>	Scalar of the standardized x-value of ECJ.
<code>ecj.y</code>	Scalar of the standardized y-value of ECJ.
<code>m.y</code>	Numeric vector of the standardized y-value of cross-section between growth lines and longitudinal central axis of tooth (i.e., y-axis).
<code>n.y</code>	Numeric vector of the standardized y-value of cross-section between sectioning planes and longitudinal central axis of tooth (i.e., y-axis).
<code>EShape</code>	Function describing the crown dentin outer shape.
<code>DShape</code>	Function describing the root dentin outer shape.
<code>Gcurve</code>	Function describing the tooth dentin growth lines.
<code>call</code>	The matched call.

**Author(s)**

Takumi Tsutaya developed this model.

**References**

Tsutaya T 2020. Blurred time resolution of tooth dentin serial sections. *American Journal of Physical Anthropology* 173:748–759. DOI: 10.1002/ajpa.24113.

**See Also**

[MDSS](#), [cca](#), [plot.mds](#)

**Examples**

```
## 18 sections for 18 mm lateral incisor
l18_I2_s18.mds <- mds(
  tooth = "I",
  rt.y = 18,
  section.y = 0:18,
  n.GL = 100)

# Plot tooth dentin anatomy.
plot(l18_I2_s18.mds)

## Example of the first molar of ST61 from the Unseiji temple.
unseiji_ST61_M1.mds <- mds(
  tooth = "M1",
  rt.y = unseiji_ST61_M1$rt.y,
  ecj = unseiji_ST61_M1$ecj,
  section.y = unseiji_ST61_M1$section.y,
  n.GL = 100)

# Plot tooth dentin anatomy.
plot(unseiji_ST61_M1.mds)

## Irregular sectioning for 20 mm canine.
l20_C_irr.mds <- mds(
  tooth = "C",
  rt.y = 20,
  section.y = c(2:14, 15, 17, 19),
  n.GL = 100)

# Plot tooth dentin anatomy.
plot(l20_C_irr.mds)
```

## Description

plot.cca is a plotting utility for quick visualization of the modeled age range of tooth dentin serial sections under an object of class "cca". The modeled age ranges are plotted for each section.

## Usage

```
## S3 method for class 'cca'  
plot(x, age = NULL, delta = NULL, error = 0.1, ...)
```

## Arguments

x	An object of class "cca" generated by <a href="#">cca</a> .
age	Numeric vector of originally assigned ages for each section. If omitted, midpoint ages calculated with equal temporal division according to the relative height of sections are used.
delta	Numeric vector of stable isotope ratios for each section. If omitted, corresponding age ranges are plotted without information on stable isotope ratios.
error	Analytical error of stable isotope ratios. Default is 0.1.
...	Additional arguments passed to <a href="#">plot</a> .

## Details

If the argument delta is omitted, the corresponding age ranges for each serial section are plotted with its positions in the standardized y-axis. If the argument delta is specified, the originally-assigned ages and the modeled age ranges for each section are plotted with its stable isotope ratios.

## Author(s)

Takumi Tsutaya developed this model.

## References

Tsutaya T 2020. Blurred time resolution of tooth dentin serial sections. American Journal of Physical Anthropology 173:748–759. DOI: 10.1002/ajpa.24113.

## See Also

[MDSS](#), [mds](#), [cca](#)

## Examples

```
## See ?cca for examples.
```



---

`plot.mds`*Plot for modeled tooth dentin serial sections*

---

## Description

`plot.mds` is a plotting utility for quick visualization of the modeled tooth dentin microstructures under an object of class "mds". The modeled dentin growth layers and outer shape are plotted on a geometric plane.

## Usage

```
## S3 method for class 'mds'  
plot(x, ...)
```

## Arguments

`x` An object of class "mds" generated by [mds](#)  
`...` Additional arguments passed to [plot](#).

## Details

The modeled tooth dentin is plotted on a geometric plane. Dentin horn and root tip equal the geometric origin and the coordinate (0, 1), respectively. Growth lines are shown with oblique colored lines inside the longitudinal half of tooth dentin outer shape. Horizontal sections are shown with horizontal solid black lines.

## Author(s)

Takumi Tsutaya developed this model.

## References

Tsutaya T 2020. Blurred time resolution of tooth dentin serial sections. *American Journal of Physical Anthropology* 173:748–759. DOI: 10.1002/ajpa.24113.

## See Also

[MDSS](#), [mds](#)

## Examples

```
## See ?mds for examples.
```

---

PlotSections

*Plot multiple corresponding age rangse for measured data*

---

### Description

PlotSections plots the corresponding age range for horizontal dentin serial sections with multiple class "cca" objects.

### Usage

```
PlotSections(age, delta, obj,  
             error = 0.1, col = "black", pch = 21, ...)
```

### Arguments

age	List of user-assigned ages for each sections.
delta	List of vector observed delta values for each sections.
obj	List of class "cca" objects.
error	Vector of analytical error. Used for the height of "beans".
col	Vector of "col" values for plot.
pch	Vector of "pch" values for plot.
...	Additional arguments passed to <a href="#">plot</a> .

### Details

Function PlotSections plots corresponding age range with its measured delta values and equally assigned ages for a series of serial sections. Multiple trajectories can be plotted together into a single figure.

### Value

A plot of multiple trajectories of dentin serial sections.

### Author(s)

Takumi Tsutaya developed this model.

### References

Tsutaya T 2020. Blurred time resolution of tooth dentin serial sections. American Journal of Physical Anthropology 173:748–759. DOI: 10.1002/ajpa.24113.

### See Also

[MDSS](#), [mds](#), [cca](#)

**Examples**

```

## Example of the first molar of ST61 from the Unseiji temple.
unseiji_ST61_M1.mds <- mds(
  tooth = "M1",
  rt.y = unseiji_ST61_M1$rt.y,
  ecj = unseiji_ST61_M1$ecj,
  section.y = unseiji_ST61_M1$section.y,
  n.GL = 100)
unseiji_ST61_M1.cca <- cca(
  x = unseiji_ST61_M1.mds,
  t.start = unseiji_ST61_M1$t.start,
  t.end = unseiji_ST61_M1$t.end)
unseiji_ST61_C.mds <- mds(
  tooth = "C",
  rt.y = unseiji_ST61_C$rt.y,
  ecj = unseiji_ST61_C$ecj,
  section.y = unseiji_ST61_C$section.y,
  n.GL = 100)
unseiji_ST61_C.cca <- cca(
  x = unseiji_ST61_C.mds,
  t.start = unseiji_ST61_C$t.start,
  t.end = unseiji_ST61_C$t.end)

# Plot C and M1 modeled age ranges with stable nitrogen isotope ratios.
PlotSections(
  age = list(
    unseiji_ST61_C$section$age,
    unseiji_ST61_M1$section$age),
  delta = list(
    unseiji_ST61_C$section$d15N,
    unseiji_ST61_M1$section$d15N),
  obj = list(
    C = unseiji_ST61_C.cca,
    M1 = unseiji_ST61_M1.cca))

# Plot the same data with different colors.
PlotSections(
  age = list(
    unseiji_ST61_C$section$age,
    unseiji_ST61_M1$section$age),
  delta = list(
    unseiji_ST61_C$section$d15N,
    unseiji_ST61_M1$section$d15N),
  obj = list(
    C = unseiji_ST61_C.cca,
    M1 = unseiji_ST61_M1.cca),
  col = c("red", "blue"),
  pch = c(1, 2))

```

**Description**

This data set gives the stable carbons and nitrogen isotope ratios of dentin serial sections obtained from a human mandibular canine tooth of an individual ST61 (AD 1655–1732) from the Unseiji temple, Japan, reported in Tsutaya et al. (2016).

**Usage**

unseiji\_ST61\_C

**Format**

unseiji\_ST61\_C is a list containing 6 elements.

rt.y	y-value for the root tip (i.e., length [mm] of the dentin).
ecj	x- and y-coordinates of enamel-cement junction. Dentin horn is placed on the geometric origin, and root tip is placed on the y-axis.
section.y	y-values for the horizontal sections.
t.start and t.end	The age at the start and end of dentin formation, respectively.
section	Data frame with 18 dentin serial sections (rows) and 3 variables (columns) of assigned midpoint age with respect to the root tip.

**Details**

See detail for Tsutaya et al. (2016).

**Source**

Tsutaya T, Miyamoto H, Uno H, Omori T, Gakuhari T, Inahara A, Nagaoka T, Abe M, Yoneda M. 2016. From cradle to grave: multi-isotopic investigations on the life history of a higher-status female in the Edo period Japan. *Anthropological Science* 124:185–197. DOI: 10.1537/ase.161029.

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unseiji_ST61_M1	<i>Stable isotopic data of first molar from ST61</i>
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**Description**

This data set gives the stable carbons and nitrogen isotope ratios of dentin serial sections obtained from a human maxillary first molar tooth of an individual ST61 (AD 1655–1732) from the Unseiji temple, Japan, reported in Tsutaya et al. (2016).

**Usage**

unseiji\_ST61\_M1

**Format**

unseiji\_ST61\_C is a list containing 6 elements.

rt.y	y-value for the root tip (i.e., length [mm] of the dentin).
ecj	x- and y-coordinates of enamel-cement junction. Dentin horn is placed on the geometric origin, and root tip is placed on the y-axis.
section.y	y-values for the horizontal sections.
t.start and t.end	The age at the start and end of dentin formation, respectively.
section	Data frame with 16 dentin serial sections (rows) and 3 variables (columns) of assigned midpoint age with respect to the root tip.

**Details**

See detail for Tsutaya et al. (2016).

**Source**

Tsutaya T, Miyamoto H, Uno H, Omori T, Gakuhari T, Inahara A, Nagaoka T, Abe M, Yoneda M. 2016. From cradle to grave: multi-isotopic investigations on the life history of a higher-status female in the Edo period Japan. *Anthropological Science* 124:185–197. DOI: 10.1537/ase.161029.

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