第八次頭暈讀書會

乙狀骨缺損之脈搏性耳鳴

SIGMOID PLATE DEHISCENCE FOR PULSATILE TINNITUS

A Fuss or A Fact?

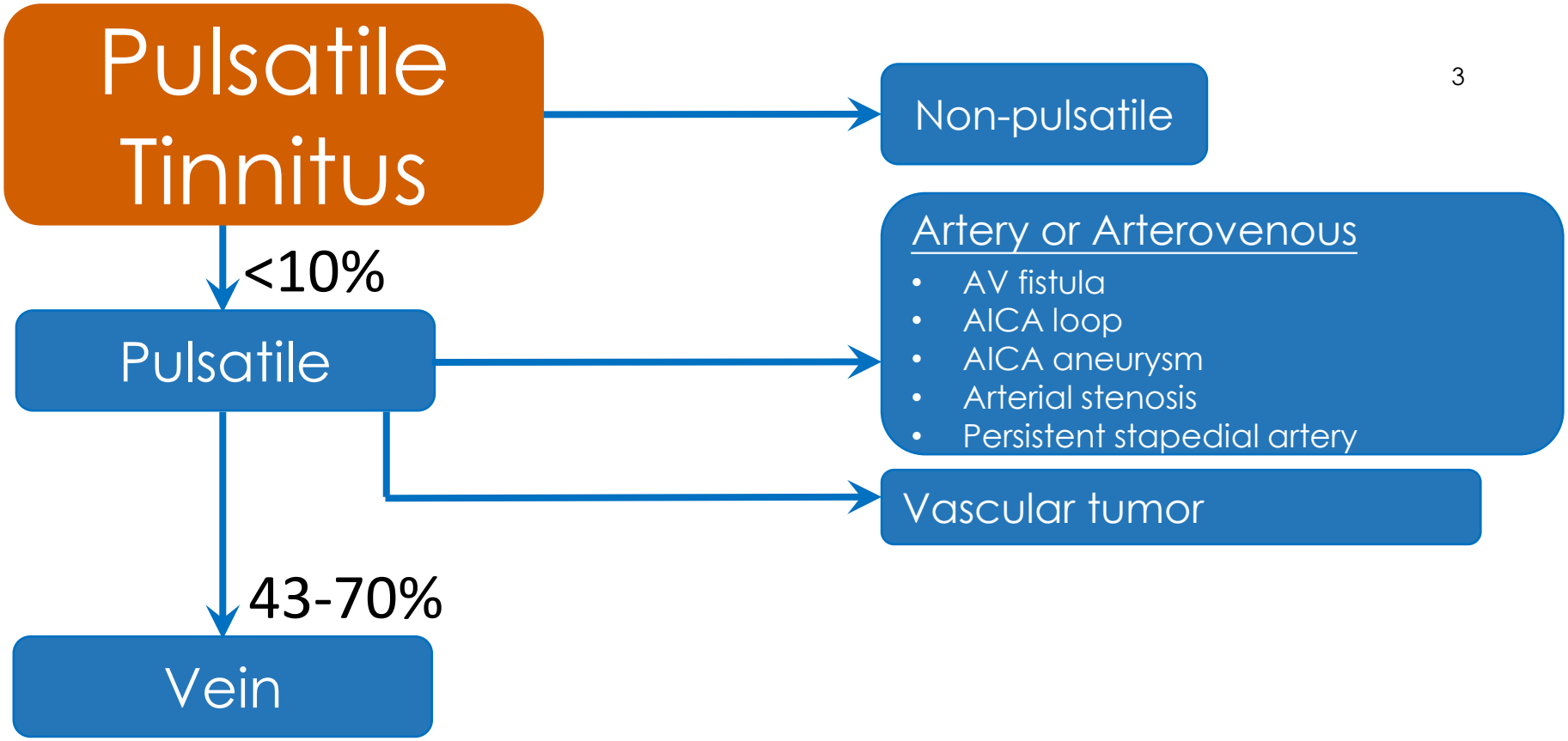
台北醫學大學

台北神經醫學中心　雙和醫院神經外科

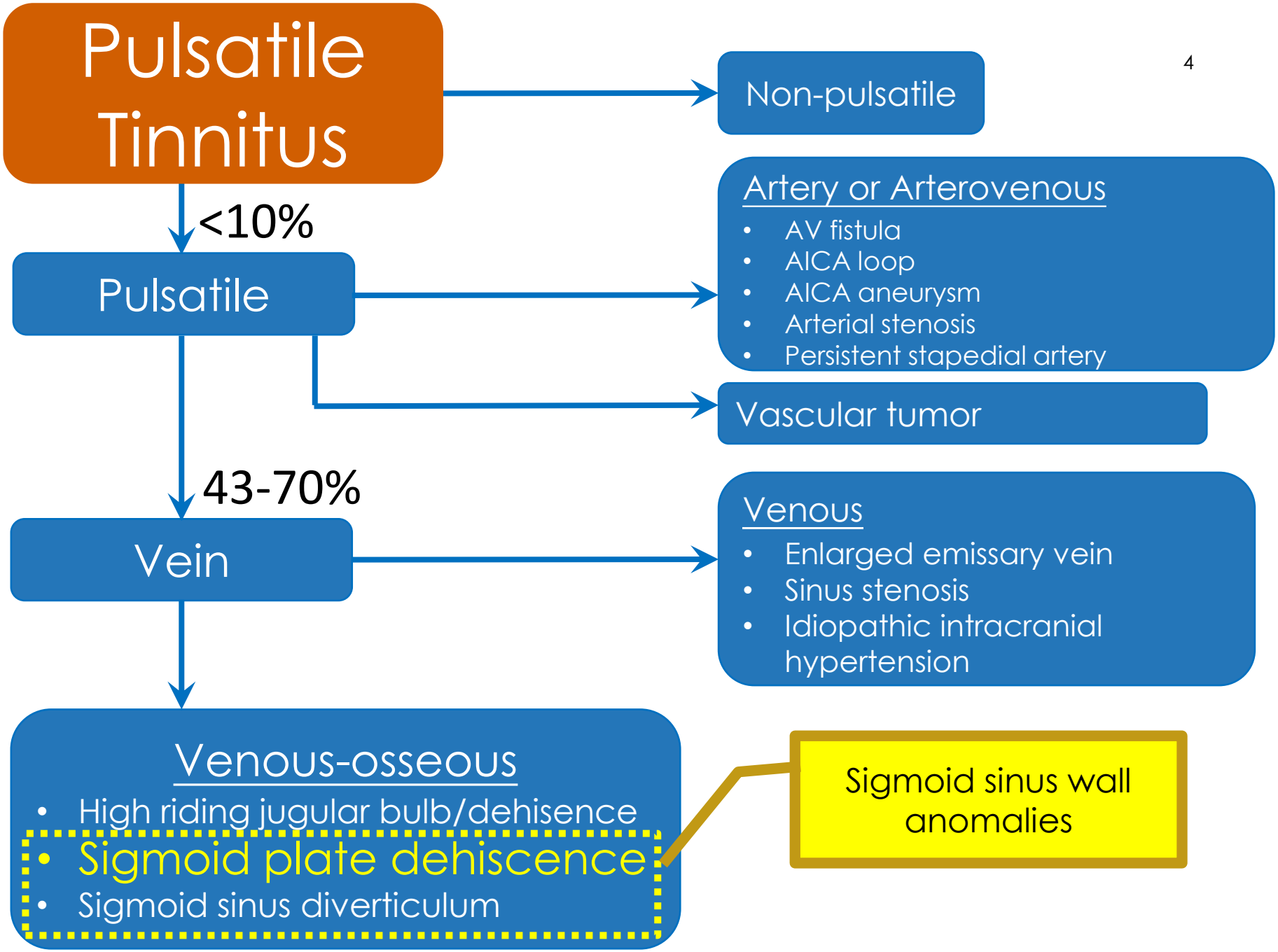
蘇亦昌

2023/10/14

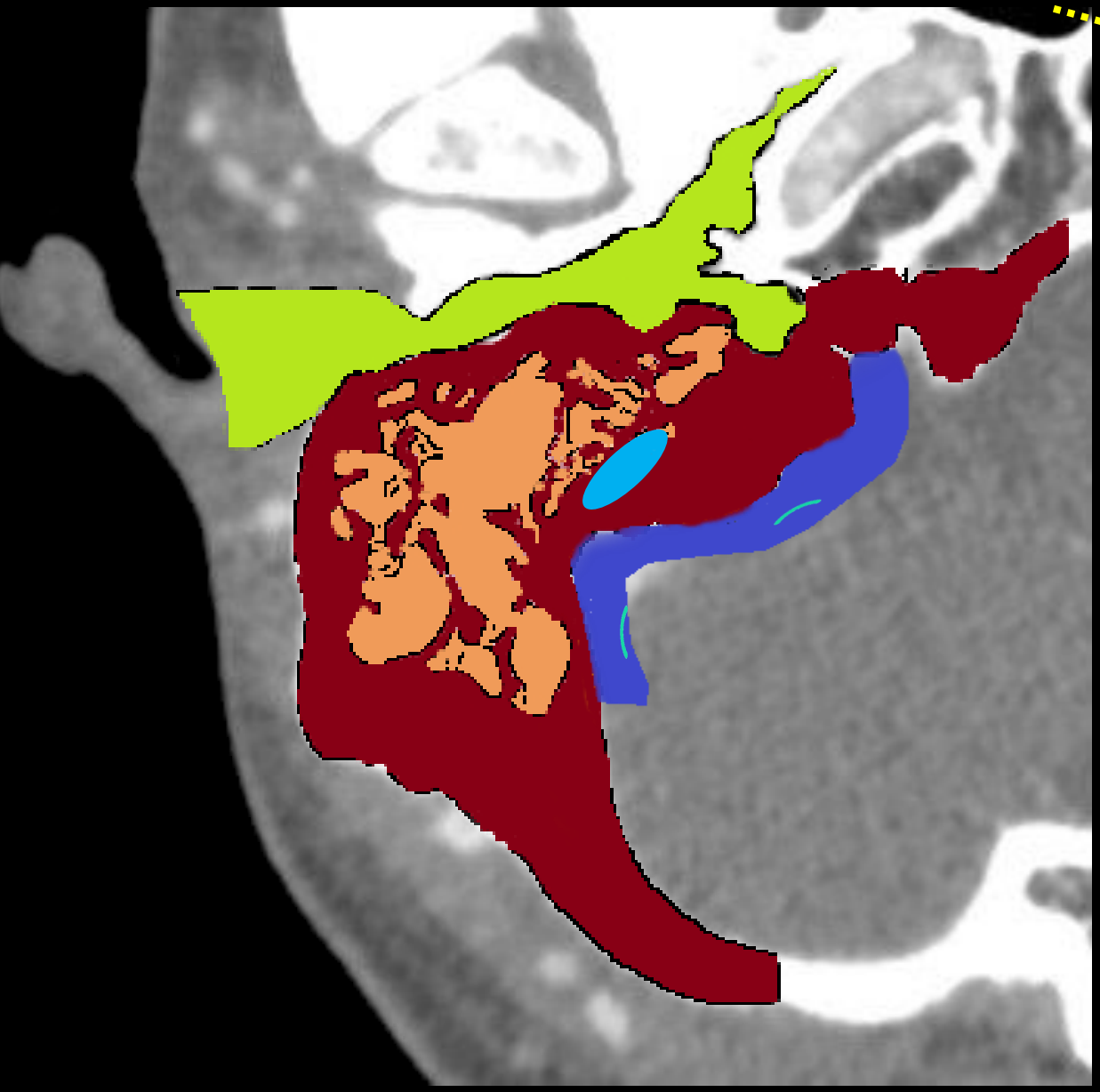
NO CONFLICT OF INTERESTS



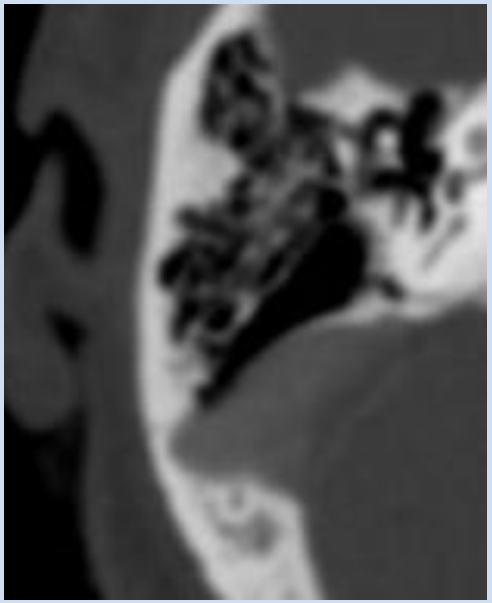
- Rhythmic tinnitus
- Synchronous to heart beats
- Alleviated by compressing the veins or tilting the neck

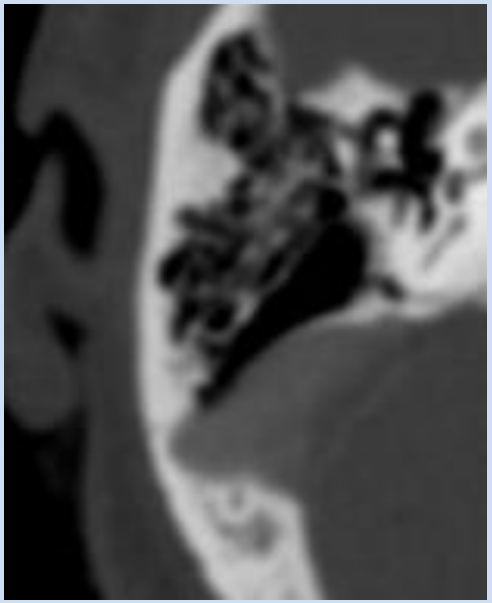

Pulsatile Tinnitus
Non-pulsatile
<10%
Pulsatile
Artery or Arterovenous
AV fistula
AICA loop
AICA aneurysm
Arterial stenosis
Persistent stapedial artery
Vascular tumor
43-70%
Vein
Venous
Enlarged emissary vein
Sinus stenosis
Idiopathic intracranial hypertension
Venous-osseous
High riding jugular bulb/dehisence
Sigmoid plate dehiscence
Sigmoid sinus diverticulum
Sigmoid sinus wall anomalies

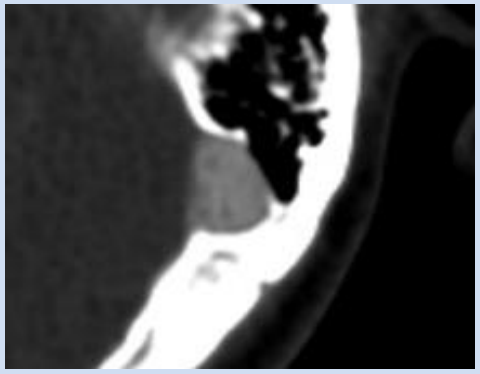
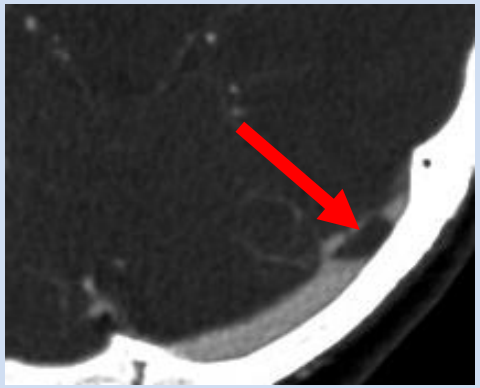
What is sigmoid plate ?

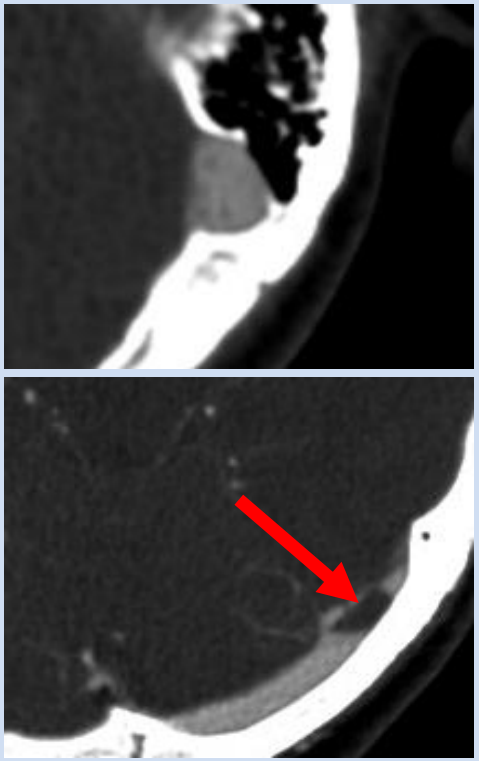


What is sigmoid plate ?

Sigmoid plate Dehiscence	Patient A
"Air on sinus sign" in CT	
Dehiscence length	9.0 mm
Associated diverticulum	Yes
Transverse sinus stenosis	No

Sigmoid plate Dehiscence	Patient A	Patient B
"Air on sinus sign" in CT		
Dehiscence length	9.0 mm	6.2 mm
Associated diverticulum	Yes	Yes
Transverse sinus stenosis	No	No

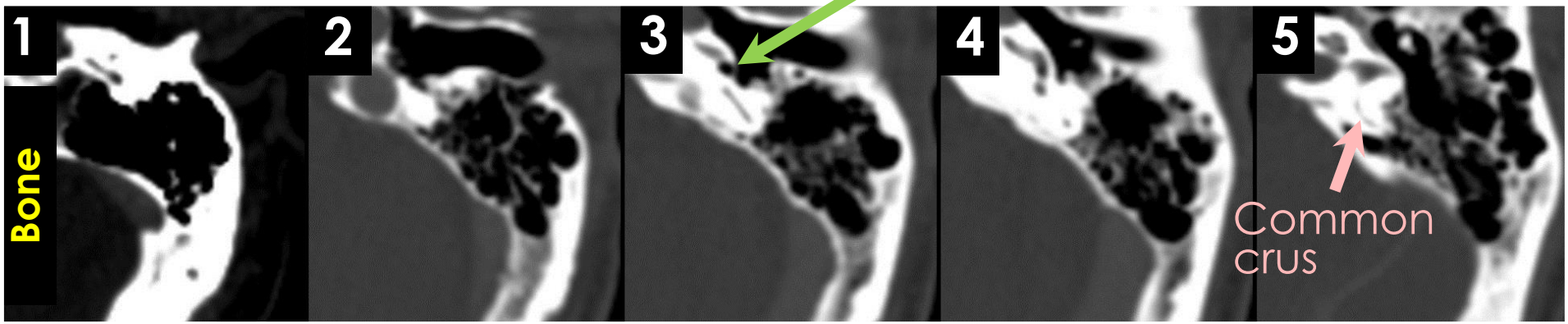
Sigmoid plate Dehiscence	Patient A	Patient B	Patient C
"Air on sinus sign" in CT			 
Dehiscence length	9.0 mm	6.2 mm	6.8 mm
Associated diverticulum	Yes	Yes	No
Transverse sinus stenosis	No	No	Yes

Sigmoid plate Dehiscence	Patient A	Patient B	Patient C
"Air on sinus sign" in CT			
Dehiscence length	9.0 mm	6.2 mm	6.8 mm
Associated diverticulum	Yes	Yes	No
Transverse sinus stenosis	No	No	Yes
Location	Upper	Lower	Upper

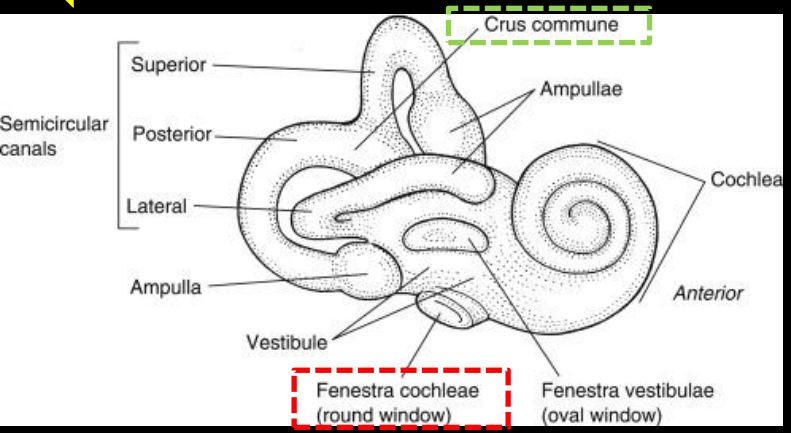
Dehiscence location

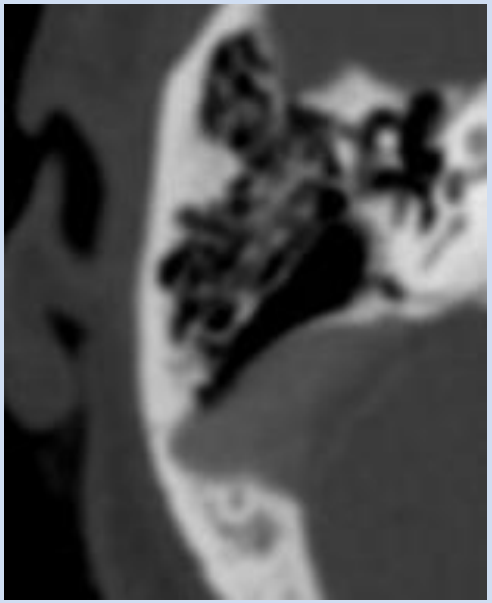
Lower | Middle | Upper

Round window

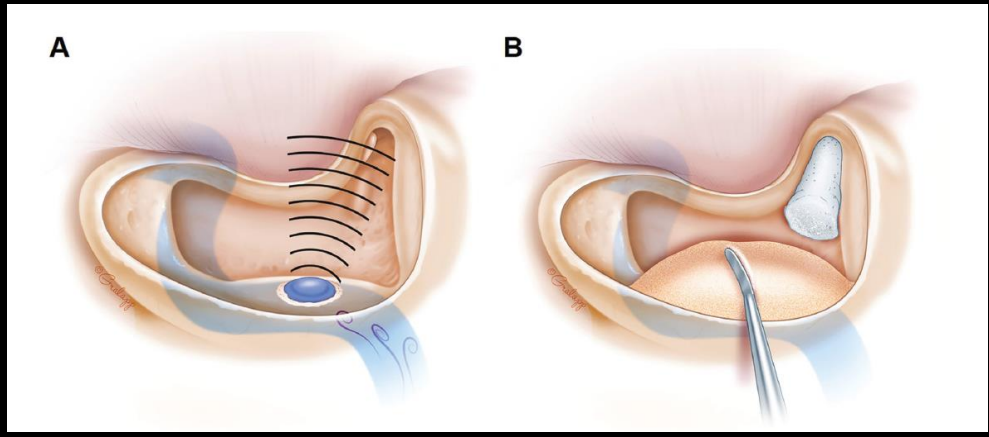


Inferior — Superior

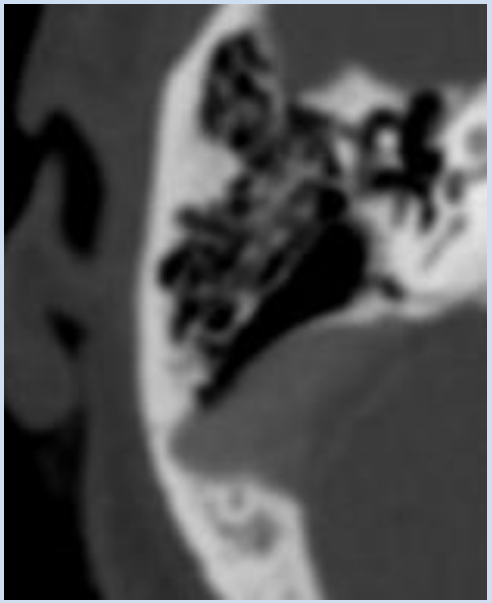


Sigmoid plate Dehiscence	Patient A
"Air on sinus sign" in CT	
Length	9.0 mm
Associated diverticulum	Yes
Transverse sinus stenosis	No
Location	Upper

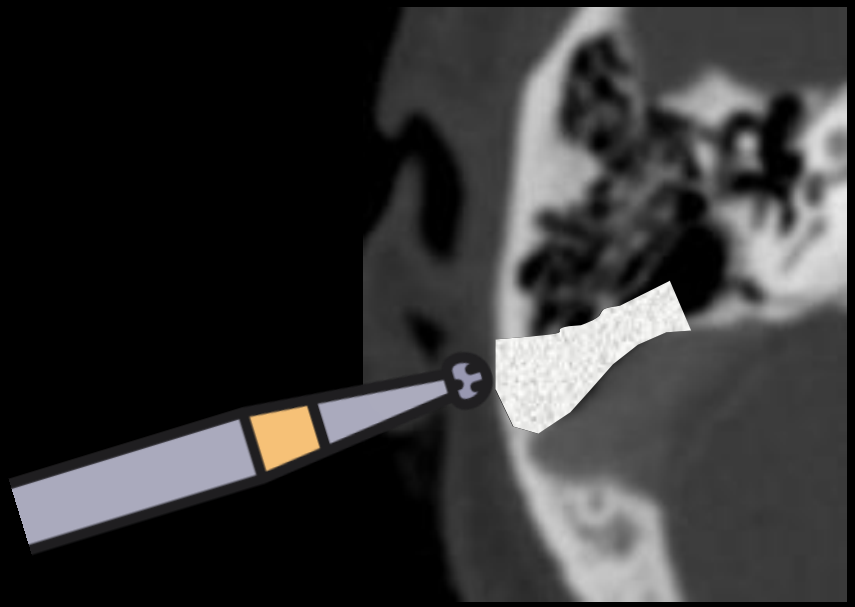
Resurfacing procedure



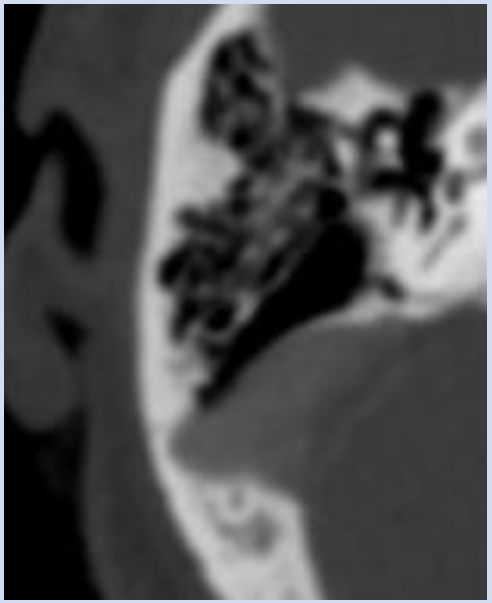
耳鳴嚴重度	治療前
耳鳴評量表 Tinnitus handicap inventory	80
自覺耳鳴響度評量表	8

Sigmoid plate Dehiscence	Patient A
"Air on sinus sign" in CT	
Length	9.0 mm
Associated diverticulum	Yes
Transverse sinus stenosis	No
Location	Upper

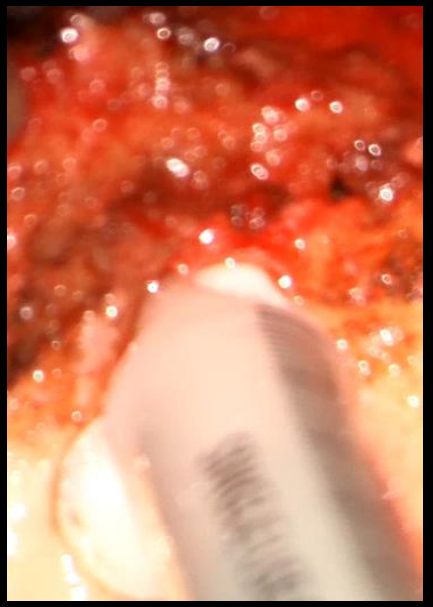
Resurfacing procedure



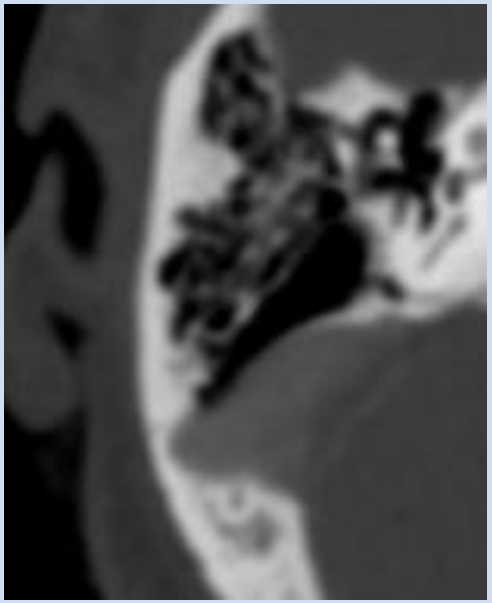
耳鳴嚴重度	治療前
耳鳴評量表 Tinnitus handicap inventory	80
自覺耳鳴響度評量表	8

Sigmoid plate Dehiscence	Patient A
"Air on sinus sign" in CT	
Length	9.0 mm
Associated diverticulum	Yes
Transverse sinus stenosis	No
Location	Upper

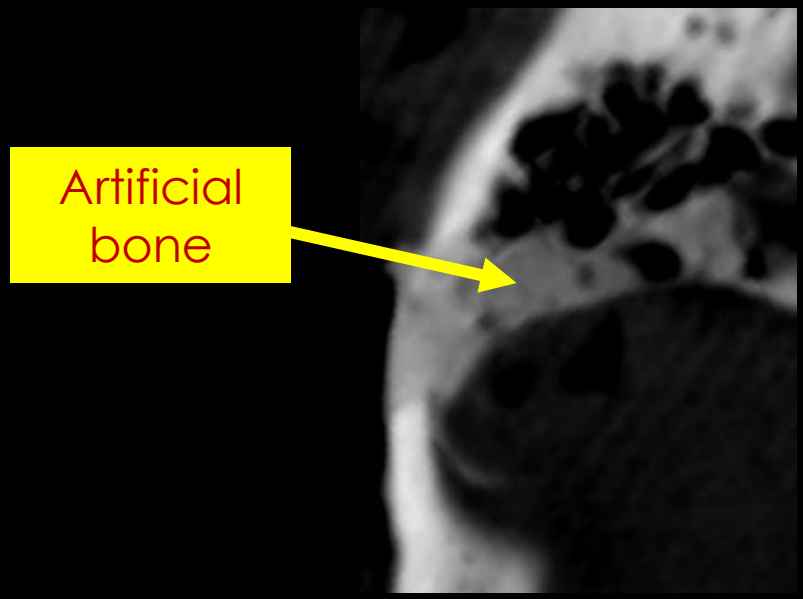
Resurfacing procedure



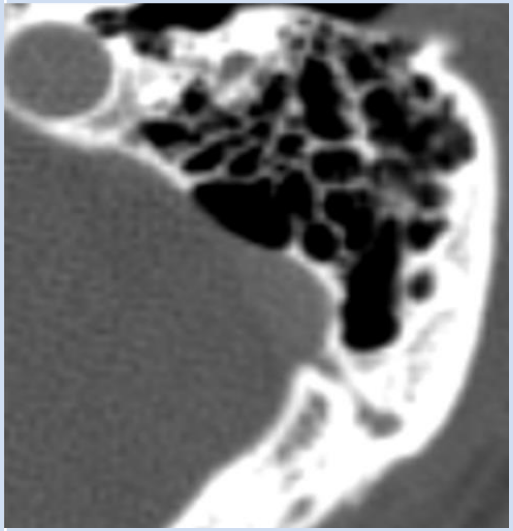
耳鳴嚴重度	治療前	治療後
耳鳴評量表 Tinnitus handicap inventory	80	2
自覺耳鳴響度評量表	8	0

Sigmoid plate Dehiscence	Patient A
"Air on sinus sign" in CT	
Length	9.0 mm
Associated diverticulum	Yes
Transverse sinus stenosis	No
Location	Upper

Resurfacing procedure

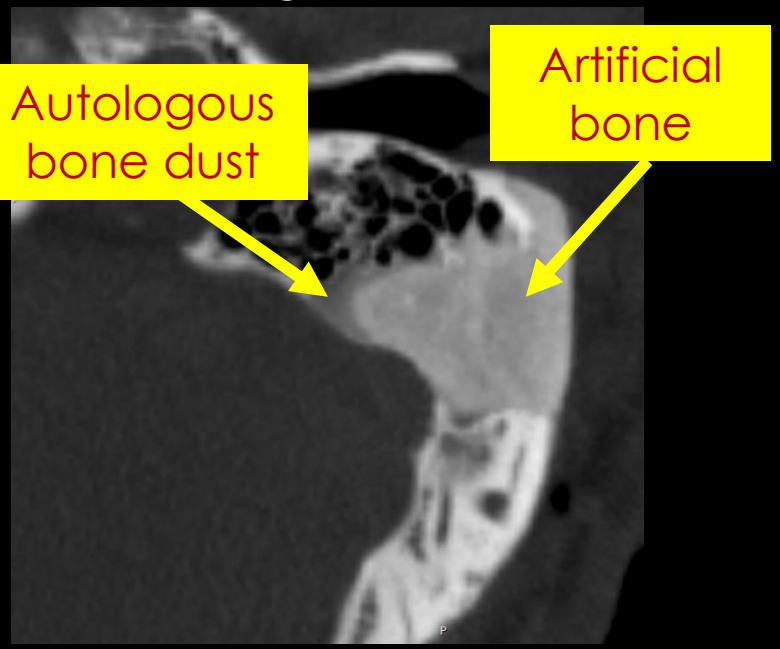


耳鳴嚴重度	治療前	治療後
耳鳴評量表 Tinnitus handicap inventory	80	2
自覺耳鳴響度評量表	8	0

Sigmoid plate Dehiscence	Companion case to patient A
"Air on sinus sign" in CT	
Length	7.0 mm
Associated diverticulum	No
Transverse sinus stenosis	No
Location	Upper

Lt: pulsatile tinnitus
Rt: non-pulsatile tinnitus

Resurfacing procedure

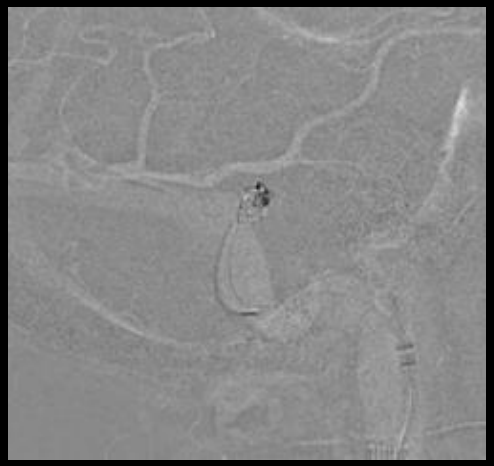


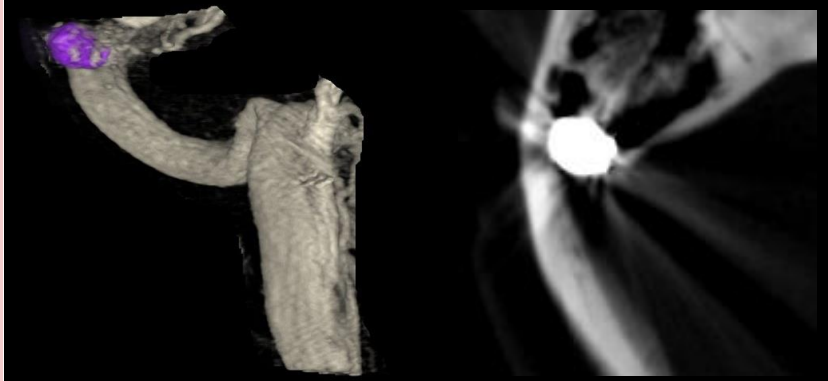
耳鳴嚴重度	治療前	治療後
耳鳴評量表 Tinnitus handicap inventory	88	44
自覺耳鳴響度評量表	9	5

Sigmoid plate Dehiscence	Patient B
"Air on sinus sign" in CT	
Length	6.2 mm
Associated diverticulum	Yes
Transverse sinus stenosis	No
Location	Lower

耳鳴嚴重度	治療前
耳鳴評量表 Tinnitus handicap inventory	90
自覺耳鳴響度評量表	9

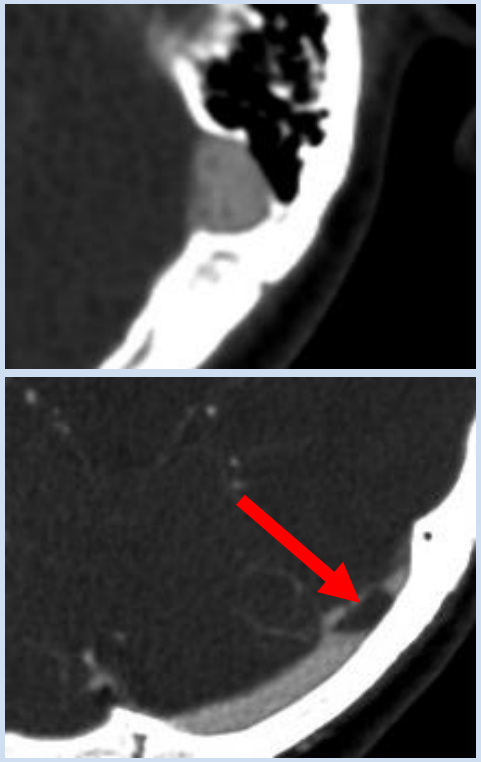
Sigmoid plate Dehiscence	Patient B
"Air on sinus sign" in CT	
Length	6.2 mm
Associated diverticulum	Yes
Transverse sinus stenosis	No
Location	Lower



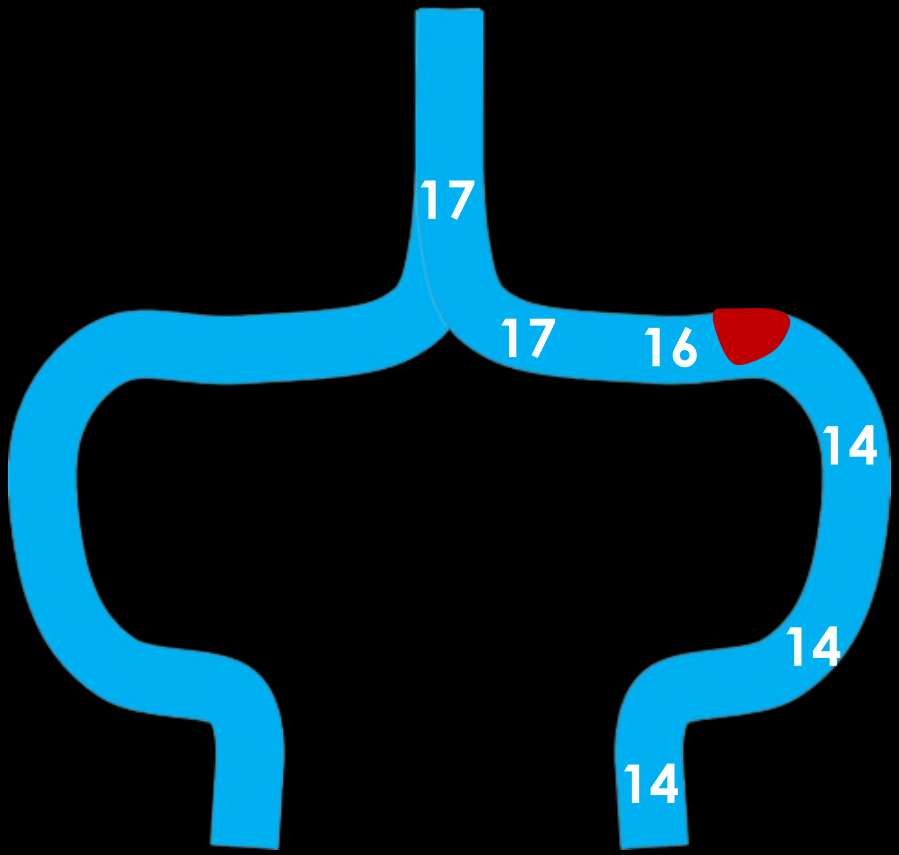


An alternative to *"Surgical Resurfacing"*

耳鳴嚴重度	治療前	治療後
耳鳴評量表 Tinnitus handicap inventory	90	4
自覺耳鳴響度評量表	9	1

Sigmoid plate Dehiscence	Patient C
"Air on sinus sign" in CT	
Length	6.8 mm
Associated diverticulum	No
Transverse sinus stenosis	Yes
Location	Upper

Venous manometry (mmHg)



Normal sigmoid plate

Dehiscent sigmoid plate

Symptomatic pulsatile tinnitus

Q1: Pathophysiology

Q2: Symptomatology

Normal sigmoid plate

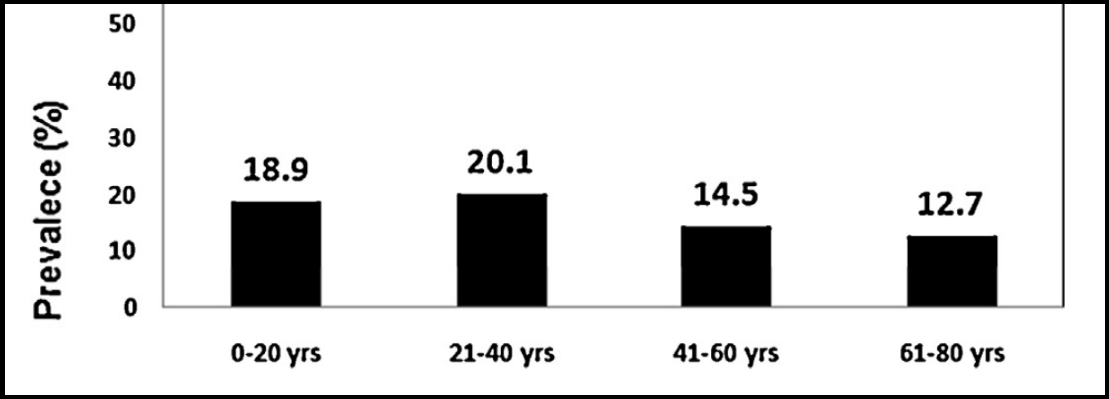
Dehiscent sigmoid plate

Q1: Pathophysiology

Is it acquired or congenital?

*Acquired or **Congenital**?*

1. Prevalence of dehiscence across different age group is similar



2. Dehiscence size across different age group is similar

Age group (years)	Anteroposterior diameter ($M \pm SD$)	Vertical diameter ($M \pm SD$)
0–20	3.7 ± 1.7 mm	3.6 ± 2.3 mm
21–40	3.0 ± 1.3 mm	2.6 ± 1.2 mm
41–60	3.1 ± 1.5 mm	3.2 ± 1.5 mm
61–80	3.0 ± 1.1 mm	3.0 ± 1.7 mm

Eur Rad 2015;84:862-4

Acquired *or Congenital?*

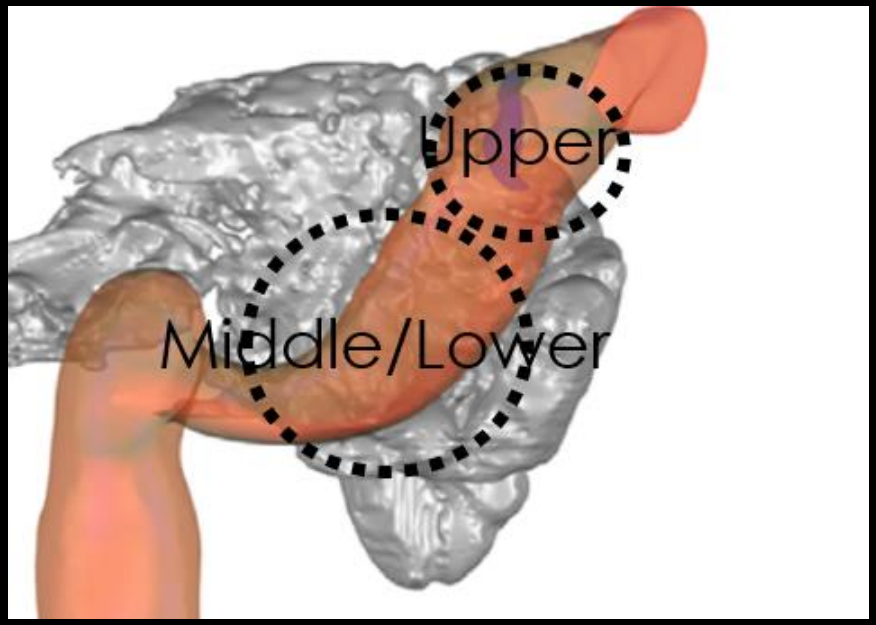
Dehiscence location: Upper > Middle/lower

Dehiscence location	Number (N=44)
Upper	25 (56.8%)
Middle + Lower	15 (34.1%)
Combined	4 (9.1)%

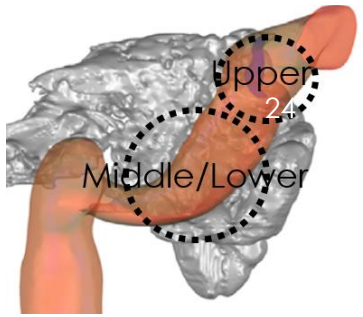
Eur Rad 2016;26:9-14

Dehiscence location	Number (N=60)
Upper	31(51.7%)
Middle + Lower	20 (33.3%)
Combined	9 (15.0%)

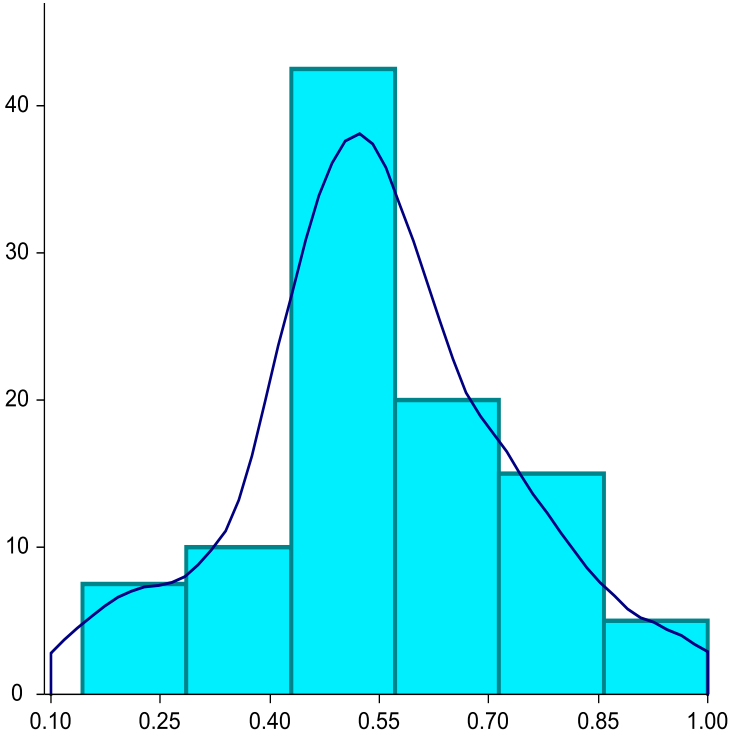
Our series



Dehiscence length distribution

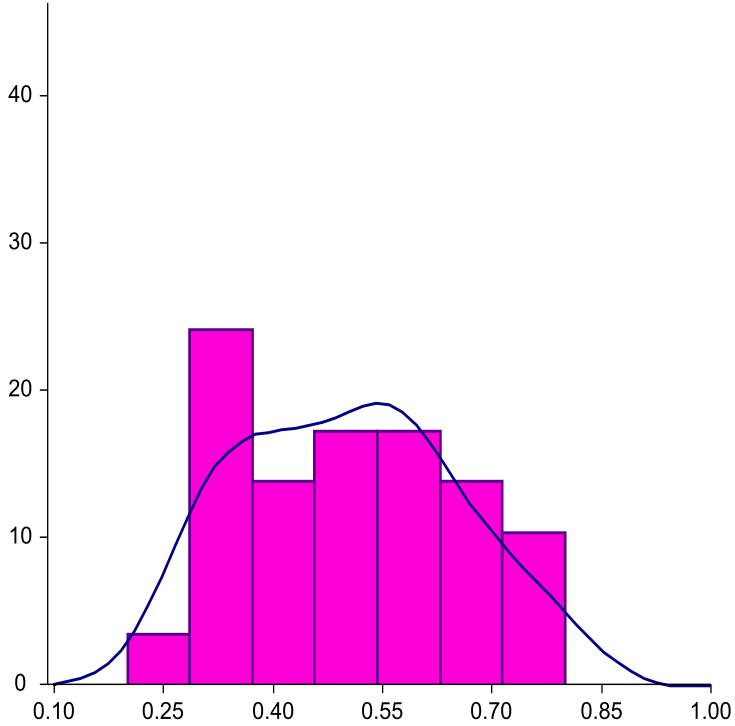


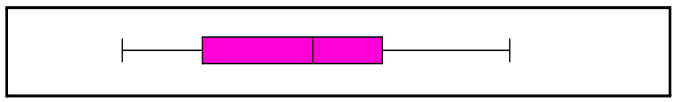
Upper sigmoid plate



0.53 cm (0.44-0.65)

Middle/Lower sigmoid plate

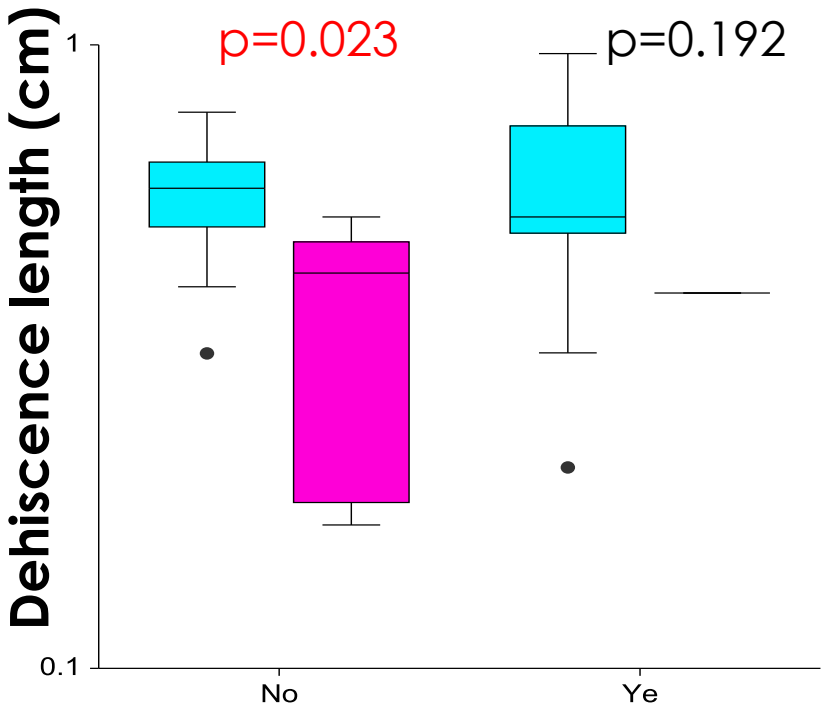




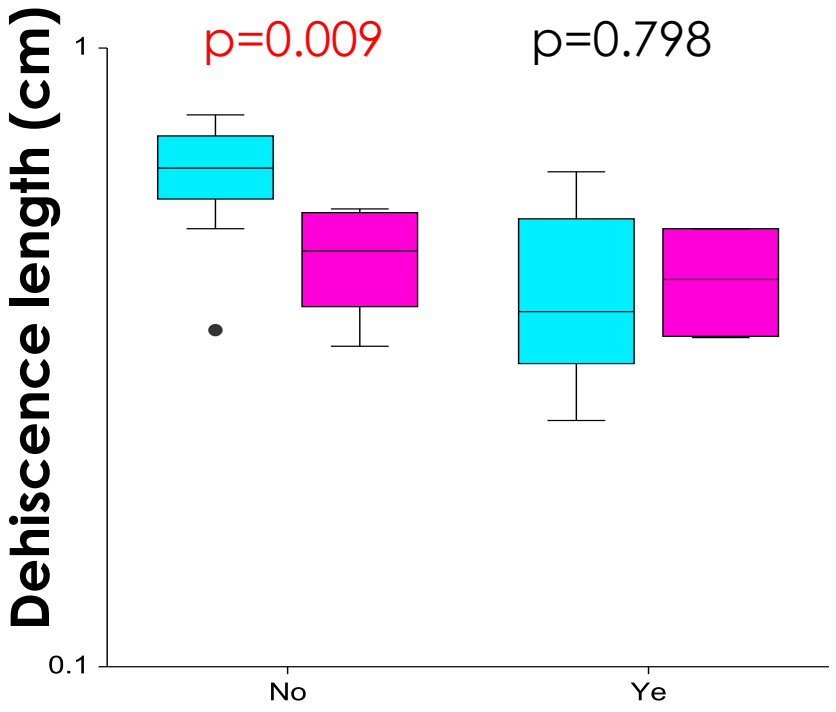
0.51cm (0.36-0.60)

Dehiscence length distribution

Upper sigmoid plate



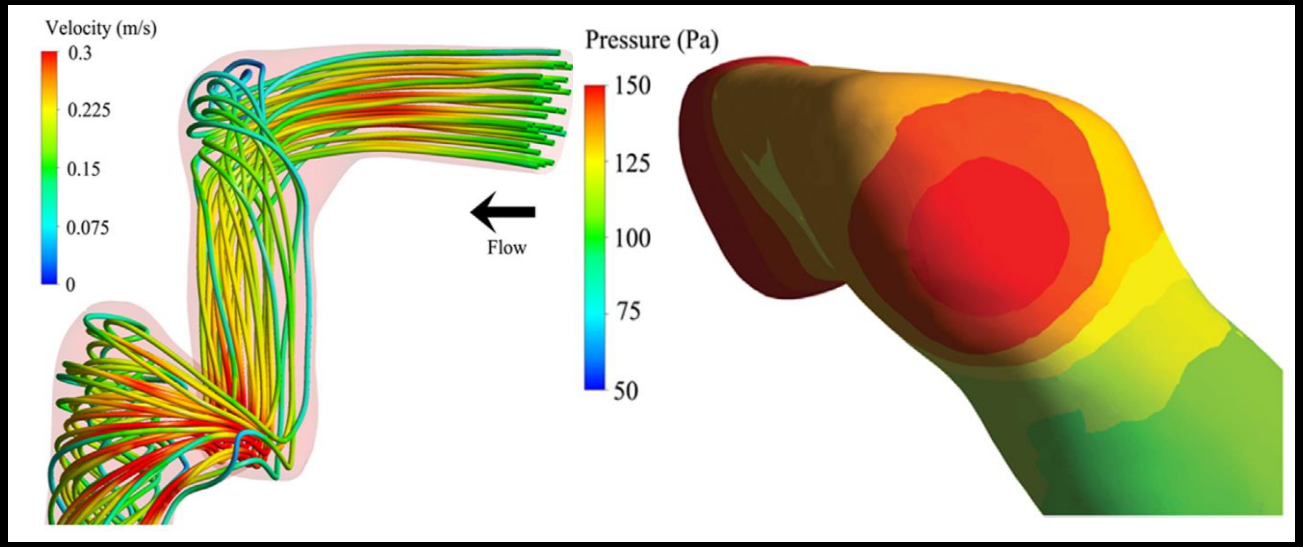
Middle/Lower sigmoid plate



Dominant/Codominant transverse sinus

Non-dominant transverse sinus

Acquired *or Congenital?*



J Biomech 2017;52:68-73

The continuous impact of venous flow from transverse sinus was suspected to be the reason causing dehiscence

Otol Neurotol 2011;32:1116-9

Acquired *or Congenital?*

Intracranial hypertension: another hypothetical explanation

	Sigmoid wall anomaly (n=33)	Control (n=101)	p value
Male BMI	27.1	27.9	P=0.4
Female BMI	35.6	27.1	<0.01
Female: Male	10:1	1.5:1	<0.01

Otol Neurotol 2013;35:7-15

➔Similar demographic features in patients with idiopathic intracranial hypertension

Normal sigmoid plate

Dehiscent sigmoid plate

Q1: Pathophysiology

Acquired or Congenital?

Although initially congenital, sigmoid plate dehiscence's size and location differences are likely due to long-term acquired hemodynamic stress from the ipsilateral transverse sinus.

Normal sigmoid plate

Q1: Pathophysiology

Dehiscent sigmoid plate

Q2: Symptomatology

Symptomatic pulsatile tinnitus

- Cortical plate dehiscence results in the decline of soundproof effect
  “Air on sinus sign"
- “Sigmoid resurfacing surgery” is effective in ~86% of symptomatic patients

- Sigmoid dehiscence is also observed among individuals without tinnitus
- Sigmoid dehiscence is commonly associated with other established factors of pulsatile tinnitus

Symptomatic patient

Asymptomatic patient

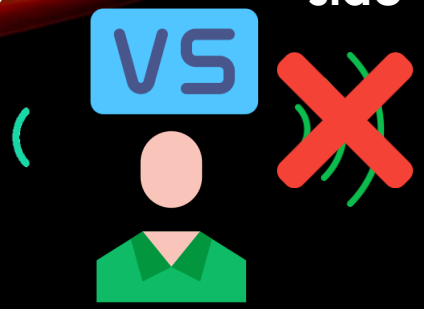
Pulsatile tinnitus	Symptomatic		P
	+	-	
Dehiscence (+)	23.3%	1.2%	<0.01
Dehiscence (-)	76.7%	98.8%	

- Sigmoid dehiscence is also observed among individuals without tinnitus
- Sigmoid dehiscence is commonly associated with other established factors of pulsatile tinnitus

*Otolaryngol Head Neck Surg 2013:150:841-846

Symptomatic side

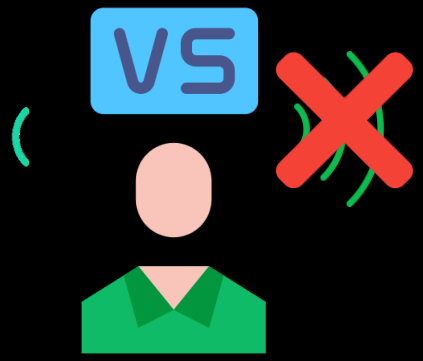
Asymptomatic side



Pulsatile tinnitus	Symptomatic		P
	+	-	
Dehiscence (+)	37.0%	45.2%	0.31
Dehiscence (-)	63.0%	54.8%	

- Sigmoid dehiscence is also observed among individuals without tinnitus
- Sigmoid dehiscence is commonly associated with other established factors of pulsatile tinnitus

Our series



Pulsatile tinnitus	Symptomatic		P
	+	-	
Dehiscence (+)	23.3%	1.2%	<0.01
Dehiscence (-)	76.7%	98.8%	

Otolaryngol Head Neck Surg 2013:150:841-846

Pulsatile tinnitus	Symptomatic		P
	+	-	
Dehiscence (+)	37.0%	45.2%	0.31
Dehiscence (-)	63.0%	54.8%	

Our series

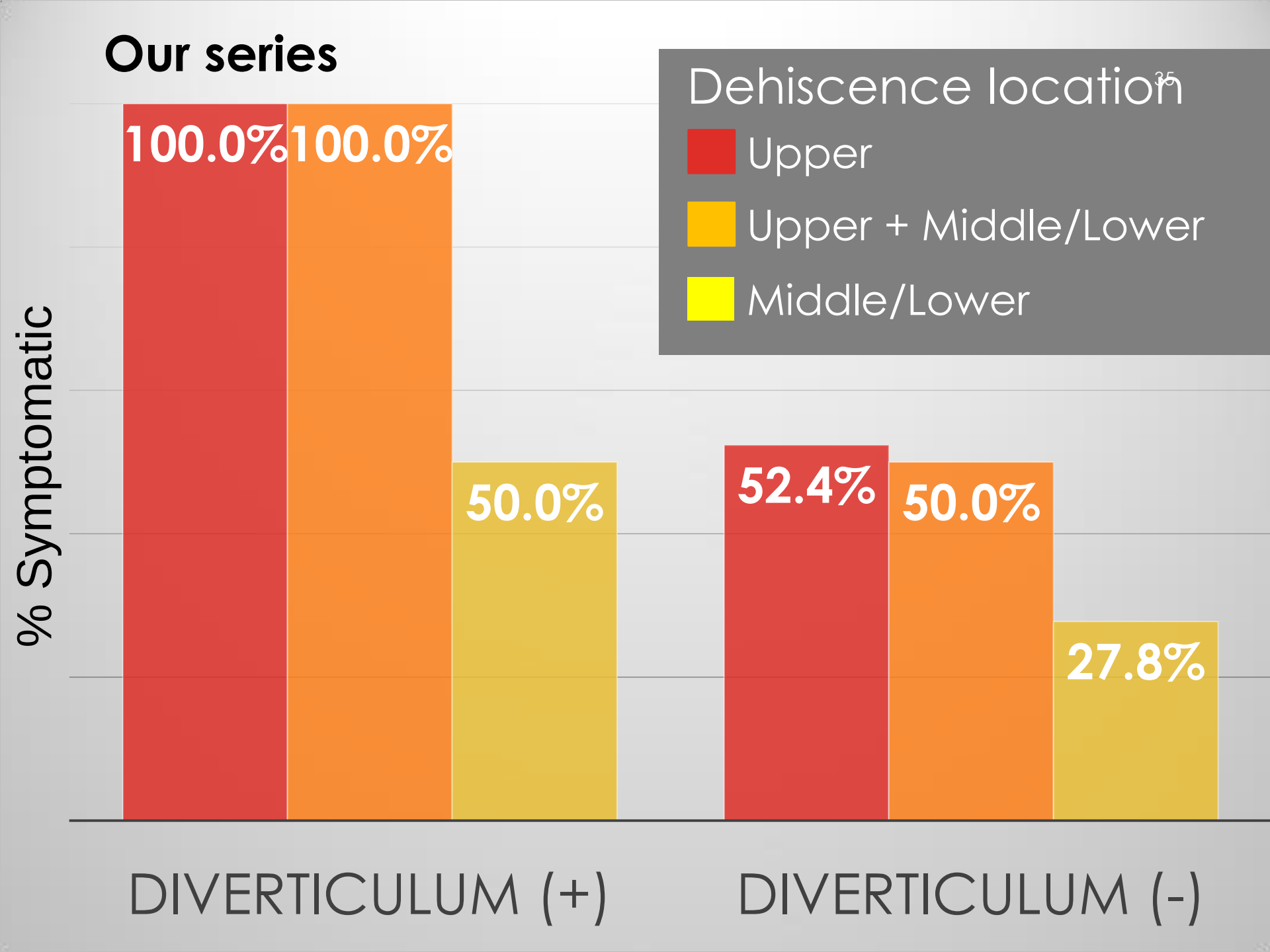
Factors	Dehiscence		P value
	+	-	
Transverse stenosis	48.3%	36.0%	0.14
IJV stenosis	23.3%	20.9%	0.73
Large emissary vein	13.3%	22.1%	0.18
High jugular bulb	20.0%	14.0%	0.33
Jugular bulb diverticulum	43.3%	33.7%	0.24
Sigmoid sinus diverticulum	25.0%	5.8%	<0.01

- Sigmoid dehiscence is also observed among individuals without tinnitus

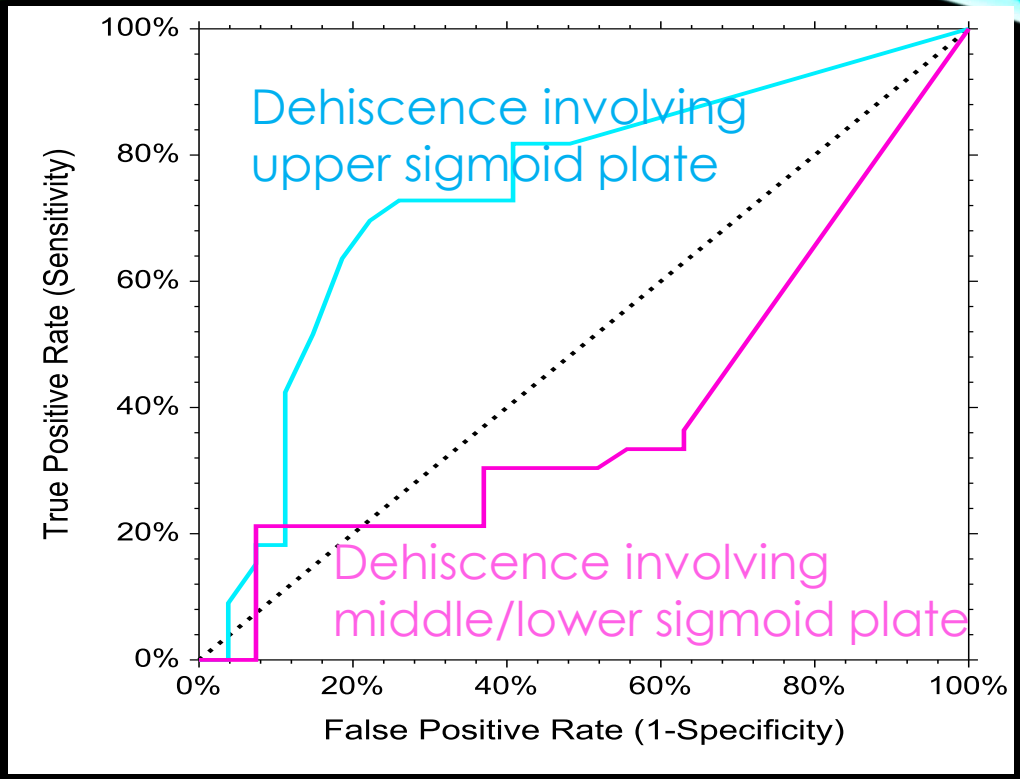
- Sigmoid dehiscence is commonly associated with other established factors of pulsatile tinnitus

Our series

Our series


Dehiscence location
Upper
Upper + Middle/Lower
Middle/Lower
% Symptomatic
100.0%
100.0%
50.0%
52.4%
50.0%
27.8%
DIVERTICULUM (+)
DIVERTICULUM (-)

ROC analysis of dehiscence length (mm)



Our series

Dehiscence location	AUC	P value	Cutoff value (accuracy rate)
Upper	0.741 (0.581-0.845)	<0.01	0.50 (73.3%)
Middle/Lower	0.397 (0.250-0.525)	0.93	-

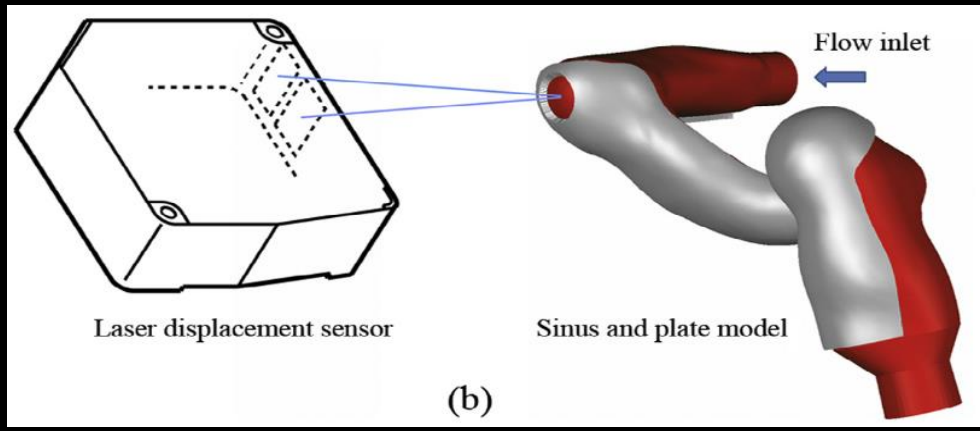
When is dehiscence clinically relevant among patients with venous pulsatile tinnitus?

1. Upper sigmoid plate dehiscence (> 0.5cm): Highly predictive
2. Dehiscence with diverticulum: Symptomatic tinnitus likely

- Cortical plate dehiscence results in the decline of soundproof effect
  “Air on sinus sign"

- “Sigmoid resurfacing surgery” is effective in ~86% of symptomatic patients

Simulation study

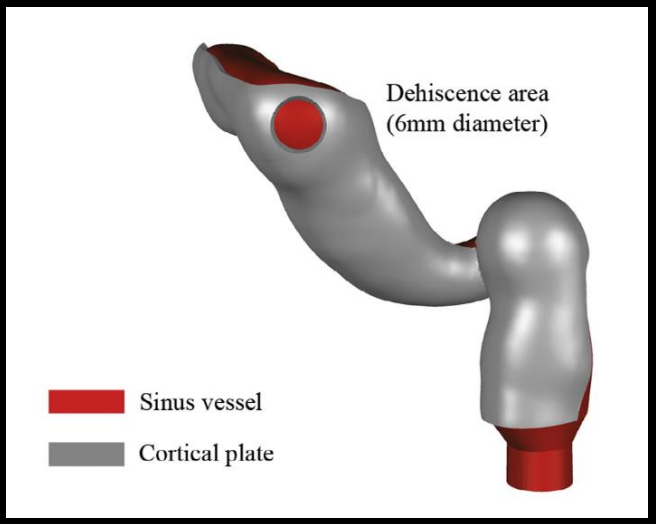


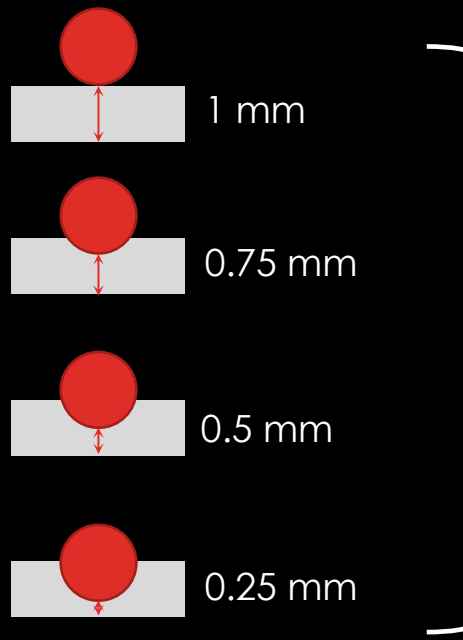
Measurements

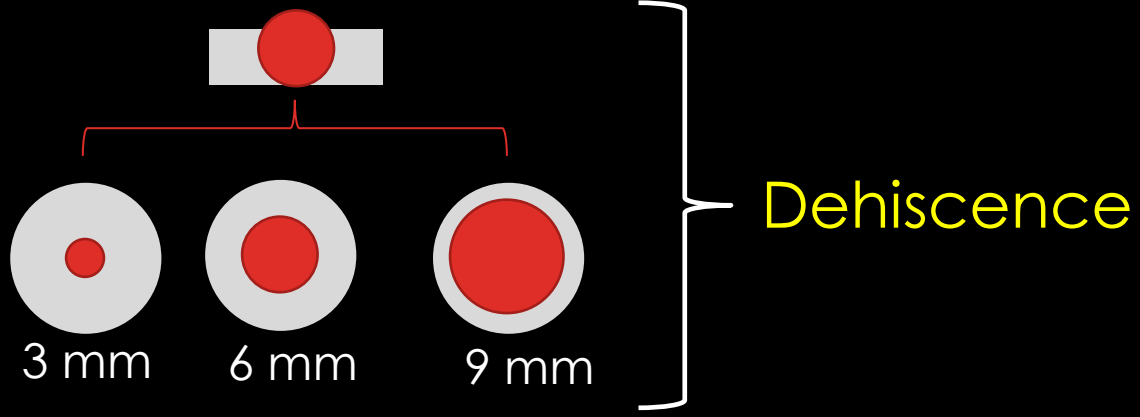
1. Sound pressures (Pa)
2. Vibration displacement (μm)

J Biomech 2019:84:197-203

Simulation on different degrees of sigmoid plate thinning or dehiscence







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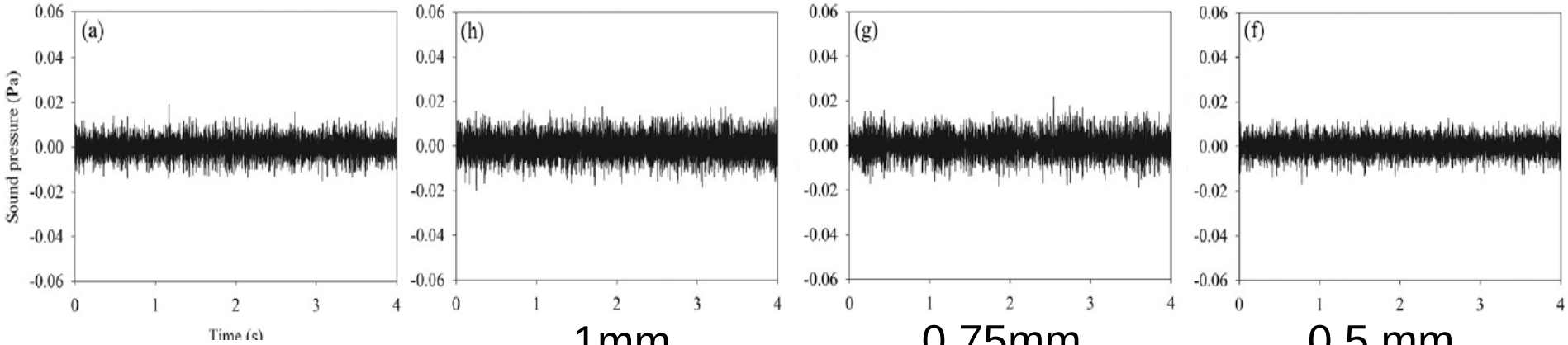
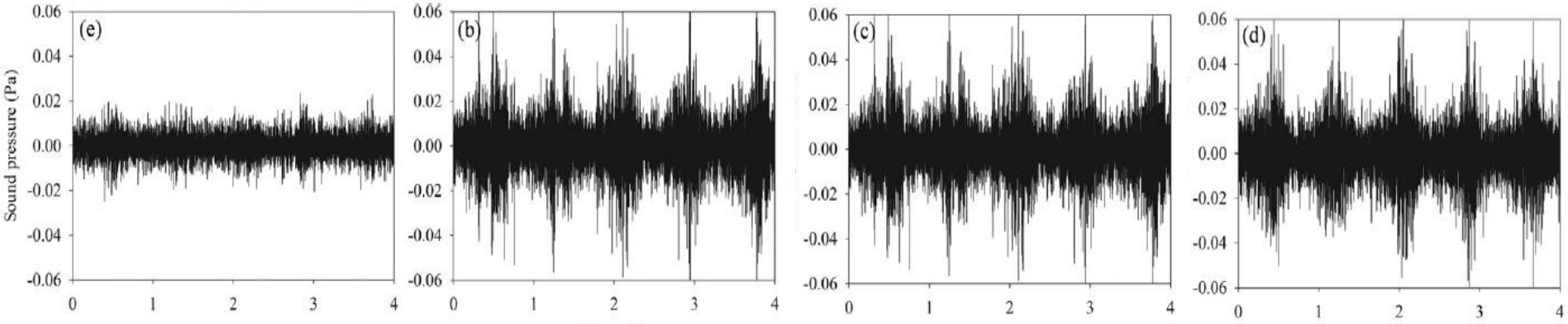
Sound pressures (Pa)



Control | 1mm intact | 0.75mm thickness | 0.5 mm thickness



0.25 mm thickness | 3 mm dehiscence | 6 mm dehiscence | 9 mm dehiscence

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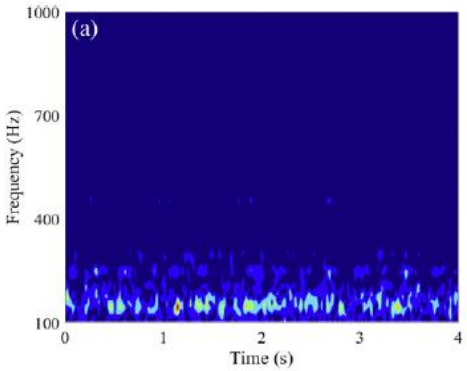
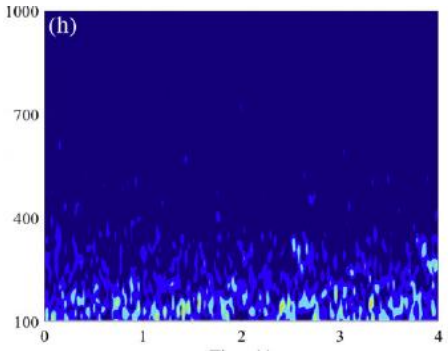
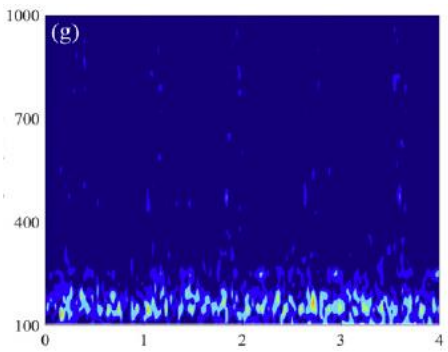
Spectral-temporal analysis of sound pressure (Pa)



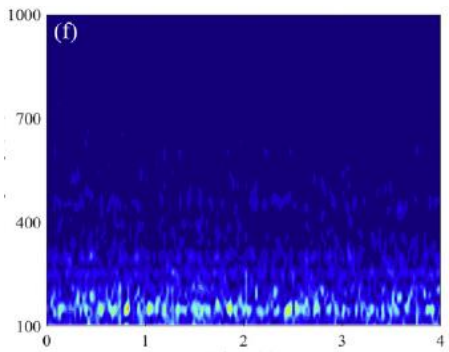
Control



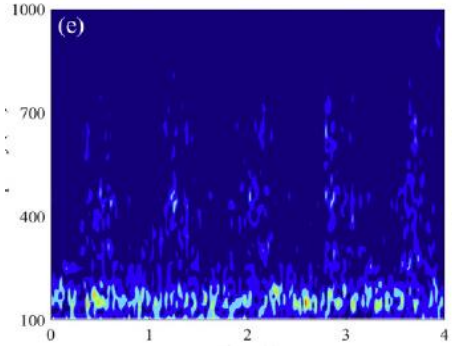
1mm intact



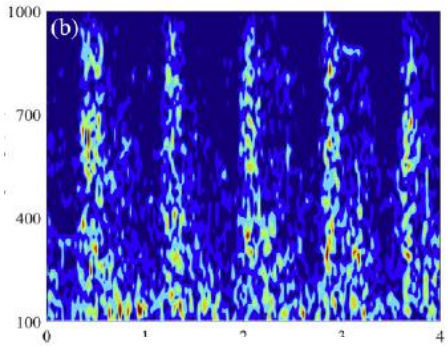
0.75mm thickness



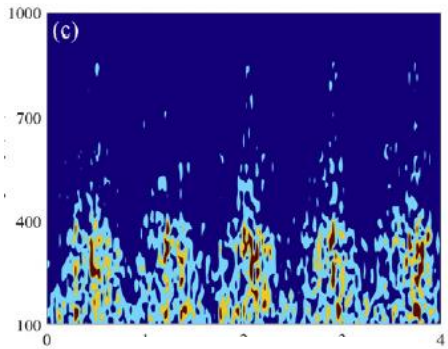
0.5 mm thickness



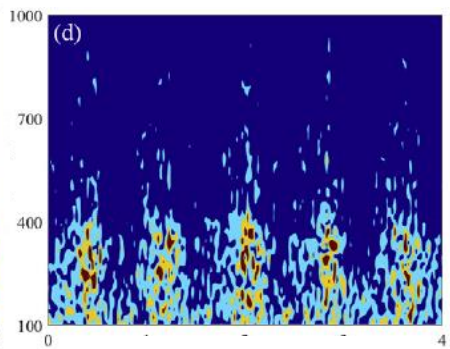
0.25 mm thickness



3 mm dehiscence



6 mm dehiscence



9 mm dehiscence

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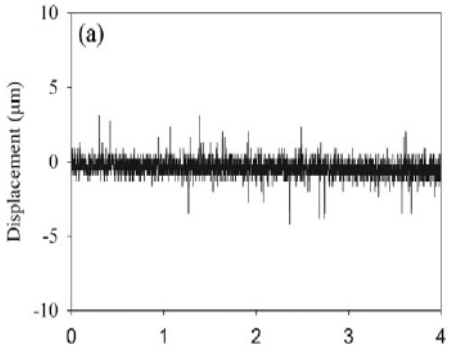
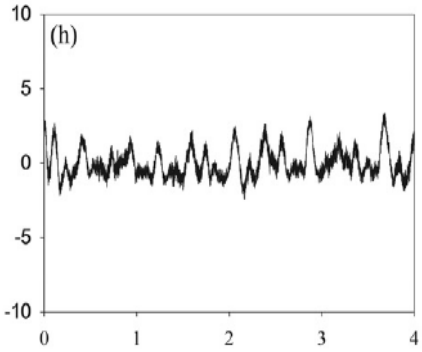
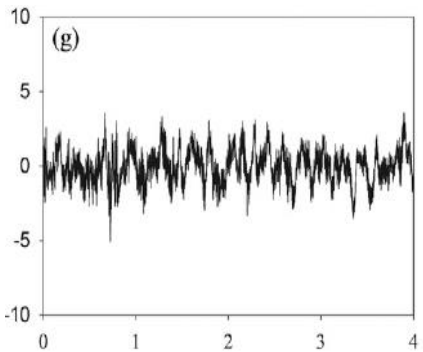
Vibration displacement (μm)



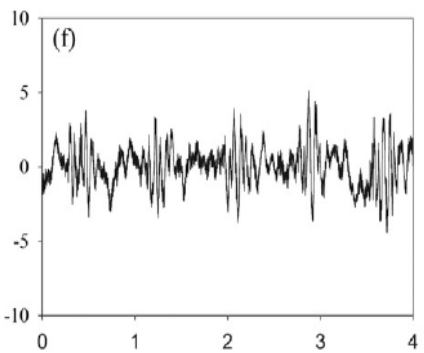
Control



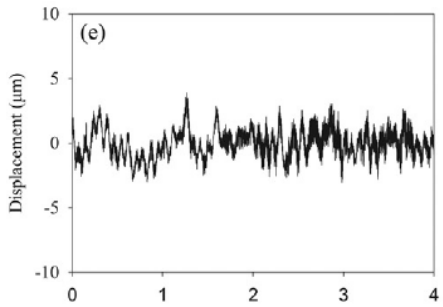
1mm intact



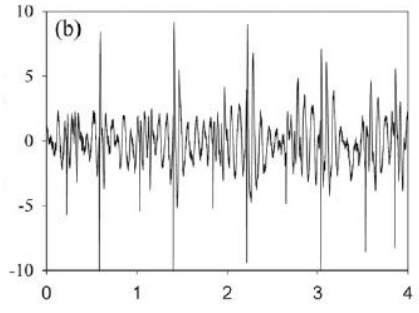
0.75mm thickness



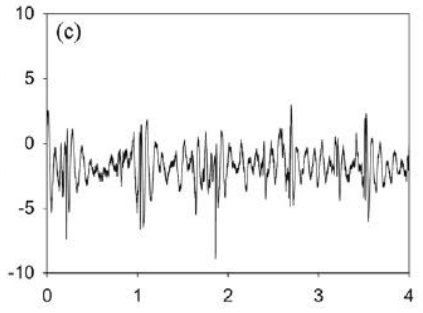
0.5 mm thickness



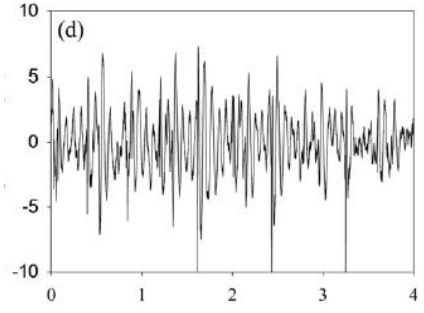
0.25 mm thickness



3 mm dehiscence



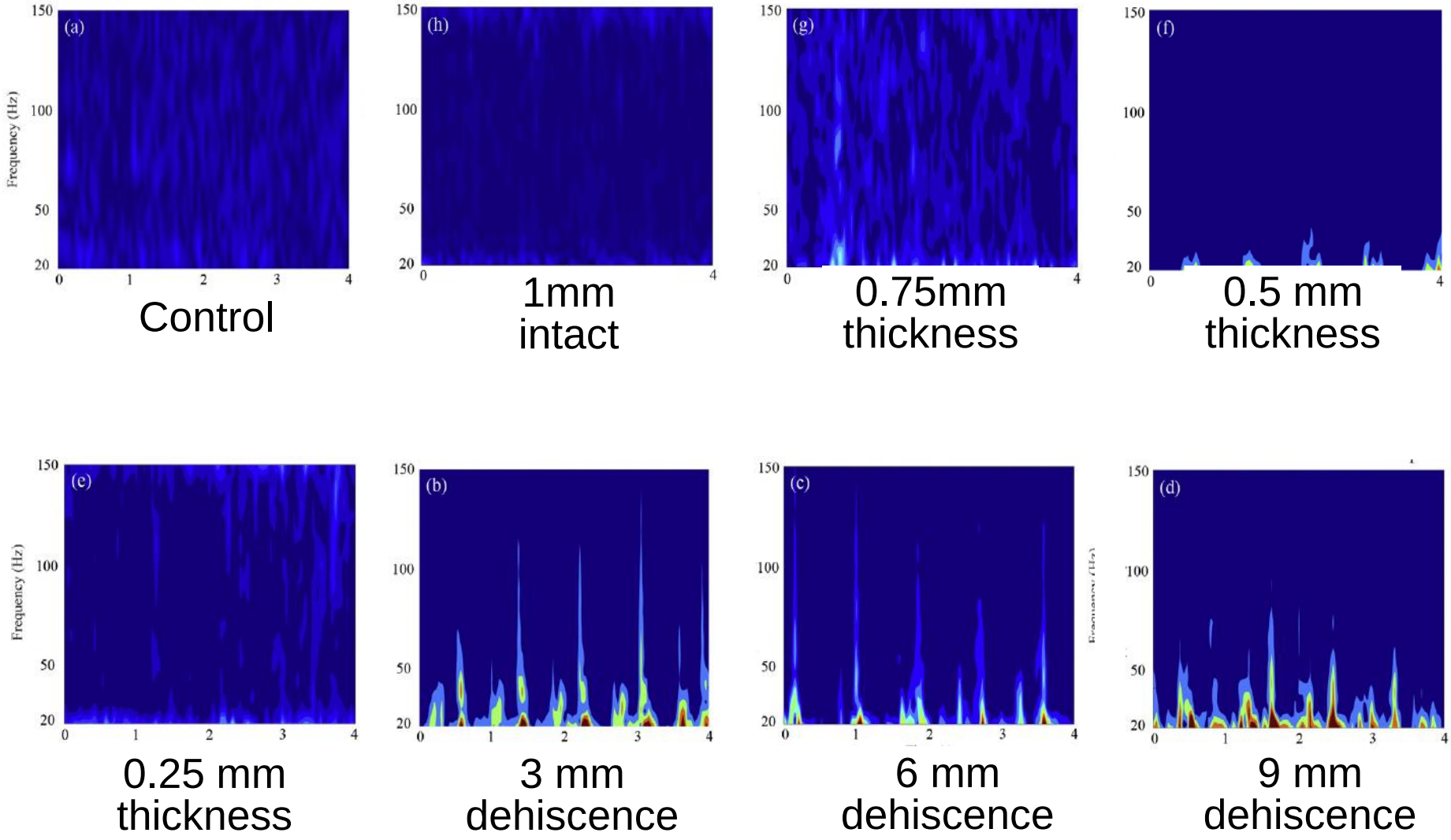
6 mm dehiscence



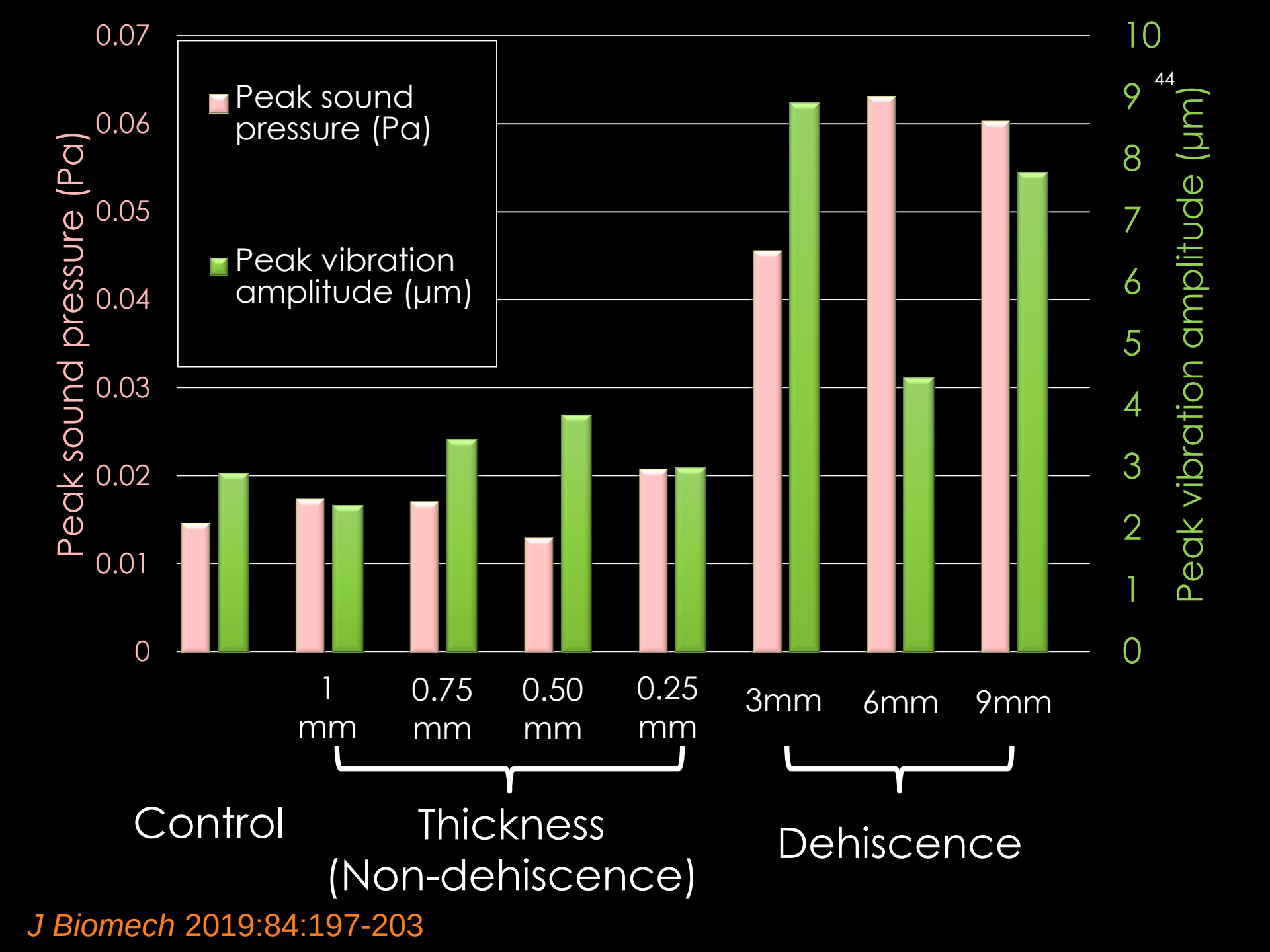
9 mm dehiscence

J Biomech 2019:84:197-203

Spectral-temporal analysis of vibration displacement (μm)



J Biomech 2019:84:197-203

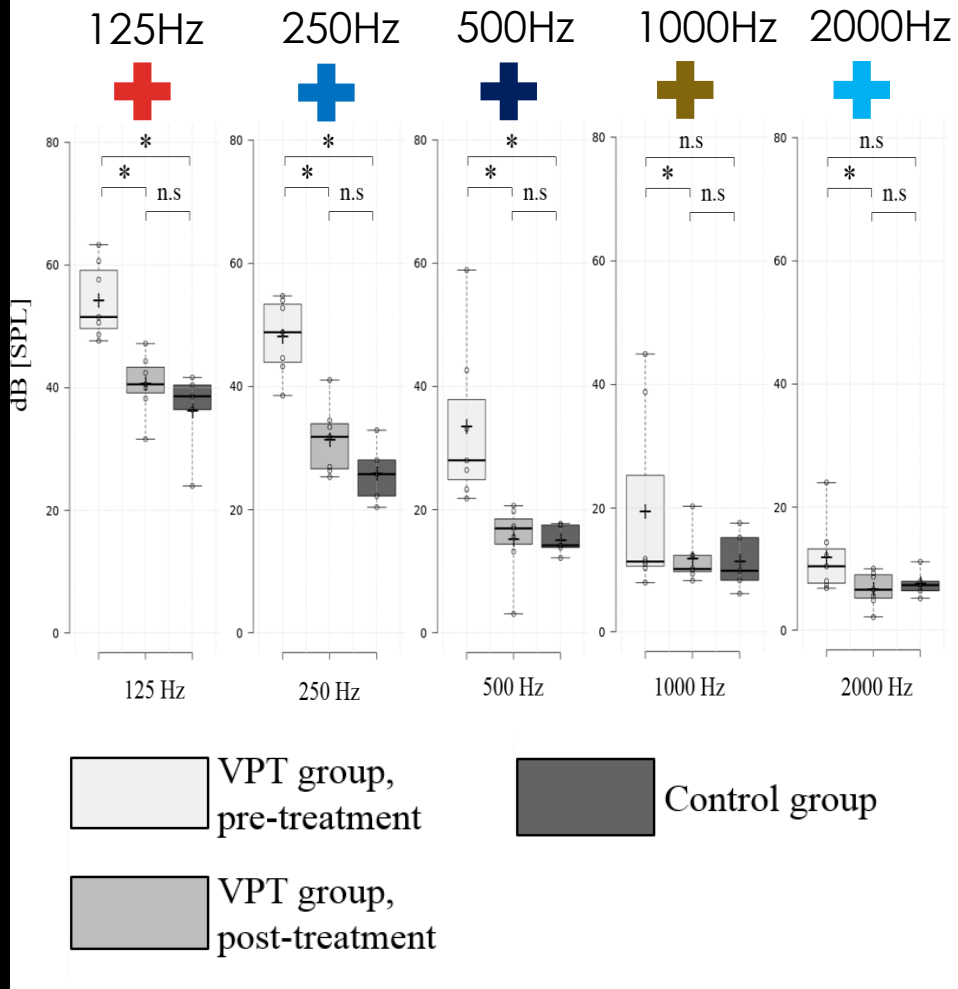


J Biomech 2019:84:197-203

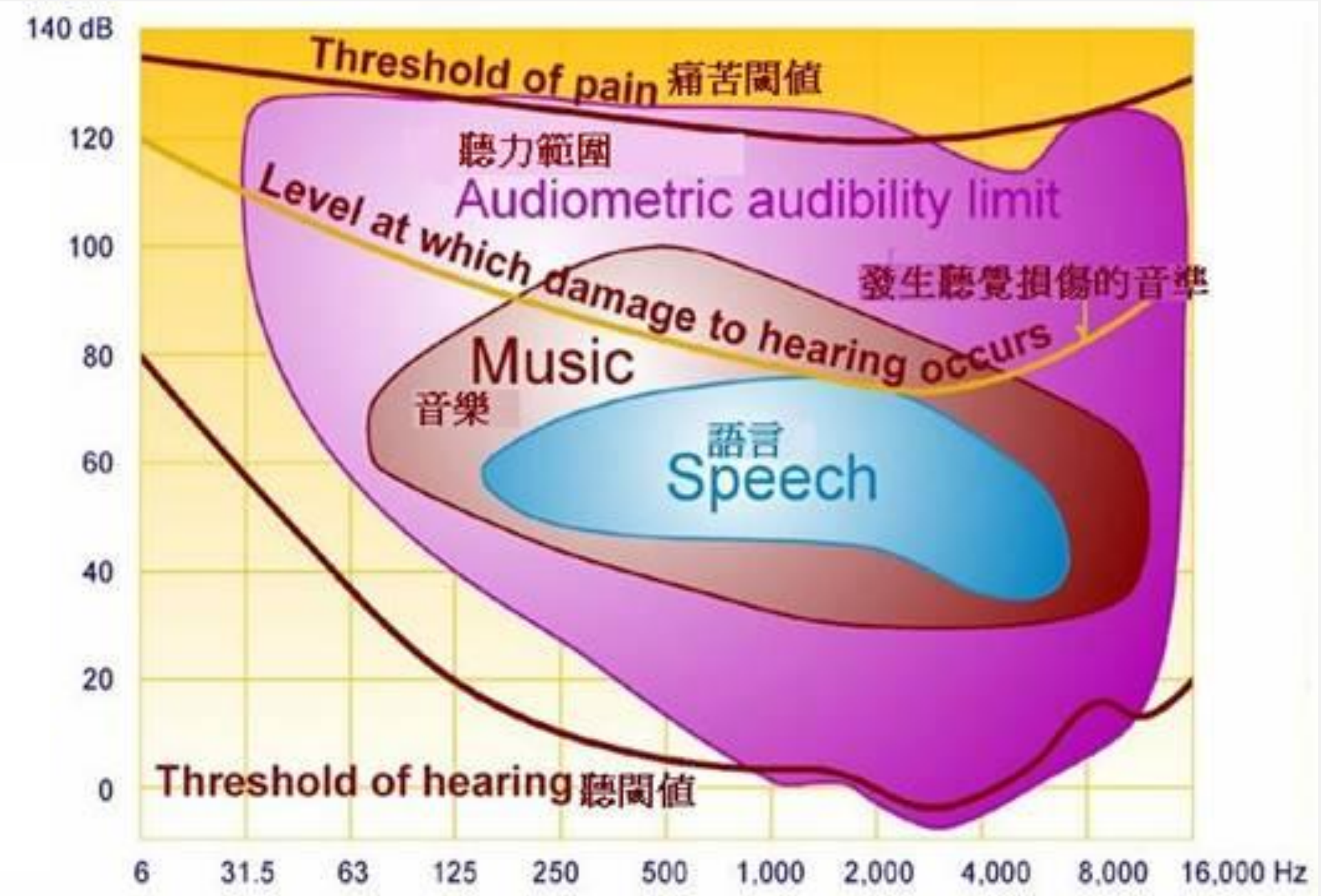
- Cortical plate dehiscence results in the decline of soundproof effect "Air on sinus sign"

- "Sigmoid resurfacing surgery" is effective in ~86% of symptomatic patients

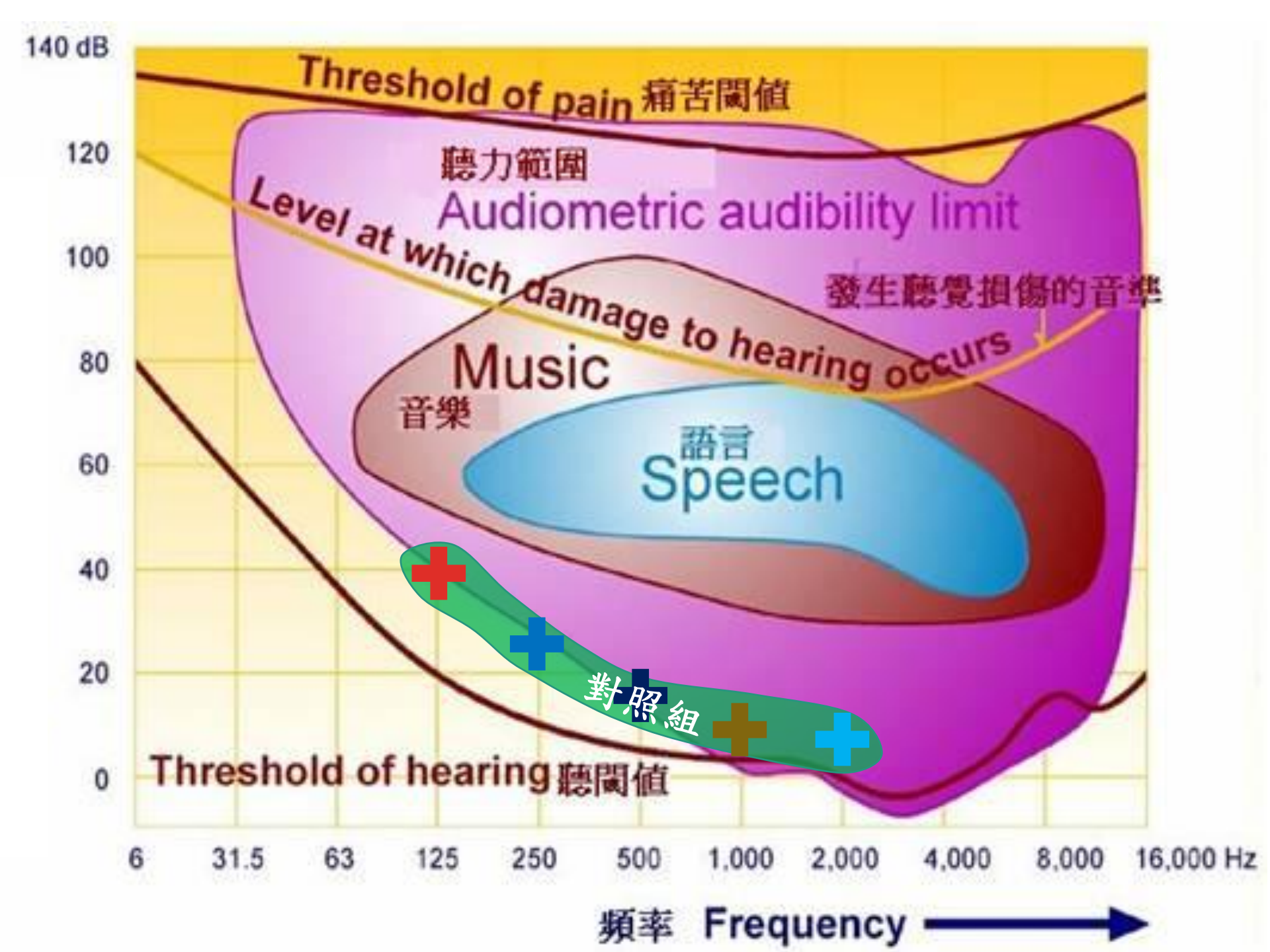
Trans-ear canal recording (with frequency analysis)



PLoS One 2016;11:e0157722


140 dB
120
100
80
60
40
20
0
Threshold of pain 痛苦閾值
聽力範圍
Audiometric audibility limit
Level at which damage to hearing occurs
發生聽覺損傷的音樂
Music
音樂
語言
Speech
Threshold of hearing 聽閾值
6
31.5
63
125
250
500
1,000
2,000
4,000
8,000
16,000 Hz
頻率 Frequency

聽域圖（聽覺反應區）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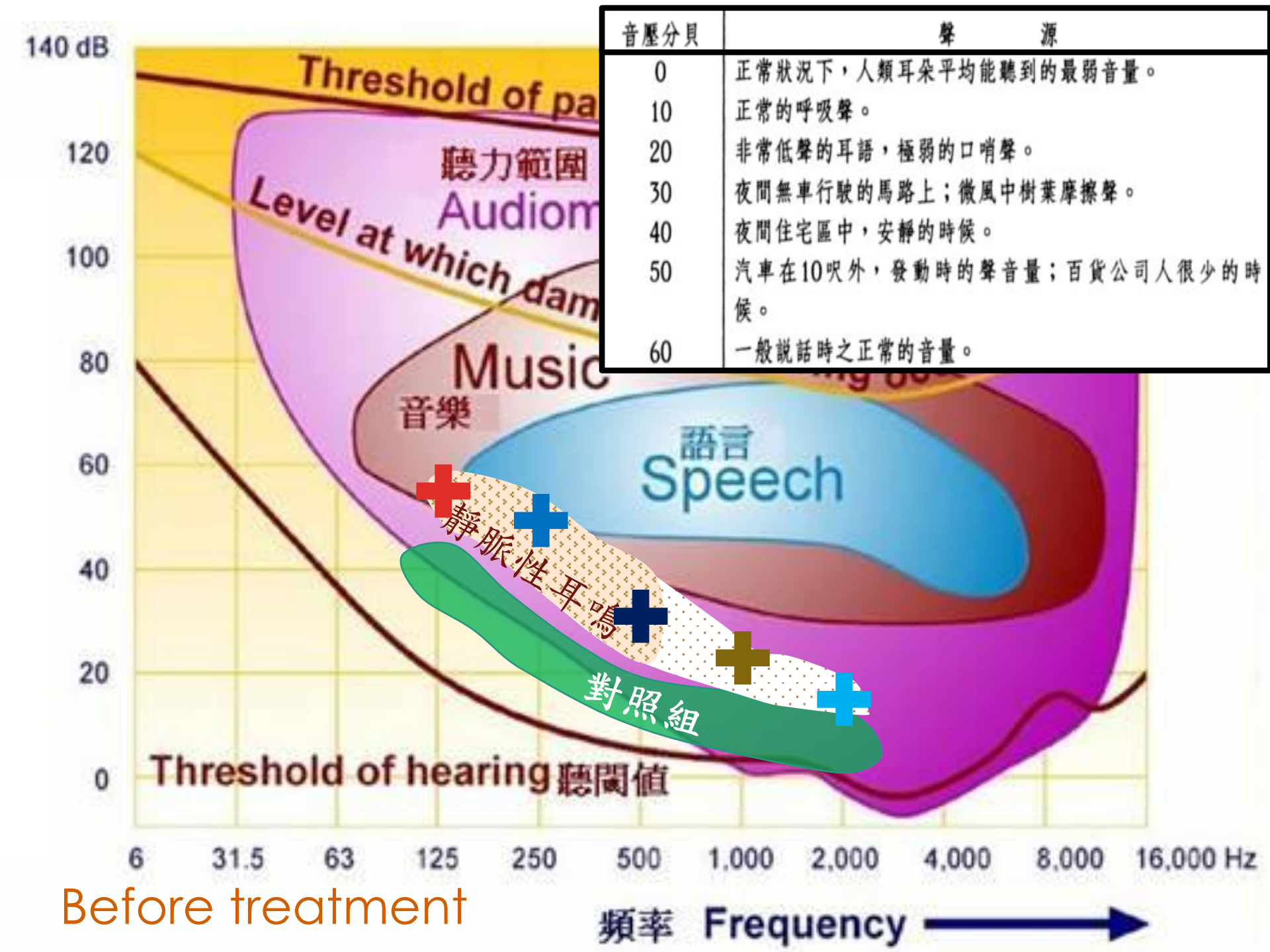
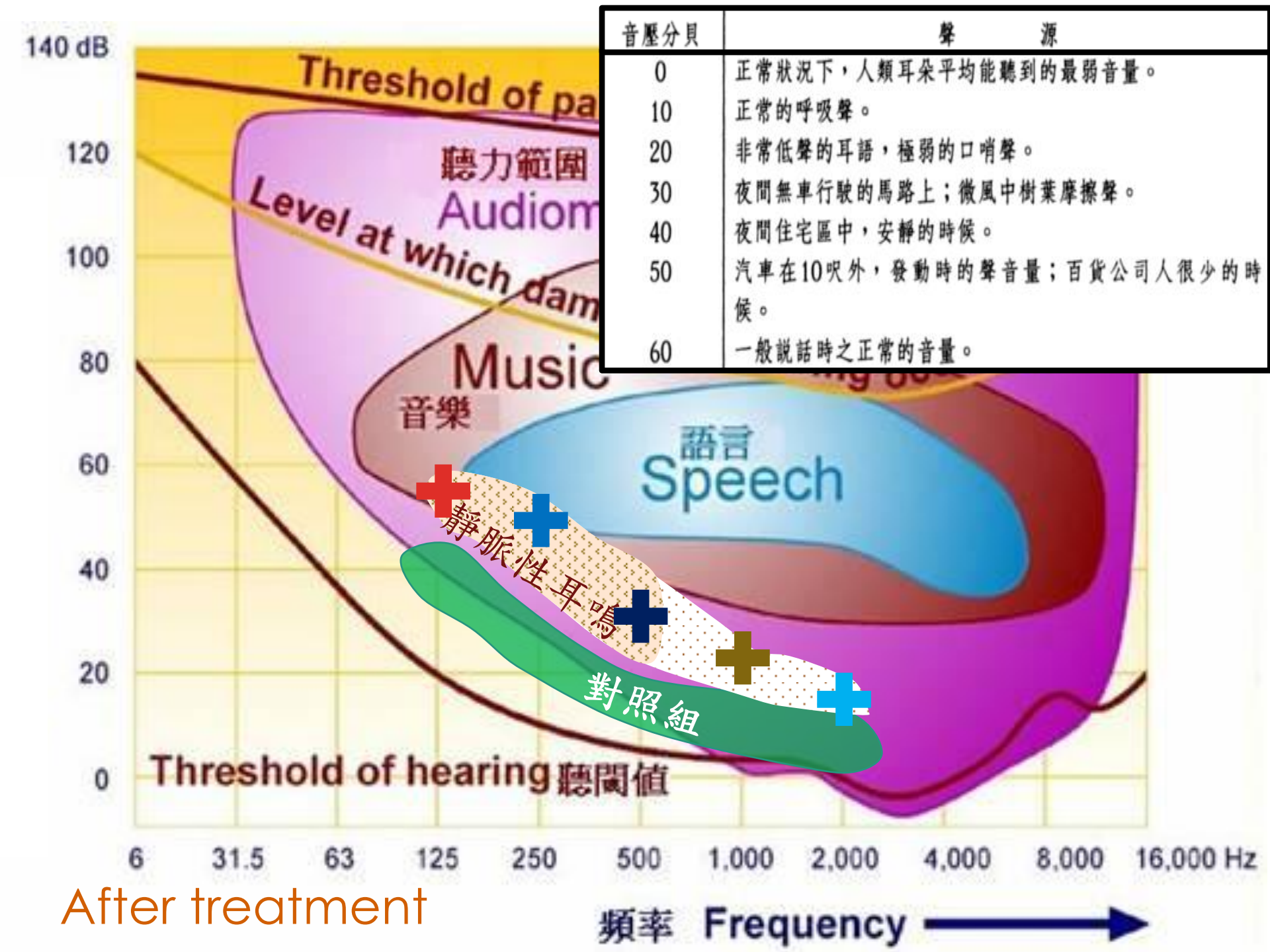


音壓分貝	聲　　源
0	正常狀況下，人類耳朵平均能聽到的最弱音量。
10	正常的呼吸聲。
20	非常低聲的耳語，極弱的口哨聲。
30	夜間無車行駛的馬路上；微風中樹葉摩擦聲。
40	夜間住宅區中，安靜的時候。
50	汽車在10呎外，發動時的聲音量；百貨公司人很少的時候。
60	一般說話時之正常的音量。

Before treatment



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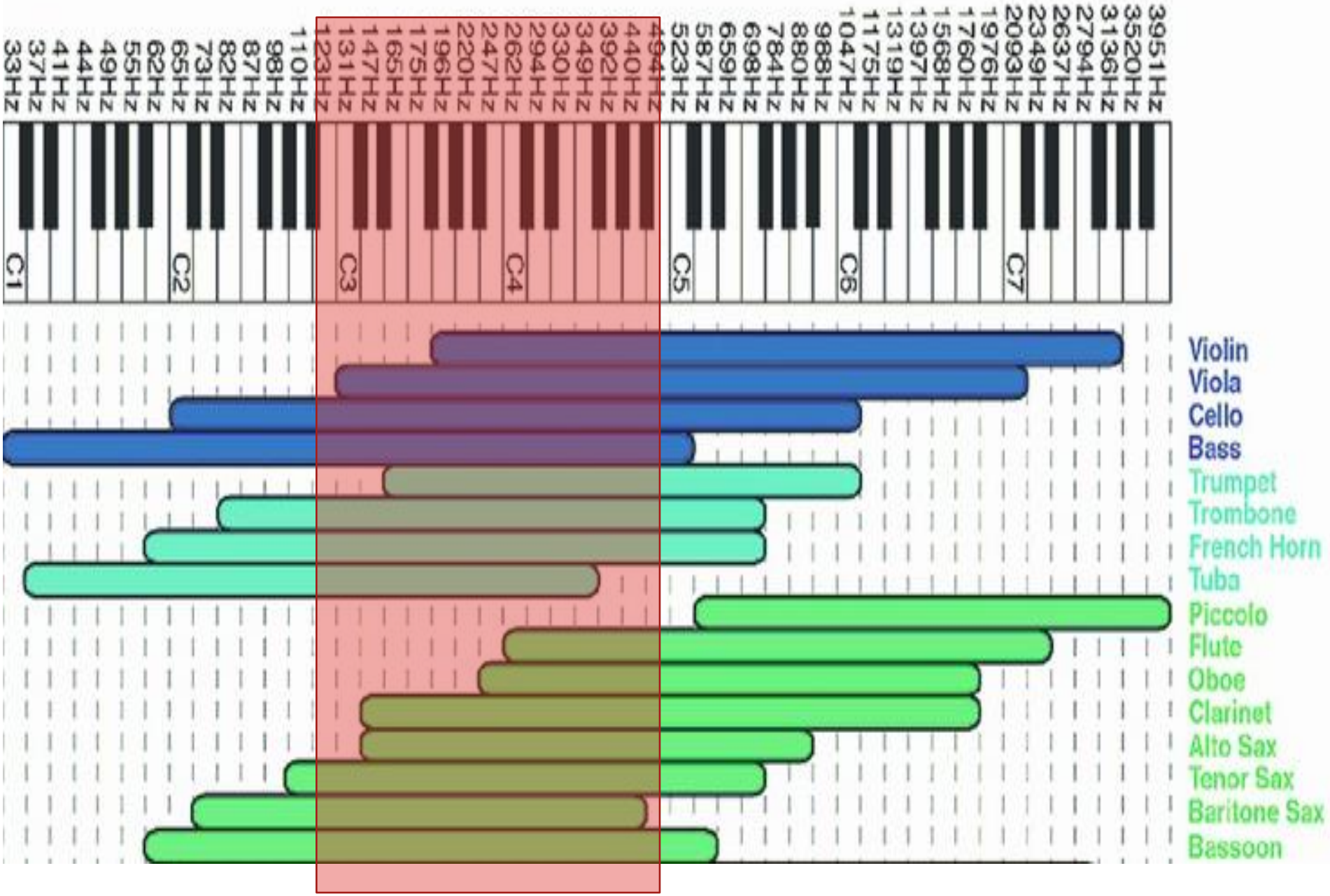
60	一般說話時之正常的音量。

After treatment

TAKE HOME MESSAGES

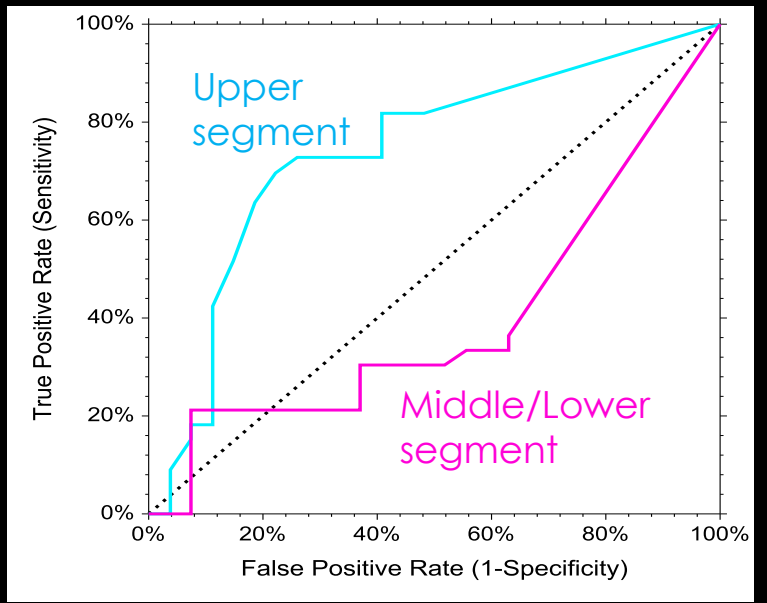
1. Don’t forget “venous pulsatile tinnitus”
   - Rhythmic tinnitus
   - Synchronous to heart beats
   - Alleviated by compressing the veins or tilting the neck

靜脈性耳鳴的主要頻寬:125-500Hz



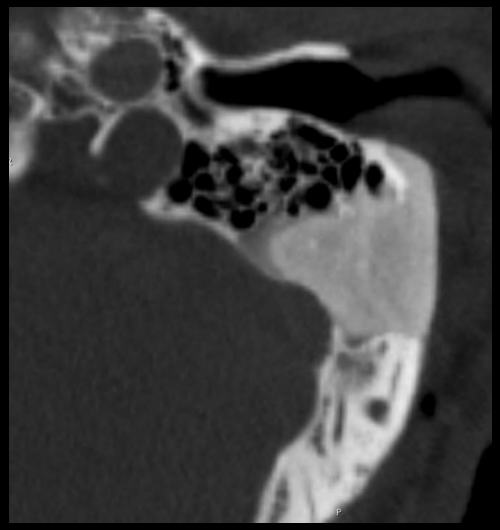
TAKE HOME MESSAGES

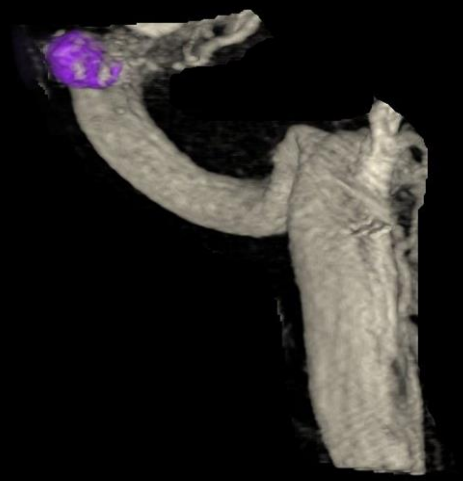
2. Strong indictor of symptomatic pulsatile tinnitus for patients with sigmoid plate dehiscence:
   - Upper sigmoid plate dehiscence
   - >5mm dehiscence length
   - Sigmoid diverticulum



TAKE HOME MESSAGES

3. Sigmoid plate dehiscence can be treated surgically (resurfacing procedure) or endovascularly (when associated with diverticulum). *Aware of treatment indication!*





TAKE HOME MESSAGES

3. Also look for other possible etiologies of pulsatile tinnitus before definite treatment.

Temporal bone CT is sufficient to diagnose sigmoid plate dehiscence, but CT angiography is more sufficient to diagnose vascular etiologies of pulsatile tinnitus

Thanks for your attention

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ichangsu@gmail.com