

**Table S1 Clinical and histological data for the meningioma tissues set used in the study**

| SAMPLE ID | WHO | HISTOLOGICAL SUBTYPE                                | AGE                | SEX | LOCATION  |
|-----------|-----|---|--------------------|-----|---|
| MN005     | I   | Fibrous   | 58/59 <sup>#</sup> | F   | Left post fossa (tentorial)                           |
| MN033     | I   | Transitional  | 65                 | F   | Anterior cranial fossa floor                          |
| MN036     | I   | Not reported  | 51/52 <sup>#</sup> | /   | Right cerebellopontine angle                          |
| MN038     | I   | Transitional  | 79                 | F   | Right parietal  |
| MN048     | I   | Fibrous   | 57                 | F   | Left parietal   |
| MN052     | I   | Psammomatous  | 70                 | F   | Right parasagittal                                    |
| MN054     | I   | Not reported  | 58                 | F   | Not reported  |
| MN055     | I   | Not reported  | 50                 | F   | Left frontal  |
| MN056     | I   | Not reported  | 61                 | F   | Right posterior fossa                                 |
| MN058     | I   | Angiomatous   | 65                 | F   | Right frontal   |
| MN073     | I   | Fibrous   | 70                 | F   | Left frontal -paracentral                             |
| MN074     | I   | Transitional  | 37                 | F   | Right parietal convexity                              |
| MN077     | I   | Transitional  | 66                 | F   | Large bilateral parasagittal                          |
| MN078     | I   | Transitional  | 70                 | M   | Left frontal  |
| MN080     | I   | Fibrous   | 64                 | F   | Cerebellopontine angle                                |
| MN082     | I   | Fibrous   | 57                 | F   | Tentorial   |
| MN085     | I   | Mixed - Psammomatous and fibrous                    | 56                 | F   | Left frontal  |
| MN087     | I   | Not reported  | 47                 | M   | Cerebellopontine angle                                |
| MN088     | I   | Transitional  | 56                 | F   | Sphenoid wing   |
| MN089     | I   | Transitional  | 53                 | M   | Left parasagittal                                     |
| MN091     | I   | Not reported  | 62                 | F   | Left sphenoid wing                                    |
| MN092     | I   | Microcystic   | 59                 | F   | Convexity   |
| MN098     | I   | Not reported  | 45                 | F   | Left cerebellopontine angle                           |
| MN102     | I   | Transitional  | 56                 | F   | Left frontal intracranial extra axial                 |
| MN106     | I   | Psammomatous  | 46                 | F   | Planum sphenoidale                                    |
| MN107     | I   | Transitional  | 77                 | M   | Sphenoid wing   |
| MN109     | I   | Transitional  | 48                 | F   | Left frontal convexity                                |
| MN110     | I   | Transitional  | 47                 | F   | Left sphenoid wing                                    |
| MN113     | I   | Secretory   | 52                 | F   | Right temporal  |
| MN114     | I   | Meningothelial                                      | 62                 | M   | Left parasagittal                                     |
| MN115     | I   | Mixed - meningothelial, microcystic and angiomatous | 69                 | M   | Falcine tumour  |
| MN117     | I   | Meningothelial                                      | 69                 | M   | Olfactory groove                                      |
| MN118     | I   | Meningothelial with foci of microcystic changes     | 39                 | F   | Right tubercular sellar                               |
| MN122     | I   | Transitional  | 79                 | M   | Olfactory groove                                      |
| MN125     | I   | Secretory   | 41                 | F   | Left sphenoid wing with interosseus component (orbit) |
| MN126     | I   | Transitional  | 41                 | F   | Planum sphenoidale                                    |
| MN130     | I   | Transitional  | 74                 | M   | Temporal  |
| MN132     | I   | Psammomatous  | 51                 | F   | Left frontal extra axial lesion                       |
| MN133     | I   | Meningothelial                                      | 87                 | M   | Right fronto parietal extra axial tumour              |
| MN137     | I   | Meningothelial                                      | 57                 | F   | Fronto-parietal lobe                                  |
| MN139     | I   | Transitional  | 68                 | F   | Right sphenoid wing extra axial                       |
| MN143     | I   | Fibrous   | 74                 | M   | Left medial temporal fossa                            |
| MN144     | I   | Transitional  | 66                 | F   | Left petrous ridge                                    |

|       |   |  |                    |   |  |
|-------|---|--|--------------------|---|--|
| MN147 | I | Meningothelial   | 62                 | F | Left paraclinoid   |
| MN149 | I | Meningothelial   | 63                 | F | Right frontal convexity +<br>parafalcine/parasagittal<br>component |
| MN154 | I | Meningothelial   | 52                 | F | Tentorial  |
| MN157 | I | Meningothelial   | 61                 | F | Frontal  |
| MN160 | I | Meningothelial   | 48                 | F | Anterior cranial fossa   |
| MN161 | I | Transitional   | 79                 | M | Left occipital   |
| MN162 | I | Meningothelial   | 56                 | F | Olfactory groove   |
| MN170 | I | Meningothelial   | 70                 | F | Frontal parafalcine  |
| MN176 | I | Not reported   | 43                 | F | Left frontal extra axial   |
| MN177 | I | Not reported   | 37                 | F | Left cerebellopontine angle  |
| MN180 | I | Transitional   | 45                 | F | Occipital lobe   |
| MN187 | I | Meningothelial   | 70                 | F | Left sphenoidal extra axial  |
| MN188 | I | Fibrous  | 33                 | F | Posterior fossa extra axial  |
| MN197 | I | Psammomatous   | 62                 | F | Left sphenoid wing   |
| MN201 | I | Meningothelial   | 61                 | M | Right fronto temporal  |
| MN204 | I | Not reported   | 76                 | F | Left frontal   |
| MN214 | I | Meningothelial   | 59                 | F | Planum sphenoidale   |
| MN215 | I | Fibrous  | 70                 | M | Right parasagittal   |
| MN222 | I | Meningothelial   | 41                 | F | Right petrous apex   |
| MN227 | I | Transitional   | 56                 | F | Left posterior fossa   |
| MN231 | I | Transitional   | 58                 | F | Left frontoparietal-convexity                                      |
| MN232 | I | Secretory  | 70                 | F | Right sphenoid wing  |
| MN233 | I | Transitional   | 38                 | F | Right sphenoid wing  |
| MN236 | I | Meningothelial   | 62                 | F | Olfactory groove   |
| MN242 | I | Fibrous  | 61                 | F | Olfactory groove   |
| MN243 | I | Transitional   | 73                 | F | Left frontal convexity   |
| MN244 | I | Not reported   | 63                 | F | Left frontal convexity   |
| MN246 | I | Meningothelial   | 37                 | F | Left petroclival   |
| MN247 | I | Metaplastic  | 50                 | F | Right sphenoid wing  |
| MN248 | I | Mixed - metaplastic, transitional &<br>microcystic (sphenoid wing) and<br>transitional (frontal) | 66                 | M | Left paraclinoid + frontal<br>convexity                            |
| MN251 | I | Fibrous  | 67                 | F | Tentorial (posterior fossa)  |
| MN253 | I | Meningothelial   | 66                 | M | Right frontal  |
| MN254 | I | Not reported   | 49                 | F | Left sphenoid wing   |
| MN255 | I | Meningothelial   | 36                 | F | Left sphenoid wing   |
| MN257 | I | Fibrous  | 34                 | F | Left occipital   |
| MN261 | I | Transitional   | 42                 | M | Right parasagittal   |
| MN264 | I | Mixed - Meningothelial and<br>angiomatous  | 46                 | F | Planum sphenoidale   |
| MN267 | I | Meningothelial   | 44                 | F | Olfactory groove   |
| MN268 | I | Meningothelial   | 67                 | F | Olfactory groove   |
| MN272 | I | Meningothelial   | 81                 | F | Right sphenoid wing  |
| MN274 | I | Fibrous  | 68                 | F | Left parietal convexity  |
| MN275 | I | Fibrous  | 52/62 <sup>#</sup> | F | Left tentorial (supratentorial)                                    |
| MN277 | I | Fibrous  | 54                 | F | Parieto-occipital parasagittal                                     |
| MN278 | I | Meningothelial   | 46                 | F | Right sphenoid wing  |

|       |    |   |                    |   |  |
|-------|----|---|--------------------|---|--|
| MN284 | I  | Transitional  | 35                 | F | Left frontal parasagittal/parafalcine                                  |
| MN286 | I  | Meningothelial  | 68                 | F | Left frontal   |
| MN289 | I  | Microcystic   | 61                 | F | Right frontal  |
| MN299 | I  | Meningothelial  | 56                 | F | Right sphenoid wing  |
| MN305 | I  | Meningothelial  | 69                 | F | Olfactory groove   |
| MN314 | I  | Meningothelial  | 76                 | F | Cavernous sinus  |
| MN315 | I  | Psammomatous  | 76                 | F | Left paraclinoid   |
| MN317 | I  | Fibrous   | 56                 | F | Right intraventricular   |
| MN318 | I  | Mixed meningothelial + microcystic                              | 66                 | F | Left sphenoid wing   |
| MN319 | I  | Mixed - fibrous + psammomatous + microcystic                    | 57                 | F | Right posterior fossa  |
| MN321 | I  | Transitional  | 45                 | F | Left occipital   |
| MN322 | I  | Meningothelial  | 78                 | F | Left sphenoid wing + cavernous sinus involvement                       |
| MN324 | I  | Angiomatous   | 69                 | F | Olfactory groove with suprasellar + sellar + cavernous sinus extension |
| MN325 | I  | Psammomatous  | 67                 | F | Right convexity  |
| MN326 | I  | Transitional  | 50                 | F | Left parasagittal  |
| MN327 | I  | Fibrous   | 57                 | F | Left cavernous sinus   |
| MN328 | I  | Angiomatous + microcystic                                       | 72                 | M | Left frontal convexity   |
| MN341 | I  | Fibrous   | 69                 | F | Right parietal convexity   |
| MN344 | I  | Transitional  | 66                 | M | Right parasagittal   |
| MN369 | I  | Fibrous   | 48                 | F | Right parietal   |
| MN395 | I  | Meningothelial  | 48/52 <sup>#</sup> | F | Right sphenoid wing  |
| J5    | I  | Fibroblastic  | 50                 | F | Occipital  |
| J6    | I  | Transitional  | 37                 | F | Parasagittal   |
| J7    | I  | Transitional  | 72                 | F | Parasagittal   |
| J8    | I  | Transitional  | 68                 | F | Parasagittal   |
| J14   | I  | Fibroblastic  | 80                 | F | Frontal  |
| J15   | I  | Meningothelial  | 75                 | F | Olfactory groove   |
| J18   | I  | Transitional  | 67                 | F | Parietal   |
| J19   | I  | Secretory   | 47                 | F | Petrous apex   |
| J1    | II | Atypical  | 62                 | F | Sphenoid wing  |
| J2    | II | Atypical  | 51                 | F | Parafalcine  |
| J3    | II | Atypical  | 64                 | M | Frontal  |
| J4    | II | Atypical  | 66                 | M | Occipital  |
| J13   | II | Atypical  | 59                 | M | Parietal   |
| J22   | II | Atypical  | 69                 | M | Occipital  |
| J23   | II | Atypical  | 62                 | F | Temporal   |
| J24   | II | Atypical  | 60                 | F | Frontal  |
| J25   | II | Atypical  | 65                 | F | Frontal  |
| MN001 | II | Atypical  | 50                 | M | Right frontal lobe   |
| MN018 | II | Atypical  | 71                 | F | Left posterior fossa   |
| MN020 | II | Atypical  | 39                 | F | Right parietal-convexity   |
| MN045 | II | Atypical with dural infiltration and possible skull involvement | 56                 | M | Right extra-axial fronto-parietal                                      |
| MN076 | II | Atypical  | 53                 | F | Olfactory groove   |
| MN101 | II | Atypical  | 51                 | F | Right frontal lobe   |

|              |     |  |                    |   |  |
|--------------|-----|--|--------------------|---|--|
| <b>MN104</b> | II  | Atypical   | 37                 | F | Right paracentral lobular<br>parafalcine   |
| <b>MN148</b> | II  | Atypical   | 79                 | M | Right frontal lobe                         |
| <b>MN182</b> | II  | Atypical   | 66                 | F | Right fronto-parietal                      |
| <b>MN183</b> | II  | Chordoid   | 75                 | F | Clival region                              |
| <b>MN189</b> | II  | Atypical   | 55                 | M | Left intraventricular                      |
| <b>MN196</b> | II  | Atypical   | 39                 | M | Left parafalcine                           |
| <b>MN219</b> | II  | Atypical   | 55                 | M | Left frontal parafalcine                   |
| <b>MN225</b> | II  | Atypical   | 57                 | M | Right frontal parafalcine                  |
| <b>MN234</b> | II  | Atypical   | 79                 | F | Right temporal + petrous-<br>temporal bone |
| <b>MN235</b> | II  | Atypical   | 71                 | F | Right frontal parafalcine                  |
| <b>MN252</b> | II  | Atypical   | 73                 | F | Right parasagittal                         |
| <b>MN263</b> | II  | Atypical   | 78/80 <sup>#</sup> | M | Left frontal convexity                     |
| <b>MN279</b> | II  | Atypical   | 72                 | F | Occipital                                  |
| <b>MN294</b> | II  | Atypical   | 59                 | F | Right parietal                             |
| <b>MN332</b> | II  | Atypical   | 68                 | M | Left frontal parafalcine                   |
| <b>MN352</b> | II  | Atypical   | 63                 | M | Frontal                                    |
| <b>MN359</b> | II  | Atypical   | 72                 | F | Parasagittal                               |
| <b>J9</b>    | III | Anaplastic   | 82                 | F | Not reported                               |
| <b>J10</b>   | III | Anaplastic   | 85                 | M | Not reported                               |
| <b>J11</b>   | III | Anaplastic   | 85                 | M | Not reported                               |
| <b>J12</b>   | III | Anaplastic   | 87                 | M | Not reported                               |
| <b>J17</b>   | III | Anaplastic   | 76                 | M | Frontal                                    |
| <b>J28</b>   | III | Anaplastic   | 48                 | M | Left frontal                               |
| <b>J29</b>   | III | Anaplastic   | 68                 | F | Frontal                                    |
| <b>J30</b>   | III | Anaplastic   | 64                 | F | Left posterior fossa                       |
| <b>J31</b>   | III | Anaplastic   | 76                 | F | Left frontal                               |
| <b>J32</b>   | III | Anaplastic   | 70                 | F | Left posterior fossa                       |
| <b>MN241</b> | III | Mixed - rhabdoid, angiomatous, and<br>microcystic features | 34                 | M | Right parietal                             |
| <b>MN256</b> | III | Anaplastic   | 62                 | M | Not reported                               |

<sup>#</sup> Age at presentation and at time of surgery, respectively.

**Table S2 Clinical and histological data for the meningioma serum exosomes discovery set**

| SAMPLE ID | WHO | HISTOLOGICAL SUBTYPE                                    | AGE                | SEX | LOCATION   |
|-----------|-----|---|--------------------|-----|--|
| MN087     | I   | Not reported  | 47                 | M   | Cerebellopontine angle   |
| MN107     | I   | Transitional  | 77                 | M   | Sphenoid wing  |
| MN125     | I   | Secretory   | 41                 | F   | Left sphenoid wing with interosseus component (orbit)                  |
| MN144     | I   | Transitional  | 66                 | F   | Left petrous ridge   |
| MN162     | I   | Meningothelial  | 56                 | F   | Olfactory groove   |
| MN180     | I   | Transitional  | 45                 | F   | Occipital lobe   |
| MN187     | I   | Meningothelial  | 70                 | F   | Left sphenoidal extra axial  |
| MN192     | I   | Not reported  | /                  | /   | Not reported   |
| MN201     | I   | Meningothelial  | 61                 | M   | Right fronto temporal  |
| MN204     | I   | Not reported  | 76                 | F   | Left frontal   |
| MN215     | I   | Fibrous   | 70                 | M   | Right parasagittal   |
| MN222     | I   | Meningothelial  | 41                 | F   | Right petrous apex   |
| MN227     | I   | Transitional  | 56                 | F   | Left posterior fossa   |
| MN242     | I   | Fibrous   | 61                 | F   | Olfactory groove   |
| MN257     | I   | Fibrous   | 34                 | F   | Left occipital   |
| MN264     | I   | Mixed - Meningothelial and angiomatous                  | 46                 | F   | Planum sphenoidale   |
| MN277     | I   | Fibrous   | 54                 | F   | Parieto-occipital parasagittal   |
| MN315     | I   | Psammomatous  | 76                 | F   | Left paraclinoid   |
| MN322     | I   | Meningothelial  | 78                 | F   | Left sphenoid wing + cavernous sinus involvement                       |
| MN324     | I   | Angiomatous   | 69                 | F   | Olfactory groove with suprasellar + sellar + cavernous sinus extension |
| MN341     | I   | Fibrous   | 69                 | F   | Right parietal convexity   |
| MN344     | I   | Transitional  | 66                 | M   | Right parasagittal   |
| MN346     | I   | Fibrous   | 55                 | M   | Not reported   |
| MN148     | II  | Atypical  | 79                 | M   | Right frontal lobe   |
| MN183     | II  | Chordoid  | 75                 | F   | Clival region  |
| MN263     | II  | Atypical  | 78/80 <sup>#</sup> | M   | Left frontal convexity   |
| MN332     | II  | Atypical  | 68                 | M   | Left frontal parafalcine   |
| MN352     | II  | Atypical  | 63                 | M   | Frontal  |
| J28       | III | Anaplastic  | 48                 | M   | Left frontal   |
| J30       | III | Anaplastic  | 64                 | F   | Left posterior fossa   |
| J31       | III | Anaplastic  | 76                 | F   | Left frontal   |
| J32       | III | Anaplastic  | 70                 | F   | Left posterior fossa   |
| MN241     | III | Mixed - rhabdoid, angiomatous, and microcystic features | 34                 | M   | Right parietal   |

<sup>#</sup> Age at presentation and at time of surgery, respectively.

**Table S3 Clinical and histological data for the meningioma serum exosomes validation set**

| SAMPLE ID | WHO | HISTOLOGICAL SUBTYPE            | AGE                | SEX | LOCATION                |
|-----------|-----|---------------------------------|--------------------|-----|-------------------------|
| MN197     | I   | Psammomatous                    | 62                 | F   | Left sphenoid wing      |
| MN314     | I   | Meningothelial                  | 76                 | F   | Cavernous sinus         |
| MN317     | I   | Fibrous                         | 56                 | F   | Right intraventricular  |
| MN321     | I   | Transitional                    | 45                 | /   | Left occipital          |
| MN325     | I   | Psammomatous                    | 67                 | F   | Right convexity         |
| MN327     | I   | Fibrous                         | 57                 | F   | Left cavernous sinus    |
| MN369     | I   | Fibrous                         | 48                 | F   | Right parietal          |
| MN395     | I   | Meningothelial                  | 48/52 <sup>#</sup> | F   | Right sphenoid wing     |
| 17-001    | II  | Metaplastic with brain invasion | 49                 | F   | Left                    |
| 17-057    | II  | Atypical                        | 73                 | F   | Left frontal            |
| 17-078    | II  | Atypical                        | 49                 | M   | Right lateral ventricle |
| 17-248    | II  | Atypical                        | 70                 | M   | Right frontal convexity |
| 17-304    | II  | Atypical                        | 77                 | F   | Left frontal            |
| 17-320    | II  | Atypical                        | 33                 | F   | Right posterior fossa   |
| 17-337    | II  | Atypical                        | 74                 | F   | Right frontal           |
| N09.501   | II  | Chordoid                        | 57                 | F   | Right frontal           |
| N09.568   | II  | Atypical                        | 92                 | F   | Right frontal           |
| N09.582   | II  | Atypical                        | 78                 | F   | Right frontal           |
| N09.817   | II  | Atypical                        | 74                 | M   | Left frontal            |
| N10.49    | II  | Atypical                        | 62                 | F   | Left posterior fossa    |
| N10.52    | II  | Psammomatous                    | 64                 | F   | Left frontal            |
| N10.552   | II  | Atypical                        | 46                 | M   | Right temporal          |
| N10.784   | II  | Benign with invasion of bone    | 67                 | M   | Right frontal           |
| N11.706   | II  | Atypical                        | 43                 | F   | Right temporal          |
| N14.465   | II  | Atypical                        | 60                 | F   | Right frontal           |
| N15.346   | II  | Atypical                        | 70                 | F   | Right temporal          |
| N15.696   | II  | Atypical                        | 69                 | F   | Right occipital         |
| N19.566   | II  | Atypical                        | 54                 | F   | Left temporal           |

<sup>#</sup> Age at presentation and at time of surgery, respectively.

**Table S4 GATA-4 IHC single score analysis.** Samples highlighted in bold are represented in figure 2c.

| <b>WHO I</b>  | <b>GATA-4</b> | <b>WHO II</b> | <b>GATA-4</b> | <b>WHO III</b> | <b>GATA-4</b> | <b>Meninges</b> | <b>GATA-4</b> |
|---------------|---------------|---------------|---------------|----------------|---------------|-----------------|---------------|
| J5            | 2             | J1            | 1             | J9             | 2             | NM1             | 1             |
| J6            | 2             | J2            | 1             | <b>J10</b>     | <b>3</b>      | NM8             | 1             |
| <b>J14</b>    | <b>1</b>      | J3            | 2             | <b>J11</b>     | <b>3</b>      | <b>NM9</b>      | <b>0</b>      |
| <b>J15</b>    | <b>1</b>      | J4            | 1             | J12            | 3             | NM11            | 1             |
| MN005         | 2             | <b>MN020</b>  | <b>3</b>      | NRG3M1         | 3             | NM14            | 1             |
| NRG1M8        | 2             | <b>J13</b>    | <b>3</b>      | NRG3M6         | 3             | NM3             | 0             |
| G1M34         | 2             | MN018         | 3             | NRG3M7         | 2             | NM23            | 1             |
| <b>NRG1M7</b> | <b>1</b>      | <b>MN001</b>  | <b>2</b>      | NRG3M11        | 3             | NM6             | 1             |
| G1M42         | 2             | NRG2M7        | 2             | NRG3M15        | 3             | NM5             | 0             |
| G1M45         | 2             | NRG2M14       | 1             | <b>NRG3M16</b> | <b>3</b>      | NM16            | 1             |