For a full sib pair, the IBD sharing at a locus is calculated:
$\pi = 0.5\pi^p + 0.5\pi^m$, and $E(\pi^p) = E(\pi^m) = 0.5$, $Var(\pi) = 1/4Var(\pi^p) + 1/4Var(\pi^m)$, and $Cov(\pi^p, \pi^m) = 0$ because the transmission of the paternal haploids is independent from the maternal ones.

For a chromosome, with k genotyped markers, $E(\pi) = E(0.5\frac{\sum \pi_i^p}{k} + 0.5\frac{\sum \pi_i^m}{k}) = 0.5$, and

$Var(\frac{\sum \pi_i^p}{k} + \frac{\sum \pi_i^m}{k}) = \frac{1}{4k^2}\{[\sum_i \sum_j Cov(\pi_i^p, \pi_j^p)] + [\sum_i \sum_j Cov(\pi_i^m, \pi_j^m)]\}$ **(1)**

Note: all $2\sum\sum Cov(\pi_i^p, \pi_j^m) = 0$ and thus eliminated; 2) As when $i = j$, $Cov(\pi_i^o, \pi_i^o) = Var(\pi_i^o)$, the equation above included the variance terms. It should be noticed that, in W.G.Hill's papar(J Hered 84:212-213), the statement that "contains many more covariance than variance terms, so terms in $Var(Z_{i(n)})$ can be ignored" is incorrect because the variance terms are included in the expression.

Now, we consider the IBD transmitted from paternal origins. We know, $Cov(\pi_i^p, \pi_j^p) = E(\pi_i^p \pi_j^p) - E(\pi_i^p)E(\pi_j^p)$,

the term $E(\pi_i^p, \pi_j^p)$ can be calculated below $P(\pi_i^p = \delta_i, \pi_j^p = \delta_j) = P(\pi_i^p = \delta_i)P(\pi_i^p | \pi_j^p = \delta_j)$, where $\delta = 1$ if the alleles are IBD or 0 otherwise.

		Locus j	
		$\pi_j^p = 1$	$\pi_j^p = 0$
Locus i	$\pi_i^p = 1$	$\frac{r_p^2 + (1-r_p)^2}{2}$ State $(\pi_i^p = 1, \pi_j^p = 1)$	$r_p(1-r_p)$ State $(\pi_i^p = 1, \pi_j^p = 0)$
	$\pi_i^p = 0$	$r_p(1-r_p)$ State $(\pi_i^p = 0, \pi_j^p = 1)$	$\frac{r_p^2 + (1-r_p)^2}{2}$ State $(\pi_i^p = 0, \pi_j^p = 0)$

$$\begin{aligned} Cov(\pi_i^p, \pi_j^p) &= 1 \cdot 1 \cdot p(\pi_i^p = 1, \pi_j^p = 1) + 1 \cdot 0 \cdot p(\pi_i^p = 1, \pi_j^p = 0) \\ &\quad +0 \cdot 1 \cdot p(\pi_i^p = 0, \pi_j^p = 1) + 0 \cdot 0 \cdot p(\pi_i^p = 0, \pi_j^p = 0) \\ &\quad -1/4 \\ &= \frac{r_p^2 + (1-r_p)^2}{2} - 1/4 \\ &= \frac{(1-2r_p)^2}{4} \end{aligned} \quad \textbf{(2)}$$

Assuming the Haldane mapping function $r_p = 0.5[1 - \exp(-2d)]$, then $Cov(\pi_i^p, \pi_j^p) = \frac{\exp(-4d)}{4}$, where d is the genetic distance measured in Morgan.

For the maternal haploids, if the recombination fractions are different from that of paternal, the similar table should be made for maternally raised IBD. $P(\pi_i^m=\delta,\pi_j^m=\delta)=P(\pi_i^m=\delta)P(\pi_i^m|\pi_j^m=\delta)$, and it is

		Locus j	
		$\pi_j^m=1$	$\pi_j^m=0$
Locus i	$\pi_i^m=1$	$\frac{r_m^2+(1-r_m)^2}{2}$ State $(\pi_i^m=1,\pi_j^m=1)$	$r_m(1-r_m)$ State $(\pi_i^m=1,\pi_j^m=0)$
	$\pi_i^m=0$	$r_m(1-r_m)$ State $(\pi_i^m=0,\pi_j^m=1)$	$\frac{r_m^2+(1-r_m)^2}{2}$ State $(\pi_i^m=0,\pi_j^m=0)$

Assume the difference between maternal and paternal recombination fractions is ϵ,

$Cov(\pi_i^m,\pi_j^m)=(1-2r_m)^2=\exp(-4d)+\epsilon$ **(3)**

Now

$$\begin{aligned}
Var(\frac{\sum\pi_i^p}{k}+\frac{\sum\pi_i^m}{k}) &= \frac{1}{4k^2}\{[\sum_i\sum_j Cov(\pi_i^p,\pi_j^p)]+[\sum_i\sum_j Cov(\pi_i^m,\pi_j^m)]\} \\
&= \frac{1}{4k^2}\{\sum_i\sum_j\frac{\exp(-4|x_i-x_j|)}{4}+\sum_i\sum_j[\frac{\exp(-4|x_i-x_j|)}{4}+\epsilon_{ij}]\} \\
&= \frac{1}{4k^2}\{\sum_i\sum_j\frac{\exp(-4|x_i-x_j|)}{4}+\sum_i\sum_j\frac{\exp(-4|x_i-x_j|)}{4}\}+\frac{1}{4k^2}\sum_i\sum_j\epsilon_{ij}
\end{aligned}$$

When k is very large, it can be expressed as an integral, and the analytical solution is:

$$\begin{aligned}
Var(\frac{\sum\pi_i^p}{k}+\frac{\sum\pi_i^m}{k}) &= \frac{1}{4l^2}\int_0^l\int_0^l\exp(-4|x_i-x_j|)dx_idx_j+\frac{1}{4n^2}\int_0^l\int_0^l\epsilon_{ij}dx_idx_j \\
&= \frac{1}{16l^2}[l-0.5r_p(2l)]+\Omega
\end{aligned}$$

Where Ω is the sum of the terms associated with ϵ.
The existence of Ω makes difference to what is in Peter Visscher's paper (PLoS Genet 2:e41) in which table 3 gives the theoretical sd when assuming the recombination fractions are same between the males and the females.

Dominance

For dominance code, it requires a full sib pair sharing the both paternal and maternal alleles are IBD for a given locus.
Let Δ_i=1 if both $\pi_i^p=1$ and $\pi_i^m=1$ are IBD, or 0 otherwise.
$p(\pi^p=1,\pi^m=1)=1/4$, $p(\pi^p=1,\pi^m=0)=p(\pi^p=0,\pi^m=1)=p(\pi^p=0,\pi^m=0)=1/4$
$E(\Delta_i)=1/4$, and $Var(\Delta_i)=3/16$

$Var(\frac{\sum\Delta_i}{k})=\frac{1}{k^2}\sum_i\sum_j Cov(\Delta_i,\Delta_j)$

Now, let's look at the covariance term $Cov(\Delta_i,\Delta_j)=E(\Delta_i\Delta_j)-E(\Delta_i)E(\Delta_j)$, in order to get the form of $E(\Delta_i\Delta_j)$, we need a table

This table represents

$$
\begin{aligned}
p(\Delta_i = \eta_i, \Delta_j = \eta_j) &= p(\pi_i^p = \delta_i^p, \pi_j^p = \delta_j^p, \pi_i^m = \delta_i^m, \pi_j^m = \delta_j^m) \\
&= p(\pi_i^p = \delta_i^p, \pi_j^p = \delta_i^m, \pi_i^m = \delta_i^m, \pi_j^m = \delta_j^m) \\
&= p(\pi_i^p = \delta_i^p) p(\pi_i^p = \delta_i^p | \pi_j^p = \delta_i^m) p(\pi_i^m = \delta_i^m) p(\pi_i^m = \delta_i^m | \pi_j^m = \delta_j^m)
\end{aligned}
$$

		Locus j			
		$\Delta_j = 1$ $state$ $(\delta_j^p = 1, \delta_j^m = 1)$	$\Delta_j = 0$ $state$ $(\delta_j^p = 1, \delta_j^m = 0)$	$\Delta_j = 0$ $state$ $(\delta_j^p = 0, \delta_j^m = 1)$	$\Delta_j = 0$ $state$ $(\delta_j^p = 0, \delta_j^m = 0)$
Locus i	$\Delta_i = 1$ $state$ $(\delta_i^p = 1, \delta_i^m = 1)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 1, \delta_j^p = 1)$ $(\delta_i^m = 1, \delta_j^m = 1)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 1, \delta_j^p = 1)$ $(\delta_i^m = 1, \delta_j^m = 0)$	$[r_p(1-r_p)]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 1, \delta_j^p = 0)$ $(\delta_i^m = 1, \delta_j^m = 1)$	$[r_p(1-r_p)]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 1, \delta_j^p = 0)$ $(\delta_i^m = 1, \delta_j^m = 0)$
	$\Delta_i = 0$ $state$ $(\delta_i^p = 1, \delta_i^m = 0)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 1, \delta_j^p = 1)$ $(\delta_i^m = 0, \delta_j^m = 1)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 1, \delta_j^p = 1)$ $(\delta_i^m = 0, \delta_j^m = 0)$	$[r_p(1-r_p)]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 1, \delta_j^p = 0)$ $(\delta_i^m = 0, \delta_j^m = 1)$	$[r_p(1-r_p)]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 1, \delta_j^p = 0)$ $(\delta_i^m = 0, \delta_j^m = 0)$
	$\Delta_i = 0$ $state$ $(\delta_i^p = 0, \delta_i^m = 1)$	$[r_p(1-r_p)]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 0, \delta_j^p = 1)$ $(\delta_i^m = 1, \delta_j^m = 1)$	$[r_p(1-r_p)]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 0, \delta_j^p = 1)$ $(\delta_i^m = 1, \delta_j^m = 0)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 0, \delta_j^p = 0)$ $(\delta_i^m = 1, \delta_j^m = 1)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 0, \delta_j^p = 0)$ $(\delta_i^m = 1, \delta_j^m = 0)$
	$\Delta_i = 1$ $state$ $(\delta_i^p = 0, \delta_i^m = 0)$	$[r_p(1-r_p)]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 0, \delta_j^p = 1)$ $(\delta_i^m = 0, \delta_j^m = 1)$	$[r_p(1-r_p)]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 0, \delta_j^p = 1)$ $(\delta_i^m = 0, \delta_j^m = 0)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [r_m(1-r_m)]$ State $(\delta_i^p = 0, \delta_j^p = 0)$ $(\delta_i^m = 0, \delta_j^m = 1)$	$[\frac{r_p^2 + (1-r_p)^2}{2}]$ $\times [\frac{r_m^2 + (1-r_m)^2}{2}]$ State $(\delta_i^p = 0, \delta_j^p = 0)$ $(\delta_i^m = 0, \delta_j^m = 0)$

$$
\begin{aligned}
Cov(\Delta_i, \Delta_j) &= [\frac{r_p^2 + (1-r_p)^2}{2}] \times [\frac{r_m^2 + (1-r_m)^2}{2}] - 1/16 \\
&= 1/4[(1-r)^2 + r^2]^2 - 1/16 \\
&= 1/8[\exp(-2d) + 1]^2 - 1/16
\end{aligned}
$$

If we assume Haldane's mapping function.

Analogous to the IBD sharing, when k is large,

$$
\begin{aligned}
Var(\frac{\sum \Delta_i}{k}) &= \frac{1}{k^2} \sum_i \sum_j Cov(\Delta_i, \Delta_j) \\
&= \frac{1}{l^2} \int_0^l \int_0^l \{1/8[\exp(-2|x_i - x_j| + 1])^2 - 1/16\} dx_i dx_y
\end{aligned}
$$